Available Online at ESci Journals
International Journal of Agricultural Extension
ISSN: 2311-6110 (Online), 2311-8547 (Print)
http://www.escijournals.net/IJAE

FARMER RESPONSIBILITY AND RESEARCHER LEARNING: TWO SIDES OF THE SAME COIN? REFLECTING ON FIVE YEARS OF INVOLVEMENT IN PARTICIPATORY EXPERIMENTATION IN TIGRAY, NORTHERN ETHIOPIA

[a,b,c]Richard G. Kraaijvanger, [b]Loes Witteveen

[a] *Soil Geography and Landscape, Wageningen University, Droevendaalsesteeg 3, 6708 PB Wageningen, Netherlands.*
[b] *Communication, Participation & Social Ecological Learning, Van Hall Larenstein University of Applied Sciences, Larensteinselaan 26a, 6880 GB Velp, Netherlands.*
[c] *Mekelle University, College of Dryland Agriculture,PO Box 231, Mekelle, Ethiopia.*

A B S T R A C T

Participatory experimentation involving farmers and researchers is often forwarded as a suitable approach for developing natural, human and social livelihood capital through technology, learning and empowerment, contributing in this way to resilience and sustainability. Learning in such processes takes place through interaction of farmers and researchers. Aspects like momentum, scientific rigor and farmer responsibility are, however, often at odds. This study explored how distribution of responsibilities affected outcomes for farmers and researchers. In a research project on participatory experimentation 16 farmer groups involved in five consecutive research cycles with the objective to increase crop yield. Essential control was handed over increasingly from the researchers to the farmer groups and in the course of their involvement responsibilities for farmers increased, whereas those of researchers decreased. Researchers included controls and replications and monitored different variables. In the course of their involvement responsibilities for farmers increased, whereas those of researchers decreased. Process of participatory experimentation, learning of farmers and change of attitude were documented systematically. Farmers' and researchers' involvement was analysed to reflect on their respective roles, the experimentation process and the outcomes achieved. Purposive involvement of farmers in all phases of the research resulted in relevant interventions, acquiring experimental skills, trust and commitment. Consequently, farmers' natural, human and social capital increased. Researchers obtained insight in livelihood complexity, learned how to involve with farmers and to trust farmers' competence and potential as co-researchers. The study concluded that delegating responsibilities to farmers in main stages of participatory experimentation is important to meet its objectives. At the same time, researchers involved in participatory experimentation should be sensitive to acknowledge farmers' livelihood complexity. In this way both stakeholders will learn. Farmers, for example, by becoming more autonomous. Researchers by learning about, for example, general agronomic trends and social processes taking place. Exploiting the whole potential of participatory experimentation, therefore, requires a deliberate focus on farmer involvement.

Keywords: Participatory, experimentation, farmer groups, distribution of responsibilities, Tigray, sub Saharan Africa.

INTRODUCTION

Agricultural Productivity in sub Saharan Africa: In sub Saharan Africa agricultural productivity is considered a main development focus (African-Development-Bank, 2016; Ajakaiye & de Janvry, 2010; FARA, 2014; Worldbank, 2007) as concerns about food security and sustainable crop production are evident (Flora, 2010). Both Millenium Development Goals and Sustainable Development Goals witnessed the urgency of these concerns (Sachs, 2012). In response, a transformation of existing agricultural systems into more productive ones is pursued, mostly by the use of external inputs, even though the dominant intensification paradigm failed to bring about significant change in sub Saharan Africa (Giller *et al*., 2011).

* Corresponding Author:
Email: richard.kraaijvanger@hvhl.nl

Farming systems in sub Saharan Africa are complex, diverse and risk-prone (Chambers *et al.,* 1989) and facing numerous constraints, which are diffuse and rooted in local complexity and context. In this perspective constraints can be agro-ecological or socio-economic in nature. Agro-ecological constraints relate to soil, landscape and climate. Socio-economic constraints are connected with issues like land tenure, inflexible markets, technical knowledge and extension support (Ehui & Pender, 2005).

Agronomic Research versus Farmer Research: Agronomic research is important for transformation of agricultural systems and contributed positively to productivity of farming systems through identification of constraints and addressing these by technical solutions and recommended practices (Tittonell & Giller, 2013). A strong critique is that resulting recommendations have no universal validity and implementing these recommendations is difficult due to, for example, non-uniform site-specific conditions (Dea & Scoones, 2003; Giller *et al*., 2008; Guijt, 2008).

Technologies are in many cases introduced in a one-size-fits-all format and farmers often hesitated to adopt such technologies and considered them risky (Frankema, 2014; Gebrehiwot & van der Veen, 2015; George, 2014; Rigolot et al., 2017). Real impact on crop yield, therefore, still is limited (Dalal-Clayton & Dent, 2001; Giller *et al.,* 2011; Giller *et al.,* 2009). For farmers a permanent need to adapt to changing conditions is required (Boillat & Berkes, 2013). Continuous experimentation, therefore, is a way to stay up-to-date in addressing context and consequently an important survival strategy (Leitgeb *et al*., 2014; Richards, 1986), rather than a risk. Research is part of farmers' daily routine and different authors indicated that farmers are by default experimenters, although not in a formal scientific way (Richards, 1986; Rocheleau, 1994).

Agronomic researchers often use as a starting point the zero-input control, as it allows comparison. Farmers' starting point, however, in most cases is current practice and their comparison of performance is memory based (Rocheleau, 1994) rather than relating to a specific time and place: farmers "reflect in action" (Martin & Sherington, 1997).

Participatory Approaches: One-size-fits-all agronomic recommendations are often not successful (Abate *et al*., 2011; Kebede *et al*., 2015; Spielman *et al*., 2010) and therefore a careful selection of suitable technologies adapted to specific local contexts is required. Participatory approaches, in which farmers and researchers co-operate, are an alternative for the traditional role of researchers in agricultural development (Chambers & Jiggins, 1987a) and appear particularly suitable to achieve such objectives since context is addressed better than in conventional, more top-down, extension approaches. Involving farmers in the development of recommendations that match local conditions therefore will support future implementation (Farrington, 1995; Van Mele, 2008). Essentially, participatory approaches allow better communication between stakeholders; in collaboration between farmers and different stakeholders complementarity (Sumberg *et al*., 2003), as well as synergy (Hoffmann *et al*., 2007) are considered important aspects. At the same time, indigenous knowledge, of which researchers might be unaware, is mobilized (Corbeels *et al.,* 2000) and becoming explicit (Hoffmann *et al*., 2007).

Another important outcome of farmers' involvement in participatory experimentation is farmers becoming more responsible and confident about their own development. Scholars discussing participatory approaches therefore often differentiate between a functional dimension relating to outputs in terms of, for example, yield, improved practices and sustainability, and a human-social dimension relating to, for example, empowerment and learning (Farrington, 1998; Farrington & Nelson, 1997; Hellin *et al.,* 2008).

Ways to implement participatory approaches for improving crop productivity are manifold, with each method having its advantages and disadvantages. Examples range from Farmer Field Schools (Braun *et al.,* 2000) and Local Farmer Research Groups (Probst, 2002) to demonstrations simply showing farmers what to do (Misiko, 2009; Ramisch, 2012). Approaches like these are usually framed as participatory experimentation, a form of Action Research in which farmers and researchers co-operate.

Participatory approaches differ in the level of control by the farmers involved and the distribution of responsibilities (Biggs, 1989; Pretty, 1995). Different authors, for example, de Souza *et al.* (2012), Musvoto *et al*. (2015), Raymond *et al*. (2010) and Van De Fliert (2003), stressed the necessity to give farmers a role in the research dealing with their problems. Providing a serious mandate is, however, even in the context of participatory experimentation, in many cases neglected.

Theoretical background: Farmers and agronomic researchers, apparently, share similar objectives in achieving sustainability, increasing crop production and achieving food security. At the same time, differences in backgrounds of farmers and researchers are probable to result in different choices made in processes aiming at achieving such objectives. These different choices, while searching and selecting feasible options to achieve food security and sustainability, result in different pathways for development. Communication between farmers and researchers is often troublesome and reference frameworks and perception of risks might be completely different (Ramisch, 2014; Van Asten *et al.,* 2009). Farmers in many cases use rationales, different from those presumed by researchers and other stakeholders in development work (Ramisch, 2012).

Despite shared research ambitions, the interests of farmers and researchers may diverge. Researchers are interested in the direct outcomes of the experimentation and generalization of the results (Faure et al., 2014; Martin & Sherington, 1997; Ramisch, 2012). Farmers, on the contrary, will consider to what extent research outcomes fit with the complexity of their farming and livelihood system. In the context of Tigray, exemplifying farming systems in sub Saharan Africa, different aspects of traditional farming systems are interconnected: using manure, feeding straw and weeds to livestock (Kraaijvanger *et al.,* 2015), dealing with labour shortage (to look after livestock), using legume fallow, using trees (like Acacia albida) and farmers frequently ploughing the land (up to 5 times or more) to secure infiltration (Nyssen *et al*., 2011).

Researchers often assume the performance of farmer-driven experiments to be limited and to lack momentum (Dalal-Clayton & Dent, 2001; Farrington & Martin, 1988; Martin & Sherington, 1997). On-farm experiments are often qualified as being unscientific since they lack the characteristic of being controlled and therefore are considered not reliable (Somarriba *et al*., 2001): a clear trade-off between (farmer) involvement and (scientific) rigor (Baskerville & Wood-Harper, 1996; Okali *et al.,* 1994) exists.

At the other hand, authors like Choudhary & Surf (2013), Douthwaite *et al.* (2003), Trouche *et al.* (2012) indicated that on-farm experiments supported adaptation and validation of technology and were effective in addressing complexity and contextual variability. Obtaining more scientific rigor in on-farm experiments appears possible, for example, by including replications, controls and contextual data (Mayoux & Chambers, 2005; Rocheleau, 1994).

In Action Research settings, in which farmers and researchers engage in co-learning (Almekinders *et al.,* 2009; Faure *et al.* 2014), these different roles, responsibilities and objectives (Baskerville & Wood-Harper, 1996; Ramisch, 2012; Sumberg *et al.,* 2003) become explicit. Researchers will, at the same time, have an additional role with respect to facilitation of the process.

An overview of these specific roles, responsibilities and objectives was depicted (using keywords) in a heuristic model (see Fig. 4). In this model roles, responsibilities and objectives were clustered in domains in which respectively farmers and researchers operate (see also Chambers & Jiggins (1987a)).

Participatory approaches potentially increase understanding between researchers and researchers (Anderson *et al.,* 2016; Morris & Bellon, 2004; Spielman *et al*., 2008). As a consequence, their respective domains probably become connected better, boundaries more diffuse and differences between researchers' and farmers' perspectives on sustainable ways to increase crop production smaller. Such differences might be bridged from both sides: researchers, might obtain a more in-depth understanding of local context, while farmers could expand their traditional reference framework, allowing more effective sharing of their views and (traditional) knowledge with researchers (Biggs, 2007; Biggs & Matsaert, 1999; Chambers & Jiggins, 1987b).

With the aim to contribute to on-going development of participatory methods this case study explored how distribution of responsibilities within a participatory experimentation framework affected process and outcomes for both farmers and researchers by questioning how process of participatory experimentation was influenced by providing a clear mandate to farmer participants and questioning what outcomes were achieved for both farmers and researchers involved.

METHODS AND MATERIALS

In this research activity the main researcher involved in participatory experimentation with the ambition to assess effectiveness of participatory experimentation in terms of outcomes. An approach was followed in which farmers were unambiguously in the lead: they selected the technologies they wanted to explore within their local context. This approach was selected to allow comparison between the farmer groups and to explore the potential of participatory experimentation. The research was shaped as a social experiment, in which participants, process and outcomes were monitored throughout. In total 16 groups of farmers, distributed evenly over four locations, were involved in this research. The actual process started in 2008 with a session in which the farmer groups focused explicitly on the identification of constraints relating to productivity of their crops. Then, over a period of five years (from July 2009 until November 2014) farmer groups were involved in five experimentation cycles. In each of these cycles (constituting of a clear design, experimentation and evaluation phase) outcomes were generated that served as an input for the next series of experiments.

In line with e.g., Ashby & Pretty (2006), Biggs (2007), Farrington (1997), Hellin *et al.* (2008) and Wood *et al.* (2014), this research had a double focus: both technical achievements and empowerment were considered relevant and therefore differentated between functional and human-social outcomes (see also Kraaijvanger *et al.,* (2016)). Functional outcomes included, aspects such as newly defined recommended practices or changes in crop management; human-social outcomes related to achieving human or social benefits for the farmers and communities involved, for example, in terms of learning and empowerment (Duraiappah *et al.,* 2005; Smajgl & Ward, 2015). The approach selected focused on maximum involvement of farmers; they had a full mandate for all important decisions in the experimentation process and inputs of researchers were essentially restricted to facilitation of the process and introducing novel technology. To characterize and understand the process, roles and responsibilities of farmers and researchers, the actual process and involvement in it were mainly documented through individual surveys and participant observation (of farmers). The analytical lens in this focused on functional outputs, human-social outputs, process and context, taking roles of both farmers and researchers into account.

To explore relationships between experimental outcomes and agronomic factors different agro-ecological data were collected such as, for example, rainfall, soil nutrient content and quantity of manure used in the experiments.

Study Area: The study area, Tigray in Northern Ethiopia, is exemplary for sub Saharan Africa: crop productivity is low, food-aid essential (Van der Veen & Tagel, 2011) and land degradation severe (Ciampalini *et al.,* 2012). Reasons for low crop yields in the northern Ethiopian Highlands are related to unreliable and variable rainfall in combination with problems like hail, soil erosion, poor soil fertility, pests and a low management level (Hengsdijk *et al*., 2005). Abate *et al.* (2011) indicated that also in the context of Tigray attempts to improve crop productivity failed as farmers often hesitated to implement innovations supporting agricultural productivity. In addition, farmers in Tigray were risk averse (Holden & Shiferaw, 2004).

Four locations (woredas) were selected in the highlands of central and eastern Tigray (Fig. 1). These locations differed in biophysical context (geology, landforms, soils and local climate). Farming systems were relatively similar and differences mainly related to specific crops used depending on local climate (Frankl *et al.,* 2013). Most of Tigray is considered semi-arid dryland (Nyssen *et al.,* 2004) with rainfall unevenly distributed over two rainy seasons. Agricultural production in Tigray takes place in mixed farming systems focusing on subsistence crops in combination with livestock (Abegaz, 2005).

Implementing participatory research: Like in most Action Research settings a series of (connected) research cycles was conducted, aiming in this way at progressive learning. Farmers involved in these cycles with the objective to learn about and to develop technologies and practices aiming at increased crop productivity. These research cycles consisted of specific phases (i.e. problem identification, design of research, data collection and evaluation). In each of these phases choices were made that determined the further course of the research.

An essential pre-condition in the research project was farmers having a full mandate in each of these phases. Maximum control over experimentation (analysis, selection) was delegated to the farmers to avoid biased groups due to researcher inputs. This extreme position was required to make our evaluation more meaningful and is often referred to as “collegial” (Biggs, 1989) or “interactive participation” (Pretty, 1995). As a consequence, researcher inputs were to be restricted to facilitation and introducing novel technology.

A well-defined protocol for our research was difficult to develop beforehand; the same holds true for a clear set of variables to be measured. The actual process was open and we used an iterative approach, but at the same time were guided by a set of ex ante identified points of departure constituting a framework:

- Long-term involvement in PE was envisaged (Guijt, 2008; Misiko, 2009; Misiko *et al*., 2011);
- Farmers involved as a group (Pretty, 1995; Tumbo *et al.*, 2011; Yami, 2016);
- Responsibilities were delegated as much as possible to the farmers (Arévalo & Ljung, 2006; de Souza et al., 2012; Giller *et al*., 2008; Musvoto *et al*., 2015; Nederlof *et al*., 2004; Ramisch, 2014);
- Researchers involved in participatory experimentation primarily concentrated on facilitation of the process;
- Farmer dependency on researcher input and facilitation substantially decreased in the course of their involvement (Arévalo & Ljung, 2006);
- Impact of local context was assessed by including 16 different sites;
- Incentives for farmers were reduced to a minimum (Islam *et al.*, 2011);
- Throughout the process systematic monitoring of participating farmers took place.

Based on this framework the farmer groups involved were facilitated in a similar, but not identical, way. For reasons of efficiency we concentrated on documenting the process rather than controlling it (see also Arévalo & Ljung (2006)). In each woreda four farmer groups were involved, each group coming from a specific community (see for details Kraaijvanger *et al.* (2016)). The main participatory tool applied was Focus Group Discussion, in which farmers, in line with the points of departure, indeed exerted (almost) full control over the decision-making process. In this way farmers were allowed to control experimentation and to address local context. In addition, Focus Group Discussion was assumed to support social learning by creating a forum for sharing opinions, for negotiation, for distributing responsibilities and making agreements (Chioncel *et al.*, 2003; Kaplowitz & Hoehn, 2001; Kidd & Parshall, 2000).

Documenting the process: The process was documented throughout the years by systematically collecting relevant data on actual participation of farmers such as attendance, inputs provided (e.g., tasks), workshop outcomes (e.g., experimental design), production achieved and decisions made within the groups (e.g., on continuation and follow up). The data collected were recorded in workshop minutes and in field notebooks. On the basis of these records the participatory process was described over the years, its follow up and experimental designs analysed and different inputs and outcomes for farmers and researchers identified. Essential in our analysis were the different research phases and specific tasks associated with these phases of the cycle (evaluation, design, field management and experimental management). The experiment-based knowledge of the participants was assessed based on the assumption that involvement in experimentation would result in obtaining specific knowledge related to these experiments. For this purpose triad tests (Price, 2001) were prepared and used after each completed research cycle. In these triad tests farmers listed specific combinations of keywords that they considered related. Triad tests have the advantage that a relatively abstract issue can be discussed with farmers having only a low level of literacy. Outcomes of triad tests were statistically tested (Chi-square test) and contrasted with the combinations that we assumed being related.

In the course of the research dialogues of researcher and field assistants with participating farmers took place and observations were made on formal and informal occasions such as workshops, field visits, field measurements, community celebrations and harvesting. Such dialogues and observations were recorded in field notebooks. During the long-term involvement researchers and field assistants continuously reflected on the process and its outcomes. These reflections were recorded in research diaries and field notebooks.

RESULTS

The experimentation process over the years: The field notebooks, workshop minutes and research diaries for each of the sites allowed a detailed reconstruction of the open process we engaged in. The compilation of descriptions resulted in a time line describing the process as it developed. In the course of the research responsibilities in the experimentation process were transferred deliberately more and more to the farmers (see Fig. 2). Researchers contributed through facilitation and including specific treatments in the design (controls, replications, recommended fertilizer application[1], sowing in rows and breaking up the subsoil).

[1] Recommended by the Bureau of Agriculture and Rural Development (consiting of DAP and urea)

First experimentation cycle: In the problem identification workshops soil fertility measures came out as an issue that was prioritized by the groups. In the next workshop farmer groups designed an experimental layout and selected the experimental field and host farmer. In this workshop some background about experimentation (comparing, replications, controls) was provided by the moderator. Researchers afterwards delineated experimental fields (one single field with mostly 15 plots of 3m x 3m) and implemented and monitored the different treatments.

The treatments the farmers selected were diverse and included, for example, applications of organic fertilizer. Researchers included, in addition to the design of the farmer groups, recommended application of fertilizer, a NPK-combination, replications and control plots. In the course of this cycle, field visits were organized and group members and neighbours visited the fields. At maturity, grain and straw yield were measured and first (provisional) outcomes were provided to the farmers. Farmers helped us in most cases with harvesting and measuring yield.

Second experimentation cycle: The evaluation of the previous cycle and the design phase of the second experimentation cycle took place in the same workshop and farmers used the experimental outcomes as an input for their designs; this gave their experiments a systematic character. At the same time farmers blended experimental outcomes with other insights, resulting in very diverse treatments (Kraaijvanger & Veldkamp, 2017). Researchers included row-sowing plots; implementing row sowing, however, was difficult because of stoniness. In addition, fields with recommended fertilizer application and controls were included. Harvesting proceeded as in the year before. Performance of the row-treatments was somewhat disappointing as differences with broadcasting were limited.

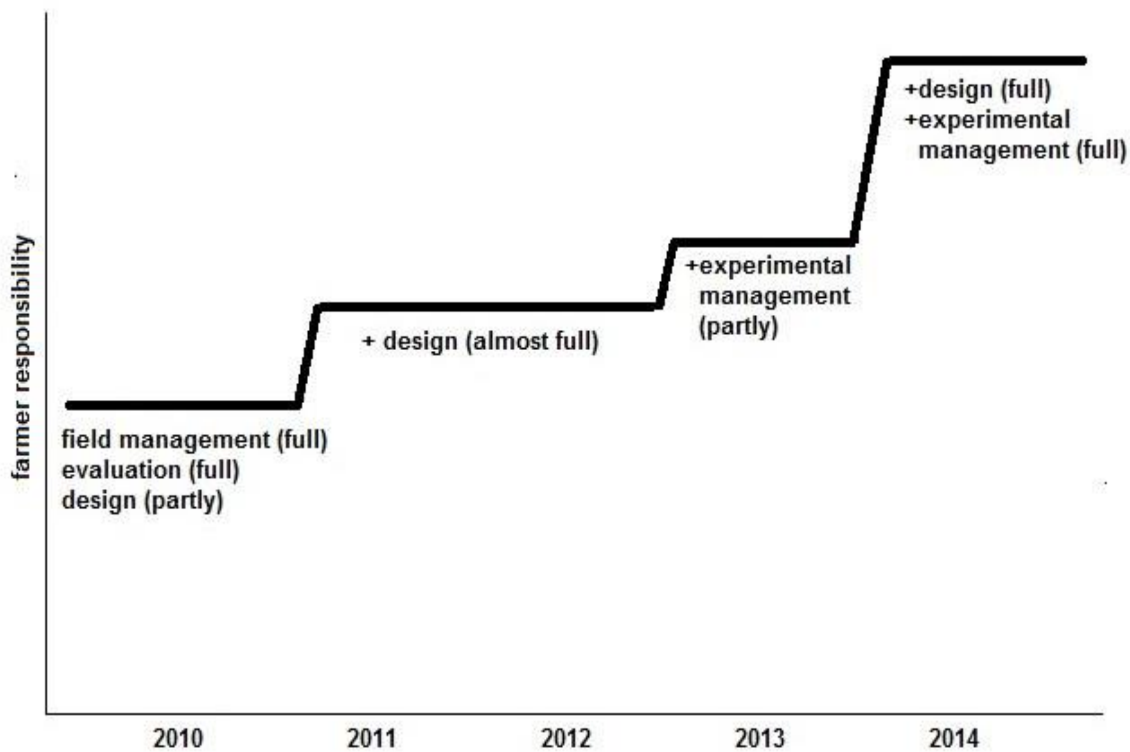

Figure 2. Progressive increase of farmer responsibility over the years of their involvement (2010-2015), ranging from shared responsibility (with researchers) to having full responsibility.

Third experimentation cycle: Farmers again prepared a design on the basis of the outcomes of the previous year. It was found that Some groups changed the field and the host. Researchers included plots with treatments perceived optimal on the basis of the experimentation of previous years. Harvesting measurement of yield proceeded as in the years before.

Fourth experimentation cycle: In the evaluation and design workshop farmers were requested to indicate the treatments they perceived best and to prepare a design on the basis of the outcomes of last year(s). Researchers included plots in which the subsoil was broken up to promote infiltration and also some additional treatments that were perceived optimal on the basis of previous experimentation. Some of the farmer groups changed fields and host farmers. Harvesting was done differently from the previous years, as farmers were requested to harvest and measure some of the plots by themselves. Performance of the digging treatment turned out to be disappointing.

Fifth experimentation cycle: For this round farmer again evaluated outcomes of the previous year and prepared on the basis of that an experimental design. Fields and host farmers were in most cases changed. Groups were responsible for implementing the designs proposed and for harvesting. Groups received materials required for conducting the experiments (including equipment for measuring fertilizers and harvesting). Host farmers were visited around harvesting time and interviewed about their achievements.

Trends observed. In the subsequent experimental designs prepared by the farmer groups diversity of treatments increased: not only by including treatments as suggested by the researchers (recommended fertilizer application, sowing in rows, applying potassium) but also by including more and more their own ideas (like combinations of inputs). At the same time, controls and to a lesser extent replication were included (Table 1).

Table 1. Overall scores of groups with respect to experimental follow up and including specific treatments (*=only reliable samples included; # = 12 groups continued experimentation).

Follow up	2010	2011	2012	2013	2014
Changing field	-	6	8	12	7
Changing host farmer	-	-	3	6	6
Harvesting and measuring yield*	-	-	-	14*	-
Continuation experimentation	16	16	16	16	12
Treatments included	2010	2011	2012	2013	2014
Recommended application	14	13	15	16	9
Replications	-	11	8	8	6
Controls	-	14	12	14	11
Organic fertilizer only	14	16	13	12	5
Combination of mineral and organic fertilizer	3	9	12	12	9
Potassium	-	15	12	8	4
Row	-	-	3	3	1
Breaking subsoil	-	-	-	0	1

In 2013 all groups were requested to harvest and measure part of the experimental plots and to take in this way also responsibility for part of the yield data collected. Following this request up we observed that groups very well managed to do so, however, outcomes (i.e. yields measured) were in two cases not reliable. In 2014 four groups did not conduct experiments: two considered the crop planted (sorghum) not suitable for experimentation; two other groups indicated that they needed more guidance.

Triad Tests: Based on the triad tests, and although no control group was involved, it appeared that farmers that involved in experimentation learned from their involvement: farmers in most cases selected the combinations that we assumed to reflect learning related to their involvement (Table 2). Learning, for example, referred to knowledge on different organic and mineral fertilizers, the effect of legumes, the use of controls and to sowing in rows. Still, unexpected combinations like "much straw – many seeds" and "rain – DAP" were also frequently selected. In explaining their choice farmers often provided arguments based on appearance of the crop; for example, in the case of the combination "rain – DAP" they made reference to "greenness".

Participants observation: The influence of process and factors on participating farmers was described by focusing on the different aspects of the actual research process.

Problem identification: Farmers did not identify single factors to which low crop yields could be attributed. Instead, mind maps with different problems and opportunities were prepared. Farmers had full responsibility for the preparation of the mind maps.

Table 2 : Scores (as a %) for the different combinations farmers selected (combinations assumed to reflect learning are shaded grey; * = significant (p = 0.01)). Control means zero application of fertilizer; DAP, urea and potassium are specific types of mineral fertilizer.

Year	No triad	Triad A-B-C	Combination (%)		
			A-B	A-C	B-C
2011	1	manure – compost – fertilizer*	51,3	28,8	20,0
2011	2	urea - compost – DAP*	17,5	60,0	22,5
2011	3	potassium – DAP – manure*	32,5	11,3	56,3
2012	1	urea - manure – DAP*	13,7	65,8	20,5
2012	2	wheat - selected seeds – hanfets*	63,0	23,3	13,7
2012	3	few plants - many plants - row sowing*	14,1	57,7	28,2
2013	1	urea+compost - urea+manure - urea+DAP*	17,4	47,8	34,8
2013	2	faba beans – wheat – lentil*	12,3	84,9	2,7
2013	3	compost - control – urea*	2,7	95,9	1,4
2014	1	rain – urea – DAP*	9,1	37,7	53,2
2014	2	control – urea – DAP*	0	5,2	94,8
2014	3	much straw - many seeds - few seeds*	97,4	1,3	1,3

Design of experiments: Farmers primarily used experimental outcomes as an input for their designs, which gave their experiments a systematic character. These experiences were blended with other insights and with tradition, curiosity and farmers' contextual reference framework. At the same time, also elements of systematic experimentation (controls and replications) and treatments relating to novel technology were included in the designs prepared.

Experimentation: The on-farm experiments were diverse and farmers appreciated "seeing different options in practice". Farmers rapidly familiarized with the formal and systematic lay-out of the experiments (delineated plots, measured quantities, controls).

Evaluation: To allow all (including illiterate) farmers to be involved in the evaluation an accessible and understandable format (i.e., weight expressed in numbers) was used. Farmers tended to focus on high produce, but in their designs also considered their actual farming system and demonstrated this by prioritizing treatments with a higher straw produce or by including traditional approaches.

Field visits: Some of the fields were used for field visits in which farmers from all four communities observed different experiments. In such cases we explained more about the different treatments and about important aspects to be observed. Farmers highly appreciated this practical exposure and platform for exchange of ideas.

Reflection on farmers' involvement: Farmers obviously did not only pursue systematic selection of optimal treatments, but instead also focused on having a best fit in their farming system. Groups, for example, repeatedly indicated: "Straw feeds our livestock, grains our families; they are equally important". It was observable that farmers became very confident in their evaluation and at the same time became acquainted to novel technologies, however, in an unconditional way. Once they had seen how the field experiments were organized, this became rapidly internalised. Following our request (in the fourth cycle) to harvest and measure part of the experimental plots by themselves one farmer proudly showed the plastic bags containing "his harvest" when we by coincidence passed his house.

Furthermore, farmers reported that they had appreciated their involvement and ownership in the research. Field-visits to research sites were also mentioned as very important in the context of human-social outputs. Host farmers, for example, often offered their visitors on such occasions local food and drinks (injera and tella).

Farmers were, more than we expected, insecure about methods of applying fertilizers and the amounts required of these. Applying mineral fertilizers was perceived as risky as it required a considerable investment.

It was observed that different aspects of farmers' identity changed in a positive way, for example, knowledge, attitude, confidence, social trust and responsibility. Such changes suggested (modest) empowerment of the farmers involved. A spokesman of one of the groups, for example, insisted that: “Outcomes of our experiments need to be communicated with staff of BoARD, so they can make use of the findings”. Using the conceptual framework of Fazey (2010), it is concluded that also epistemological beliefs of the farmers had changed towards using more sophisticated sources of knowledge (i.e. from relying on external sources to knowledge generated through interaction). Such perceptual changes indicated that double loop learning (Argyris & Schon, 1974) and that transformation outside traditional frames of reference (Duveskog et al., 2011) took place.

Choices made were, in general, rational and pragmatic and did not necessarily follow mainstream scientific ideas. Farmers employed a complex strategy to arrive at a research design, not restricting themselves to pre-defined standard options (Kraaijvanger & Veldkamp, 2017). At the same time, they were critical and often had reservations, for example, with respect to the use of fertilizers, assuming these led to “addiction”. Farmers were eager to experiment and even included many untypical treatments. Such out-of-the-box experimentation not necessarily implied trial and error, but instead merged elements of traditional practices and newer insights, for example, the use of ash instead of potassium and row application of compost. Including controls and replications meant that elements of systematic experimentation were becoming important for the farmers (Kraaijvanger & Veldkamp, 2017).

Controls, initially, were considered waste of produce; later on controls made it possible to compare what zero-input (meaning zero-cost) would yield. Whether or not replications and recommended applications of fertilizer were included, appeared to depend on the availability of sufficient “space” within the experimental field, which typically consisted out of 15 plots.

In the course of their participation farmers became familiar with the structure of the workshop and went on by themselves. Participation was respectful and all group-members could involve on equal terms. In later workshops they only needed a small hint to go on by themselves, they knew what to do and how to do it. The way farmers involved in the workshops was surprising; being very committed, and it was observed that participants organized themselves very well. Discussions, in general, were respectful and responsibilities were clear as can be exemplified by an older farmer, who stood up and addressed the assembly: “Since I am oldest here, I will thank you ...”. Farmers were proud of their involvement; in some of their houses we saw maps used in the workshops serving as a wall decoration (Fig. 3).

Figure 3. A farmer house showing the charts used in the design sessions as a wall decoration.

Reflection on researchers’ involvement: The researchers involved were eager to learn about (causal) relationships between experimental outcomes (e.g. yield, response) and agronomic variables (e.g. soil nutrient content, management, rainfall). Most important was the observation that outcome variability (of on-farm experiments) matched well with different descriptive agronomic data (see Kraaijvanger & Veldkamp, 2015). Modest control of the experiments by the researchers through including control treatments, replications and quantification of experimental and environmental variables resulted in considerable scientific rigor; the troublesome trade-off between rigor and (farmer) involvement appeared addressed satisfactory.

Assumed relationships between experimental outcomes and different variables were, however, not always confirmed and explicit. This absence of direct causality was experienced as disappointing, exemplifying in this way how conventional agronomic expectations may differ from actual agro-ecological complexity. The main researcher demonstrated a tendency to take a positivist stance, whereas farmers definitely took a more holistic perspective and included aspects of complexity. We observed, for example, trends like preferring straw yield and including combinations of mineral and organic fertilizers in the experimental designs the farmer groups prepared.

What actually drove farmers remained unclear to the main researcher as farmers’ perspective contrasted with the more formal analytical framework the researcher had in mind. At the same time, the researcher gained a deeper insight on farming system complexity and the impact of different contextual factors on outcomes achieved.

Facilitation, in general, was successful in supporting farmer groups in an unconditional way. Transparency of the process and sharing of responsibilities remained of relevance; the appreciation for the articulation of such procedures in the process was highly appreciated by the farmers. In one case, a (host)farmer requested (additional) compensation for the use of his field and the likely loss of yield. After explaining that the compensation offered was considered reasonable and referring to the preceding workshop, the farmer was requested to reconsider his responsibility. After this discussion the farmer left but returned 30 minutes later to inform that he would take his responsibility for that specific year.

Reflecting on the main researchers' role and ambitions, it was concluded that we were not that successful in achieving relevant site-specific functional outcomes in the series of research cycles; we failed to address farming system and livelihood complexity and were not able to define clear and relevant recommendations for each of the sites. Initially, we relied on our specific (science-based) reference framework, but later on, similar to the farmers involved, the research increasingly started using experienced outcomes. It was revealed that our framework of reference was not always able to fully comply with the reality observed and at the same time, observations contrasted with initial assumptions. Most important learning in relation to the process was that no single factor could be identified and that the process as such was dependent on human-social context. It became clear that blue-print methods would not be successful and that, on the contrary, iterative adjustment of the process was a better way to go ahead.

The role of researchers in the process was relatively limited and this relative distance allowed observing the process from a more periphery position. This stand enabled learning, to rely on farmers' capacities, competences and traditional knowledge of farmers and to take their ideas and insights serious. With respect to the conceptual framework of Fazey (2010), it can be concluded that the researcher' epistemological beliefs had changed with respect to certainty of knowledge: the view became more sophisticated (i.e., from absolute truth and certainty to considering knowledge more tentative and evolving).

DISCUSSION

Distribution of responsibilities: In Action Research settings stakeholders have the ambition to arrive at purposeful action and change, but at the same time have different worldviews which are, however, not fixed (Checkland & Holwell, 1998). The results indicated that handing over responsibility to farmers was effective in achieving relevant outcomes (Table 3). Farmers became competent and confident in managing their experiments and started including treatments on the basis of their own ideas and secured in this way contextual relevancy. Handing over responsibility was essential as (natural) scientists, in general, tend to take a position outside the context and even in Action Research their focus might be more on generalization and understanding (Faure et al., 2014).

Farmers will take a natural position within their context and, as a consequence, participatory approaches will not only relate to the input of the farmers to the experiments but also to the input of context to the process. The somewhat paradoxical appreciation of context by the researchers, rather than excluding it for the sake of control, appeared of major importance to achieve learning for both stakeholders in the process of participatory experimentation.

Table 3. Overview of inputs provided and outcomes achieved of farmers and researchers involved in participatory experimentation.

	Knowledge inputs	
Year	Farmer	Researcher
2010	extension, tradition	extension, university-staff
2011	experiment, extension, tradition	extension, university-staff
2012	experiment, tradition	experiment, extension
2013	experiment, tradition	Experiment
2014	experiment, tradition	Experiment

Functional outcomes		
Year	Farmer	Researcher
2010	recommended practices performed well	farmer fields performed well, compost treatments were disappointing
2011	combinations organic and mineral performed well	combinations organic and mineral performed well
2012	combinations organic and mineral performed well	row treatments were disappointing
2013	combinations organic and mineral performed well	digging treatments were disappointing
2014		
Human-social outcomes		
Year	Farmer	Researcher
2010	systematic experimentation	insight in effectiveness farming system, dependency on context
2011	confidence and competence	insight in community functioning
2012	confidence and competence	understanding agronomic complexity
2013	confidence and competence	understanding co-operation farmers
2014	confidence and competence	understanding competence

Farmers learned through their involvement not only about crop management, but in line with Smajgl & Ward (2015), also with respect to values, beliefs and attitude At the same time, we observed that farmers, as was also reported by Cornish *et al.* (2015), became more independent and started managing their own learning.

Researchers learned at a meta-level about general agronomic trends and social processes taking place. For researchers having fewer responsibilities also meant that their role became more situated at a meta-level and that scientific rigor became more difficult to achieve. As a researcher we learned about complexity (functional understanding) but also obtained trust in the performance of farmers and their role. Sharing responsibilities therefore appeared a win-win for researchers and farmers.

Process: The iterative process embarked on was more engaging than anticipated: groups continued and did not drop-out. Group antecedents were variable and needed to be respected, more than being addressed. Participatory experimentation is a context dependent process (Martin & Sherington, 1997) and requires care in designing and implementing it; blue prints are not suitable (Totin *et al.*, 2015). Different authors highlighted that functional aspects in participatory processes appear to be prioritized (Martin & Sherington, 1997), in this case, an explicit choice was made for empowerment and learning, which potentially might have affected the trade-off between involvement and scientific rigor.

At the other hand, farmers and researchers shared their interest in data; farmers highly appreciated the availability of understandable data as it helped them to structure their discussions.

Heuristic model: Outcomes of participant observation and reflections indicated that the domains of farmers and researchers became more connected as is visualised in figure 4. Transfer of responsibilities helped to achieve this: researchers, for example moved from causality towards complexity, whereas farmers started using, next to visual crop appearance, also numbers. Researchers, at the other hand, included more holistic elements and focused less on recommendations and more on site-specific adaptation. In participatory experimentation farmers and researchers take different perspectives in interpreting and implementing outcomes. External perspectives only make sense for farmers if their livelihood context is also considered. Participation of farmers in the research cycle and mandating them for the design and evaluation phase, resulted over the years indeed in achieving human-social outcomes, for example in empowerment and in farmers becoming more confident. Bridging the domains of farmers and researchers took place from both sides through increased understanding and equality resulting from involvement in participatory experimentation.

Practical implications: Transition processes aiming at farming systems with higher and more sustainable productivity in low input-high risk contexts will benefit from participatory experimentation in two ways. Firstly, the direct involvement of farmer groups (Dugué et al., 2015) will effectively address local context and preferences and secure diffusion (Darr & Pretzsch, 2008). Secondly, the involvement in participatory experimentation will equip participants with social competences that support such transition processes. To arrive at such situations, approaches should be based on open iterative processes in which feedback is essential and responsibilities are delegated to the farmers in all phases of the process.

Only in this way it is assured that farmers' perspective is reflected in outcomes achieved. This recommendation matches with the present transformation of extension services in Ethiopia towards becoming less top-down directed (Gebregziaher *et al.,* 2013).

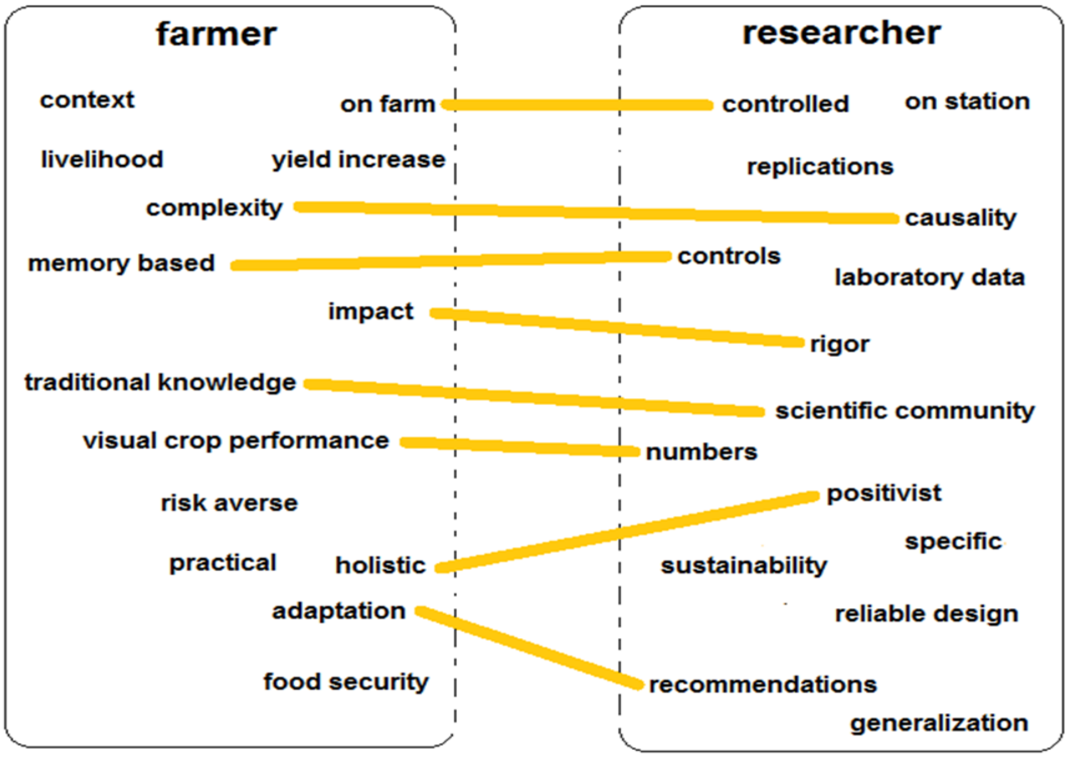

Figure 4. Visualisation of domains of farmers and researcher and potential connections resulting from joint participatory experimentation.

CONCLUSION

Farmers appropriated responsibilities handed over to them in the research with respect to evaluation and design of experiments and at the same time included in that process contextual aspects. Their involvement resulted in confidence and competence, which helped them to effectively contribute to the participatory process, and reduced their need for facilitation. Purposive involvement of farmers in all phases of the research resulted in quality of interventions, obtaining experimental skills, trust and commitment. In this way, farmers' natural, human and social capital increased. Farmers' learning was not only related to knowing the best way, but also towards confidence in finding the best way. Researchers obtained insight in livelihood complexity, learned how to involve with farmers and to trust farmers' competence and potential as co-researchers. On the basis of this transfer of responsibilities both stakeholders in the experimentation process had learning opportunities. In different stages of the participatory experimentation process choices were made that had strong impact throughout. Participatory experimentation therefore should be an iterative process in which small steps and continuous feedback loops are essential. It appears that delegating responsibilities to farmers in participatory experimentation is a major concern to meet its objectives.

At the same time, researchers involved in participatory experimentation should be sufficiently sensitive to acknowledge farmers' livelihood complexity.

Functional change of farmer systems will only be relevant and sustainable if farmers indeed have the opportunity to submerge themselves fully in participatory experimentation. Exploiting the full potential of participatory experimentation therefore requires a deliberate focus on farmer participation. Emphasizing the delegation of responsibilities to farmers definitely supports farmers' empowerment and the learning of both farmers and researchers.

Acknowledgements: The authors wish to express their gratitude to all farmers involved in participatory experimentation, to staff of BoARD for facilitation workshops, to Hidat Mesfin, Semere Gashew and Mohammed Nur for conducting workshops and interviews and to Zemen Mesfin for providing field assistance. Furthermore, we want to thank Conny Almekinders, Tom Veldkamp and Cees Leeuwis for their comments on earlier versions.

REFERENCES

Abate, T., Shiferaw, B., Gebeyehu, S., Amsalu, B., Negash, K., Assefa, K., Hagmann, J. (2011). A systems and partnership approach to agricultural research for development: Lessons from Ethiopia. Outlook on Agriculture, 40(3), 213-220.

Abegaz, A. (2005). Farm management in mixed crop-livestock systems in the Northern Highlands of Ethiopia. Tropical Resource Management Papers 70. (PhD), Wageningen University, Wageningen, The Netherlands.

African-Development-Bank. (2016). Feed Africa: Strategy for Agricultural Transformation in Africa 2016-2025. Available under: www.afdb.org/. Accessed: 21-12-2016.

Ajakaiye, O., & de Janvry, A. (2010). Agricultural sector performance & a green revolution in Africa: An overview. Journal of African Economies, 19 2),

Almekinders, C., Beukema, L., & Tromp, C. (2009). Research in Action. Theories and practices for innovation and social change. Wageningen, The Netherlands: Wageningen Academic Publishers.

Anderson, W., Johansen, C., & Siddique, K. H. M. (2016). Addressing the yield gap: a review. Agronomy and Sustainable Development, 36:18. doi: 10.1007/s13593-015-0341-y

Arévalo, K., & Ljung, M. (2006). Action Research on Land Management in the Western Amazon, Peru – A Research Process, Its Outcomes and the Researcher's Role. Systemic Practice and Action Research, 19(4), 309-324.

Argyris, C., & Schon, D. A. (1974). Theory in practice: Increasing professional effectiveness. Hoboken, NJ: Jossey-Bass.

Ashby, J., & Pretty, J. (2006). Commentary: Participatory research for sustainable agricultural research and development. International Journal of Agricultural Sustainability, 4(2), 97-98.

Baskerville, R. L., & Wood-Harper, A. T. (1996). A critical perspective on action research as a method for information systems research. Journal of Information Technology, 11(3), 235-246.

Biggs, S. (1989). Resource-poor farmer participation in research: A synthesis of experiences from nine national agricultural research systems. OFCOR Comparative Study. The Hague, Netherlands: 3ISNAR.

Biggs, S. (2007). Building on the positive: An actor innovation systems approach to finding and promoting pro poor natural resources institutional and technical innovations. International Journal of Agricultural Resources, Governance and Ecology. 6(2), 144-164.

Biggs, S., & Matsaert, H. (1999). An actor-oriented approach for strengthening research and development capabilities in natural resource systems. Public Administration and Development, 19(3), 231-262.

Boillat, S., & Berkes, F. (2013). Perception and interpretation of climate change among quechua farmers of bolivia: Indigenous knowledge as a resource for adaptive capacity. Ecology and Society, 18(4). doi: 10.5751/es-05894-180421

Braun, A. R., Thiele, G., & Fernández, M. (2000). Farmer field schools and local agricultural research committees: complementary platforms for integrated decision-making in sustainable agriculture. London: Overseas Development Institute

Chambers, R., & Jiggins, J. (1987a). Agricultural research for resource-poor farmers. Part I: Transfer-of-technology and farming systems research. Agricultural Administration and Extension, 27(1), 35-52.

Chambers, R., & Jiggins, J. (1987b). Agricultural research for resource-poor farmers. Part II: A parsimonious paradigm. Agricultural Administration and Extension, 27(2), 109-128.

Chambers, R., Pacey, A., & Thrupp, L. A. (1989). Farmers first? London: ITP.

Checkland, P., & Holwell, S. (1998). Action Research: Its Nature and Validity. Systemic Practice and Action Research, 11(1), 9-21.

Chioncel, N. E., Van der Veen, R. G. W., Wildemeersch, D., & Jarvis, P. (2003). The validity and reliability of focus groups as a research method in adult education. International Journal of Lifelong Learning, 22(5), 495-517. doi: 10.1080/0260137032000102850

Choudhary, A. K., & Surf, V. K. (2013). On-Farm Participatory Technology Development Effects on Resource Conservation Technologies in Rainfed Upland Paddy in Himsachal Pradesh, India. Communications in Soil Science and Plant Analysis, 44, 2605-2617. doi: 10.1080/00103624.2013.811521

Ciampalini, R., Billi, P., Ferrari, G., Borselli, L., & Follain, S. (2012). Soil erosion induced by land use changes as determined by plough marks and field evidence in the Aksum area (Ethiopia). Agriculture, Ecosystems and Environment, 146, 197-208. doi: 10.1016/j.agee.2011.11.006

Corbeels, M., Shiferaw, A., & Haile, M. (2000). Farmers' knowledge of soil fertility and local management strategies in Tigray, Ethiopia. London: IIED.

Cornish, P. S., Choudhary, A., Kumar, A., Das, S., Kukumbakhar, K., Norish, S., & Kumar, S. (2015). Improving crop production for food security and improved livelihoods on the East India Plateau II Crop options, alternative cropping systems and capacity building. Agricultural Systems, 137, 180-190. doi: 10.1016/j.agsy.2015.02.011

Dalal-Clayton, B., & Dent, D. (2001). Knowledge of the land: land resources information and its use in rural development. Oxford University Press.

Darr, D., & Pretzsch, J. (2008). Mechanisms of Innovation Diffusion Under Information Abundance and Information Scarcity - On the Contribution of Social Networks in Group Vs. Individual Extension Approaches in Semi-Arid Kenya. Journal of Agricultural Education and Extension, 14(3), 231-248. doi: 10.1080/13892240802207676

de Souza, H. N., Cardoso, I. M., de Sá Mendonça, E., Carvalho, A. F., de Oliveira, G. B., Gjorup, D. F., & Bonfim, V. R. (2012). Learning by doing: A participatory methodology for systematization of experiments with agroforestry systems, with an example of its application. Agroforestry Systems, 85(2), 247-262. doi: 10.1007/s10457-012-9498-4

Dea, D., & Scoones, I. (2003). Networks of knowledge: How farmers and scientists understand soils and their fertility. A case study from Ethiopia. Oxford Development Studies, 31(4), 461-478. doi: 10.1080/1360081032000146636

Douthwaite, B., Kuby, T., Van De Fliert, E., & Schulz, S. (2003). Impact pathway evaluation: An approach for achieving and attributing impact in complex systems. Agricultural Systems, 78(2), 243-265. doi: 10.1016/s0308-521x(03)00128-8

Dugué, P., Djamen Nana, P., Faure, G., & Le Gal, P.-Y. (2015). Dynamiques d'adoption de l'agriculture de conservation dans les exploitations familiales : de la technique aux processus d'innovation. Cahiers Agriculture, 24(2), 60-68. doi: 10.1684/agr.2015.0748

Duraiappah, A. K., Roddy, P., & Parry, J.-E. (2005). Have participatory approaches increased capabilities? Winnipeg, Canada: International Institute for Sustainable Development.

Duveskog, D., Friis-Hansen, E., & Taylor, E. W. (2011). Farmer field schools in rural Kenya: A transformative learning experience. Journal of Development Studies, 47(10), 1529-1544. doi: 10.1080/00220388.2011.561328

Ehui, S., & Pender, J. (2005). Resource degradation, low agricultural productivity, and poverty in sub-Saharan Africa: Pathways out of the spiral. Agricultural Economics, 32(SUPPL. 1), 225-242. doi: 10.1111/j.0169-5150.2004.00026.x

FARA. (2014). Science Agenda for Agriculture in Africa: "Connecting Science" to transform agriculture in Africa. Available under: www.faraafrica.org/programs/frameworks/science-agenda/. Accessed: 21-12-2016.

Farrington, J. (1995). The changing public role in agricultural extension. Food Policy, 20(6), 537-544. doi: 10.1016/0306-9192(95)00046-1

Farrington, J. (1997). Farmers' participation in agricultural research and extension: Lessons from last decade. Biotechnology and Development Monitor(30), 12-15.

Farrington, J. (1998). Organisational roles in farmer participatory research and extension: lessons from the last decade. Natural Resource Perspectives, 27.

Farrington, J., & Martin, A. M. (1988). Farmer participatory research: A review of concepts and recent fieldwork. Agricultural Administration and Extension, 29(4), 247-264. doi: 10.1016/0269-7475(88)90107-9

Farrington, J., & Nelson, J. (1997). Using logframes to monitor and review farmer participatory research. Network Paper No. 73. London: ODI.

Faure, G., Gasselin, P., Triomphe, B., Temple, L., & Hocdé, H. (2014). Innovating with rural stakeholders in the developing world: Action research in partnership. Wageningen, The Netherlands: CTA LM Publishers / Presses Agronomiques de Gembloux.

Fazey, I. (2010). Resilience and Higher Order Thinking. Ecology and Society, 15(3).

Flora, C. B. (2010). Food security in the context of energy and resource depletion: Sustainable agriculture in developing countries. Renewable Agriculture and Food Systems, 25(2), 118-128. doi: 10.1017/s1742170510000177

Frankema, E. (2014). Africa and the green revolution a global historical perspective. NJAS - Wageningen Journal of Life Sciences, 70, 17-24. doi: 10.1016/j.njas.2014.01.003

Frankl, A., Jacob, M., Haile, M., Poesen, J., Deckers, J., & Nyssen, J. (2013). The effect of rainfall on spatio-temporal variability in cropping systems and duration of crop cover in the Northern Ethiopian Highlands. Soil Use and Management, 29(3), 374-383. doi: 10.1111/sum.12041

Gebregziaher, K., Mathijs, E., Deckers, J., Gebrehiwot, K., Bauer, h., & Maertens, M. (2013). The Economic Impact of a New Rural Extension Approach in Northern Ethiopia. Bioeconomics Working Paper Series. Leuven, Belgium: University of Leuven.

Gebrehiwot, T., & van der Veen, A. (2015). Farmers Prone to Drought Risk: Why Some Farmers Undertake Farm-Level Risk-Reduction Measures While Others Not? Environmental Management, 55(3), 588-602. doi: 10.1007/s00267-014-0415-7

George, T. (2014). Why crop yields in developing countries have not kept pace with advances in agronomy. Global Food Security, 3, 49-58. doi: 10.1016/j.gfs.2013.10.002

Giller, K. E., Leeuwis, C., Andersson, J. A., Andriesse, W., Brouwer, A., Frost, P., . . . Windmeijer, P. (2008). Competing claims on natural resources: What role for science? Ecology and Society, 13(2).

Giller, K. E., Tittonell, P., Rufino, M. C., van Wijk, M. T., Zingore, S., Mapfumo, P., . . . Vanlauwe, B. (2011). Communicating complexity: Integrated assessment of trade-offs concerning soil fertility management within African farming systems to support innovation and development. Agricultural Systems, 104(2), 191-203. doi: 10.1016/j.agsy.2010.07.002

Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. Field Crops Research, 114(1), 23-34. doi: 10.1016/j.fcr.2009.06.017

Guijt, I. M. (2008). Seeking Surprise: Rethinking monitoring for collective learning in rural resource management. (PhD), Wageningen University, Wageningen.

Hellin, J., Bellon, M. R., Badstue, L., Dixon, J., & La Rovere, R. (2008). Increasing the impacts of participatory research. Experimental Agriculture, 44(1), 81-95. doi: 10.1017/s0014479707005935

Hengsdijk, H., Meijerink, G. W., & Mosugu, M. E. (2005). Modeling the effect of three soil and water conservation practices in Tigray, Ethiopia. Agriculture, Ecosystems and Environment, 105(1-2), 29-40. doi: 10.1016/j.agee.2004.06.002

Hoffmann, V., Probst, K., & Christinck, A. (2007). Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? Agriculture and Human Values, 24(3), 355-368. doi: 10.1007/s10460-007-9072-2

Holden, S., & Shiferaw, B. (2004). Land degradation, drought and food security in a less-favoured area in the Ethiopian highlands: A bio-economic model with market imperfections. Agricultural Economics, 30(1), 31-49.

Islam, M. M., Gray, D., Reid, J., & Kemp, P. (2011). Developing Sustainable Farmer-led Extension Groups: Lessons from a Bangladeshi Case Study. The Journal of Agricultural Education and Extension, 17(5), 425-443. doi: 10.1080/1389224x.2011.596658

Kaplowitz, M. D., & Hoehn, J. P. (2001). Do focus groups and individual interviews reveal the same information for natural resource valuation? Ecological Economics, 36(2), 237-247. doi: 10.1016/s0921-8009(00)00226-3

Kebede, E., Duncan, A., Klerkx, L., de Boer, I. J. M., & Oosting, S. J. (2015). Understanding socio-economic and policy constraints to dairy development in Ethiopia: A coupled functional-structural innovation systems analysis. Agricultural Systems, 141, 69-78. doi: 10.1016/j.agsy.2015.09.007

Kidd, P. S., & Parshall, M. B. (2000). Getting the focus and the group: Enhancing analytical rigor in focus group research. Qualitative Health Research, 10(3), 293-308.

Kraaijvanger, R., Sonneveld, M., Almekinders, C., & Veldkamp, T. (2015). Comparison of methods to identify crop productivity constraints in developing countries. A review. Agronomy for Sustainable Development, 35(2), 625-637. doi: 10.1007/s13593-014-0254-1

Kraaijvanger, R., & Veldkamp, A. (2015). The importance of local factors and management in determining wheat yield variability in on-farm experimentation in Tigray, northern Ethiopia. Agriculture, Ecosystems and Environment, 214, 1-9. doi: 10.1016/j.agee.2015.08.003

Kraaijvanger, R., Veldkamp, T., & Almekinders, C. (2016). Considering change: Evaluating four years of participatory experimentation with farmers in Tigray (Ethiopia) highlighting both functional and human–social aspects. Agricultural Systems, 147, 38-50. doi: 10.1016/j.agsy.2016.05.001

Kraaijvanger, R. G., & Veldkamp, T. (2017). Four years of farmer experimentation on soil fertility in Tigray, northern Ethiopia: trends in research strategies. The Journal of Agricultural Education and Extension, 1-19. doi: 10.1080/1389224x.2017.1289962

Leitgeb, F., Kummer, S., Funes-Monzote, F. R., & Vogl, C. R. (2014). Farmers' experiments in Cuba. Renewable Agriculture and Food Systems, 29(1), 48-64. doi: 10.1017/s1742170512000336

Martin, A., & Sherington, J. (1997). Participatory Research Methods-Implementation, Effectiveness and Institutional Context. Agricultural Systems, 55(2), 195-216.

Mayoux, L., & Chambers, R. (2005). Reversing the paradigm: quantification, participatory methods and pro-poor impact assessment. Journal of International Development, 17(2), 271-298. doi: 10.1002/jid.1214

Misiko, M. (2009). Collective experimentation: Lessons from the field. Journal of Agricultural Education and Extension, 15(4), 401-416. doi: 10.1080/13892240903309660

Misiko, M., Tittonell, P., Giller, K. E., & Richards, P. (2011). Strenghtening understanding and perceptions of mineral fertilizer use among smallholder farmers: evidence from collective trials in western kenya. Agriculture and Human Values, 28, 27-38. doi: 10.1007/s10460-010-9264-z

Morris, M. L., & Bellon, M. R. (2004). Participatory plant breeding research: Opportunities and challenges for the international crop improvement system. Euphytica, 136(1), 21-35.

Musvoto, C., Mason, N., Jovanovic, N., Froebrich, J., Tshovhote, J., Nemakhavhani, M., & Khabe, T. (2015). Applying a transdisciplinary process to define a research agenda in a smallholder irrigated farming system in South Africa. Agricultural Systems, 137, 39-50. doi: 10.1016/j.agsy.2015.03.008

Nederlof, E. S., Tossou, R., Sakyi-Dawson, O., & Kossou, D. K. (2004). Grounding agricultural research in resource-poor farmers' needs: A comparative analysis of diagnostic studies in Ghana and Benin. NJAS - Wageningen Journal of Life Sciences, 52(3-4), 421-442.

Nyssen, J., Govaerts, B., Araya, T., Cornelis, W., Bauer, H., Haile, M., . . . Deckers, J. (2011). The use of the marasha ard plough for conservation agriculture in Northern Ethiopia. Agronomy and Sustainable Development, 31(2), 287-297. doi: 10.1051/agro/2010014.

Nyssen, J., Poesen, J., Moeyersons, J., Deckers, J., Haile, M., & Lang, A. (2004). Human impact on the environment in the Ethiopian and Eritrean highlands - A state of the art. Earth-Science Reviews, 64(3-4), 273-320. doi: 10.1016/S0012-8252(03)00078-3

Okali, C., Sumberg, J., & Farrington, J. (1994). Farmer participatory research: rhetoric and reality. London: Intermediate Technology Publications.

Pretty, J. N. (1995). Participatory learning for sustainable agriculture. World Development, 23(8), 1247-1263.

Price, L. L. (2001). Demystifying farmers' entomological and pest management knowledge: A methodology for assessing the impacts on knowledge from IPM-FFS and NES interventions. Agriculture and Human Values, 18(2), 153-176.

Probst, K. (2002). Participatory Monitoring and Evaluation: A promising Concept in Participatory Research? Weikersheim: Margraf Verlag.

Ramisch, J. (2012). This field is our church. The social and agronomic challenges of knowledge generation in a participatory soil fertility management project. In J. Sumberg and J. Thompson (Ed.), Contested agronomy: agricultural research in a changing world. New York: Earthscan, Routledge.

Ramisch, J. J. (2014). 'They don't know what they are talking about': Learning from the dissonances in dialogue about soil fertility knowledge and experimental practice in western Kenya. Geoforum, 55, 120-132. doi: 10.1016/j.geoforum.2014.05.009

Raymond, C. M., Fazey, I., Reed, M. S., Stringer, L. C., Robinson, G. M., & Evely, A. C. (2010). Integrating local and scientific knowledge for environmental management. Journal of Environmental Management, 91(8), 1766-1777.

Richards, P. (1986). Coping with hunger. Hazard and experiment in an African rice-farming system. London: Allen & Unwin.

Rigolot, C., de Voil, P., Douxchamps, S., Prestwidge, D., Van Wijk, M., Thornton, P., . . . Herrero, M. (2017). Interactions between intervention packages, climatic risk, climatic change and food security in mixed crop-livestock systems in Burkina Faso. Agricultural Systems, 151, 217-224. doi: 10.1016/j.agsy.2015.12.017.

Rocheleau, D. E. (1994). Participatory research and the race to save the planet: Questions, critique, and lessons from the field. Agriculture and Human Values, 11(2), 4-25. doi: 10.1007/bf01530443

Sachs, J. D. (2012). From Millenium Development Goals to Sustainable Development Goals. The Lancet, 379, 2206-2211.

Smajgl, A., & Ward, J. (2015). Evaluating participatory research: Framework, methods and implementation results. Journal of Environmental Management, 157, 311-319. doi: 10.1016/j.envman.2015.04.014

Somarriba, E., Beer, J., & Muschler, R. G. (2001). Research methods for multistrata agroforestry systems with coffee and cacao: recommendations from two decades of research at CATIE. Agroforestry Systems, 53, 195-203.

Spielman, D. J., Byerlee, D., Salemu, D., & Kelemework, D. (2010). Policies to promote cereal intensification in Ethiopia: The search for appropriate public and private roles. Food Policy, 35, 185-194.

Spielman, D. J., Ekboir, J., Davis, K., & Ochieng, C. M. O. (2008). An innovation system perspective on strengtening agricultural education and training in sub-Saharan Africa. Agricultural Systems, 98, 1-9.

Sumberg, J., Okali, C., & Reece, D. (2003). Agricultural research in the face of diversity, local knowledge and the participation imperative: Theoretical considerations. Agricultural Systems, 76(2), 739-753.

Tittonell, P., & Giller, K. E. (2013). When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture. Field Crops Research, 143, 76-90.

Totin, E., van Mierlo, B., Mongbo, R., & Leeuwis, C. (2015). Diversity in success: Interaction between external interventions and local actions in three rice farming areas in Benin. Agricultural Systems, 133, 119-130.

Trouche, G., Lançon, J., Aguirre Acuna, S., Castro Briones, B., & Thomas, G. (2012). Compoaring decentralized participatory breeding with on-station conventional sorghum breeding in Nicaragua: II Farmer acceptance and index of global value. Fields Crop Research, 126, 70-78. doi: 10.1016/j.fcr2011.09.024.

Tumbo, S. D., Mutabazi, K. D., Byakugila, M. M., & Mahoo, H. F. M. (2011). An empirical framework for scaling-out of water system innovations: Lessons from diffusion of water system innovations in the Makanya catchment in Northern Tanzania. Agricultural Water Management, 98(11), 1761-1773. doi: 10.1016/j.agwat.2010.03.010.

Van Asten, P. J. A., Kaaria, S., Fermont, A. M., & Delve, R. J. (2009). Challenges and lessons when using farmer knowledge in agricultural research and development projects in Africa. Experimental Agriculture, 45(1), 1-14. doi: 10.1017/s0014479708006984.

Van De Fliert, E. (2003). Recognising a climate for sustainability: Extension beyond transfer of technology. Australian Journal of Experimental Agriculture, 43(1), 29-36.

Van der Veen, A., & Tagel, G. (2011). Effect of Policy Interventions on Food Security in Tigray, Northern Ethiopia. Ecology and Society, 16(1).

Van Mele, P. (2008). The importance of ecological and socio-technological literacy in R&D priority setting: The case of a fruit innovation system in Guinea, West Africa. International Journal of Agricultural Sustainability, 6(3), 183-194.

Wood, B. A., Blair, H. T., Gray, D. I., Kemp, P. D., Kenyon, P. R., Morris, S. T., & Sewell, A. M. (2014). Agricultural science in the wild: A social network analysis of farmer knowledge exchange. PLoS ONE, 9(8).

Worldbank. (2007). World development report 2008: Agriculture for development. Washington DC: The Worldbank.

Yami, M. (2016). Irrigation projects in Ethiopia: what can be done to enhance effectiveness under 'challenging contexts'? International Journal of Sustainable Development and World Ecology, 23(2), 132-142.