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Considering change: Evaluating four years of participatory experimentation with farmers in Tigray (Ethiopia) highlighting both functional and human–social aspects

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ABSTRACT

Participatory approaches are advocated as being more effective in supporting rural development processes than traditional top-down extension approaches. Participatory experimentation involving both farmers and researchers is often expected to result in processes of experiential learning. Assuming that such learning leads to change in farmers' views and practices, we wanted to identify these changes. For that purpose we applied an analytical framework that included three dimensions (process, outcomes, impact) and functional as well as human–social aspects. We involved farmers in group-based participatory experimentation for four years with minimum external intervention, aiming for maximum control of the experiments by the farmers themselves. In total 16 groups of farmers divided over four locations participated. Data were derived from interviews and observations. In general participants considered their participation worthwhile and mostly valued learning-aspects. Farmers indicated that they acquired new knowledge and became confident with respect to specific agricultural practices such as fertilizer application. They also felt more confident in conducting systematic experimentation. This confidence is supported by our observation that they managed to achieve positive yield responses, over 50% in most cases. Participating farmers responded significantly differently after the four years of experimentation compared to a control group of local farmers. After the four years they would: (1) involve non-family more in their discussions about farm management; (2) address officials more easily to solve neighbourhood problems; and (3) be more specific in their ambitions to learn about agriculture. Participants perceived significantly more (positive) change towards productivity and poverty reduction compared to the control group. In contrast to our initial expectations, all groups continued their involvement in the experiments for four years and indicated the ambition to continue on their own. Of a set of factors that might influence involvement of farmers, only benefits in the form of good responses were overall important. All other factors were highly variable among the groups. We concluded that change was achieved with respect to functional and human–social aspects, which are both essential components of agricultural systems and affect their transformation. In designing processes of participatory experimentation it is, therefore, important to take such non-uniform sets of impact factors into careful consideration. Given the diversity of groups and the context in which they operate, blue-print approaches are not likely to be effective due to insufficient incorporation of local group variability.

1. Introduction

Participatory approaches are advocated for being more effective in supporting rural development processes than traditional top-down approaches often used by extension services (Biggs, 2007; Chambers and Jiggins, 1987; Ellis and Biggs, 2001). Such participatory approaches involve farmers – together with researchers or practitioners – and are often referred to as a process of joint experiential learning. Examples of such participatory approaches are the Farmer Field School (FFS) approach (Braun et al., 2000; Duveskog et al., 2011; Misiko, 2009), Participatory Extension Approach (PEA) (Hagmann et al., 1998), Participatory Learning and Action Research (PLAR) (Defoer, 2000), and more recently Participatory Innovation Development (PID)(Scogings et al., 2009).

Whether all participants really learned during and as a result of the participatory process is difficult to assess. This is because learning

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processes and evidence for learning are for multiple reasons difficult to grasp (Boyd et al., 2006; Dienes and Altmann, 2003; Kraaijvanger and Veldkamp, submitted for publication; Prince, 2004). This holds even more in a context where language and cultural barriers hamper effective communication. Evaluation of resulting empowerment, contribution to development processes and impact on farmers' livelihoods is equally or even more complex (Barrera-Mosquera et al., 2010; Misiko, 2009; Trimble and Lázaro, 2014). Farmers often have multiple reasons to be involved with researchers and practitioners, and these motivations need not necessarily be directly aimed at the improvement of their knowledge and skills. Participation, for example, can also be driven by incentives such as free seeds and fertilizers or access to credit (Mapfumo et al., 2013; Probst, 2002). Other perceived benefits can relate to having contact with outsiders, e.g. access to knowledge and social status. External material and cognitive inputs need to be reduced to a minimum as they might lead to dependency, which hampers sustainability of participatory processes (Islam et al., 2011). Consequently, process inputs need to be restricted to facilitation.

In this publication we explore the complex interactions between process, outcomes and reported impact in the context of participatory experimentation with farmer groups in Tigray, northern Ethiopia. In addition, implications for the use of participatory approaches in agricultural rural development are discussed. From 2009 to 2014 we were involved in group-based participatory experimentation with 16 groups of about five farmers in Tigray. Incentives other than those based on learning and interaction from participatory experimentation were deliberately reduced to a minimum. From the start on and throughout the process we systematically monitored participating farmers through a series of interviews and observations. In addition, all participants as well as a control group of randomly selected comparable farmers were interviewed on aspects relating to attitude and cognitive ability at the start (baseline interviews) and the end (final interviews) of the process and questioned about perceived livelihood changes during this period.

Changes in attitude and livelihoods of farmers involved in participatory experimentation can be evaluated using three interrelated dimensions: (1) process, (2) outcomes and (3) impact/change (adapted from Blackstock et al. (2007); Fazey et al. (2014); Hassenforder et al. (2015) and Trimble and Lázaro (2014)). Douthwaite et al. (2003) indicated that from a constructivist perspective monitoring impact of participatory approaches requires considering two aspects: (1) direct benefits and (2) wider livelihood and developmental changes. Duveskog et al. (2011) referred in line with this to instrumental knowledge and collective/individual agency as important outcomes in the context of Farmer Field Schools. Also Hellin et al. (2008) used a similar division and referred to respectively functional aspects and empowerment. Both functional aspects (e.g. crop yield, technology) and human–social aspects (e.g. knowledge, co-operation) represent important components of agricultural systems. An analytical framework based on the above dimensions (process, outcomes, impact) and aspects (functional, human–social) was used to analyse farmer-reported changes. We combined this with our own observations on obtained crop yield, efficiency of use of inputs and the use of novel technologies.

Three research questions guided our analysis:

1. What changes relating to functional and human–social aspects became explicit over the four years of participatory experimentation?
2. Can these changes be linked to the involvement in the participatory experimentation?
3. What motivated participants to stay involved?

2. Methods

2.1. Process

Farmer groups were involved for four years in a participatory experimentation pathway based on four experiential learning cycles of experience-design-experimentation-reflection (Kolb, 1984). Elements of the research-cycle focusing on implementation of novel technology as described by Giller et al. (2011) were also manifest: farmers started with sessions in which description (constraints and context) and exploration (opportunities) were covered. We started the process in 2009 by involving 16 groups of farmers in four locations, with four groups for every location. These groups (each of about five farmers) were deliberately composed of neighbouring farmers. We assumed in doing so that a long term co-operation would be more feasible, connections with the communities would be secured and logistic constraints would be reduced. Additionally, interviews were conducted with a control group of about 65 farmers. These farmers were selected randomly using administrative lists at *tabia*[1]-level and came from the same locations as the involved participants. Information on the locations is presented in Kraaijvanger and Veldkamp (submitted for publication) and Kraaijvanger and Veldkamp (2015b). All experiments were designed and conducted on-farm by the farmers themselves. Annual workshops and field visits were organized to design and evaluate the experiments.

Our research is framed as participatory experimentation, and can be called a *collegial* type of participation in the terminology of Biggs (1989). On the scale proposed by Pretty (1995) the description of *interactive participation* best matched our situation. Factually we choose an even more extreme position, aiming at a *research context with less direct intervention* (Okali et al., 1994), since control over the experimentation process was almost fully delegated to the farmers. Therefore, our inputs were reduced to a minimum and we focused on overall facilitation of the process. Next to avoiding bias due to differences in interventions from our side, we also expected in doing so to promote commitment of the farmer groups and to avoid interference by external agendas. Our inputs, therefore, were restricted to facilitation of the experiments and including, in addition to the treatments the farmer groups proposed, alternative treatments. This was done for purpose of comparison (controls and current practice on farmer fields), achieving at some experimental rigor (replications) and inspiration (Arévalo and Ljung, 2006; Sumberg et al., 2003). Alternative treatments were included in the experimental lay out only when possible (the maximum number of plots was about 15). Farmer groups evaluated all treatments and had the mandate to in- or exclude these from the experiments.

2.2. On-farm experimentation and management

Experiments were conducted on-farm using fields that were selected by the farmer groups themselves. In most cases fields hosted the experiments for more than one year. The responsibility to implement the experiments was taken by the owner of the field. Accordingly, most discussions on experimental management took place with him or her. The experimental fields in most cases contained blocks with 15 plots of 3.0 m × 3.0 m. On each plot a specific treatment was applied. More information about the experimental set up can be found in Kraaijvanger and Veldkamp (2015b). In each experimentation year from our side specific treatments, such as sowing in rows, were included in the design in order to evaluate if such treatments would be adopted later on. Our inputs in the experimentation itself were restricted to delineation of the plots, establishing control plots, application of measured quantities of chemical fertilizers, manure and compost, and harvesting the crop in order to obtain exact and reproducible yield data. Field management like weeding and crop protection was the responsibility of the farmer groups. Yield data were presented to the farmers immediately after the harvest to support discussion among the farmer group prior to the workshops. In the final phase of our participatory experimentation, we delegated more responsibilities to the farmer groups and

[1] *Tabias* are lower level administrative units.

challenged them in 2013 to harvest part of the experimental plots themselves and in 2014 to continue their experimentation after termination of our involvement in April 2014.

2.3. Workshops

An important component of our research project consisted of conducting workshops with farmer groups. These workshops formed the main platform for discussions on experimentation and were conducted every year. The topic of discussion of the first workshop was constraint and opportunity identification (see Kraaijvanger et al. (submitted for publication)). The outcomes of the first workshop were analysed and served as an input for the other workshops. All following workshops dealt with the outcomes of on-going experimentation and the preparation of experimental designs based on these outcomes, covering in this way the reflection-experience-design phases of the experiential learning cycle (Kolb, 1984). During the workshops group members discussed among themselves, but also exchanged ideas with other groups in plenary sessions. When farmers participated in the workshop, they obtained, in line with the regulations of the Bureau of Agriculture and Rural Development (BoARD), a *per diem*. This covered for hiring field labour to replace them. In addition also a lunch was provided.

2.4. Individual surveys and interviews

Individual surveys and interviews were divided in three sets:

- Set 1: Individual surveys on livelihood changes (in retrospect) with participants and a control group (in 2013).
- Set 2: Baseline interviews (in 2010) and final interviews (in 2013) with participants and a control group on attitude and cognitive ability.
- Set 3: Two series of surveys with participants on benefits resulting from involvement in participatory experimentation (in 2013 and 2014).

In all surveys and interviews the same translators were involved. The control group involved in the individual surveys and interviews of set 1 and set 2 was the same and consisted of individual farmers that were not involved in our participatory experimentation. Respondents of the control group came from the same neighbourhoods as the participants and were selected randomly from administrative lists at *tabia*-level. Questionnaires were prepared in collaboration with the translators and tested and improved based on first experiences. The individual surveys of set 1 resulted in direct (quantitative) outcomes, interview responses of set 2 and 3 interviews were first categorized and relative frequencies of these outcomes were calculated in order to allow comparison. However, not all questions and responses were included in our assessment: a selection was made based on relevancy.

2.4.1. Set 1: individual surveys on livelihood changes

Chambers and Conway (1992) and later on also Bebbington (1999) and Mancini (2006) forwarded and applied the concept of seven different capitals (human, political, cultural, social, physical, natural, financial) representing the livelihood status of farmers. Since changes in livelihoods are often related to the capitals that constitute these livelihoods, we defined, in line with Cosyns et al. (2013), a set of indicators based on the concept of capitals. These indicators referred to a specific sub-set, the so-called sustainable livelihood capitals (Chambers and Conway, 1992), and covered financial, natural, social and human capital (Table 1). Physical capital was not included since we considered it far outside the main scope of our participatory experimentation. The learning aspects of human capital were dealt with in interviews and surveys of set 2 and 3.

Based on the indicators seven straight-forward questions were prepared. Participants and control group farmers indicated in response to these questions the status of specific livelihood aspects by attributing scores on a Likert scale from 1 to 10, first for the present and then in retrospect for the past situation (five years ago). Attributing scores was explained to the respondents by using a small chart with numbers. In total 133 farmers (74 participants and 59 control group farmers) were questioned. The score for the past situation was subtracted from the score for the present situation to determine whether or not respondents perceived positive change (progress) in their livelihood over the last five years. Differences between participants and control group farmers were evaluated by using Chi-square-test. Outcomes of this retrospective served to document farmer-reported change in livelihood capitals.

Table 1
Overview of livelihood aspects and corresponding capitals.

Aspect	Livelihood capital
Personal economic situation	Financial
Poverty in the neighbourhood	Financial
Productivity of the land	Natural
Co-operation in the neighbourhood	Social
Health situation	Human
Occurrence of soil erosion	Natural
Presence of trees and bushes	Natural

2.4.2. Set 2: baseline interviews (2010) and final interviews (2013) on attitude and cognitive ability

The baseline and final interviews constituted of a set of eleven indirect open-ended questions and focused in eight questions on attitude related aspects, the remaining three questions dealt with cognitive ability (for the full sets see Kraaijvanger (2015)). By conducting the baseline and final interviews we aimed at capturing differences in relation to attitude and cognitive ability over the period of involvement and between participants and non-participants. These structured interviews were designed in such a way that the same aspects were addressed by either repeating questions or by slightly altering them. Responses to these questions were categorized and used to derive trends in responses of the control group between 2010 ($n = 66$) and 2013 ($n = 60$), of the participants between 2010 ($n = 78$) and 2013 ($n = 76$) and to compare between the participants ($n = 76$) and the control group ($n = 60$) in 2013. Differences between interview outcomes were evaluated by using Chi-square-test.

2.4.3. Set 3: individual surveys on benefits resulting from involvement

Two series of surveys with participants were conducted to identify what benefits they perceived from their involvement. In 2013 participants ($n = 78$) were asked four open-ended questions to indicate the most important benefits of their involvement in participatory experimentation. In 2014, during the final workshop, the participants ($n = 76$) again responded to two open-ended questions relating to their involvement in participatory experimentation. We inductively grouped responses to these questions into categories with specific concerns based on similarity of expression. Frequencies found for these categories served as an indication of farmer-reported benefits resulting from their involvement in participatory experimentation. Outcomes, therefore, informed us about the relation between involvement and benefits, and about farmers' motivation for staying involved.

2.5. Selection of experimental treatments

The type of treatments that farmers defined was categorized and analysed. We defined inductively five categories that captured aspects of novelty and tradition. These aspects reflected the preference for specific treatments of farmer groups (see Table 2). Each cycle of experimentation we scored the frequency of treatments in each category. We assumed that changes in the type of experiments that farmers defined might be related to changes in attitude and skills.

Table 2
Overview of defined categories of experiments.

Category	Treatments
Traditional	compost, manure or compost + manure
Recommended	Urea (=N-fertilizer) + DAP* (=N & P fertilizer)
Experience/advanced practice	Combinations of mineral and organic fertilizer
"Out of the box"	DAP[a] (only), urea (only), application rates, control, ash, fallow-effect, farmer field
Introduced[b]	Applying potassium (K), row sowing, opening subsoil

[a] DAP = di-ammonium phosphate.
[b] Introduced by the researchers.

2.6. Factors motivating involvement

Based on literature (Islam et al., 2011; Klerkx et al., 2009; Marquardt et al., 2009; Misiko, 2009; Ndekha et al., 2003; Hailu, 2009; Hall et al., 2006; Poteete and Ostrom, 2004; Probst, 2002; Van Rijn et al., 2012; Wenger, 2000), we defined a set of factors that were assumed to have impact on the involvement of participants in group-based processes: external factors, group quality, resulting benefits, institutions and facilitation. The effect of these factors was monitored by using specific criteria that matched with our context (see Box 1). Various sources of information were used to evaluate the impact on involvement, ranging from interviews and calculated data on yield responses to participant observations on how specific groups functioned. Participant observations were made not only in official meetings like workshops and field visits but also in interactions on a more casual basis, for example, at harvesting. We also included observations from our field assistants and interpreters. In our qualitative assessment we used only 2 categories: 0 (=standard) and + (=above standard) for every criterion. Outcomes of this assessment were used to identify possible motivations for involvement of farmers in participatory experimentation.

To systematize our evaluation we included characteristic elements of the participatory experimentation method employed in our analytical framework and made reference to their respective data sources (Table 3). Examples of functional aspects relating to the three dimensions of our framework (i.e. process, outcomes and impact) are respectively systematic experimentation, measured yield response and change of natural livelihood capital. As examples of human–social aspects respectively participation, obtaining skills and change of social capital can be mentioned. Since strict criteria for evaluation cannot be provided beforehand, we will use in our assessment an inductive approach.

Box 1
Factors explaining motivation and involvement in participatory experimentation

External factors:
External factors represent the impact of policies of governmental or non-governmental organisations (NGOs) on the life-worlds of the farmers (Hailu, 2009; Klerkx et al., 2009). Criteria we considered were past and present impact of NGOs and BoARD in supporting farmers (for example, by providing incentives and facilities) and were based on interviews with various informants.
Group quality:
Group quality is a broad notion in which we tried to capture various aspects that might be relevant for the functioning of groups. The criteria we considered were leadership, composition (age, gender), coherence and the use of existing structures. The criterion of leadership (Hailu, 2009; Islam et al., 2011; Ndekha et al., 2003) was assessed based on interviews with participants. If three or more group members (out of five) indicated a specific person to be their leader we considered this unanimous. Age and gender (Probst, 2002) were included to cover the aspect of heterogeneity; we assessed this by considering the presence of women and young farmers (age under 35) in the group. Both being present in the group resulted in a positive score. Coherence and using existing informal networks (Marquardt et al., 2009) were scored by using observations on a casual basis.
Benefits:
Direct and indirect benefits of involvement might provide, under the assumption of rational behaviour, motivation for participants (Ndekha et al., 2003). We used yield responses of farmer-selected treatments as a proxy for such benefits and to that end considered average response of the *"best-three"* treatments (as selected by the group) during the last three years of our investigation. We excluded the first year because at that time no experiential learning was yet involved in selecting the experimental treatments. The categories were defined as being below and above 50% yield response as compared to the control plots (see also Kraaijvanger and Veldkamp (2015b)).
Institutions:
Institutions represent the formal and informal setting in which the farmers operate and are considered very important in supporting participation (Arévalo and Ljung, 2006; Dienes and Altmann, 2003; Prince, 2004). Such settings can be either productive or contra-productive (Van Rijn et al., 2012). In our evaluation we assumed embedment of the groups in their communities to be a positive factor since responsibilities in that case are expected to become more pronounced. The evaluation of this embedment was based on personal observations. Criteria that we selected were: presence of local administration leaders, participation of *keshi's* (priests), interest in group activities (for example through expansion with new members) and accountability towards the community.
Facilitation:
Facilitation of the groups is very important in relation to motivation. This was assessed by considering to what extent field assistants were involved in co-operating with the groups.

3. Results and discussion

3.1. Individual surveys and interviews

3.1.1. Individual surveys on livelihood changes (2013)

The retrospective-outcomes showed a trend that participants reported more positive change in their livelihood for the last five years in comparison to control group farmers. These positive changes concerned the aspects of co-operation, poverty, personal economy and productivity (Fig. 1). Considering the fact that the experimentation directly dealt with group participation and impact on crop productivity, the relation between participation and perceived positive change appears to be causal. The remaining set of livelihood aspects (health situation, occurrence of erosion and presence of trees and shrubs) did not differ much between participants and control group farmers. Not surprising, as occurrence of erosion and presence of trees and shrubs were outside the direct scope of our experimentation. Also health situation was considered relatively constant, mainly because scores attributed were in most cases close to the maximum for both past and present and most likely reflected effective (governmental) policies to improve the rural health situation.

3.1.2. Baseline and final interviews on attitude and cognitive ability (2010 and 2013)

Only four out of the original eleven interview questions revealed relevant differences, either over the four years or between control

Table 3
Analytical framework based on dimension (process, outcomes and impact) and aspect (functional and human–social) with specific elements of our participatory experimentation method included.

Dimension	Functional aspects	Human–social aspects
Process	Systematic experimentation	Participation (lists)
	Mandate for experimental design with the farmers	Gender representation (lists)
	Availability of quantitative yield data	Power relations (participant observation)
	On-farm experimentation	Leadership (participant observation)
Outcomes	treatment responses (measurements)	Attitude (interviews set 3, participant observation)
	Treatment selection (lists)	Skills (interviews set 3, participant observation)
Impact	Natural capital (interviews set 1)	Human and social capital (interviews set 1)
	Technology adoption (participant observation, interviews set 3)	Attitude (interviews set 2, participant observation)

group and participants (see Table 4). The other seven questions resulted in indifferent, non-discriminating outcomes. All three questions relating to cognitive ability resulted in highly variable outcomes, most likely because these questions were, in retrospect, too complex and context dependent. Of the remaining eight questions on attitude the questions dealing with "*co-operation*", "*causes for poverty*", "*giving advice to colleagues*" and "*actions taken to improve crop productivity*" also resulted in variable outcomes that appeared to be more influenced by fixed ideas and views than by (non)involvement in participatory experimentation.

In "*solving conflicts*" (question no. 1) participants were more ready to involve officials in 2013 (Fig. 2). "*Interaction with development agents*" (DAs), question no. 2, shows an interesting pattern. Four years ago farmer-participants would not easily start a discussion with a DA. However, in 2013, they had, just like the control group farmers, become more outspoken and frank in their discussions. Both participants and control group appeared to have changed from somewhat obedient followers towards a more critical attitude. Providing an adequate explanation for this shift is, based on our data, difficult and different reasons can be provided. For example, increased knowledge and confidence on the side of the farmers or less dominance on the side of the DAs. With respect to "*involving outsiders for discussion*" (question no. 3), participants increasingly engaged with officials, but the control group stopped completely doing so and on contrary started relying more on family members. The question on "*learning ambitions*" (no. 4) revealed that both participants and control group were mostly interested in acquiring more agricultural knowledge. In 2013 significant more participants preferred to learn about specific agricultural topics in comparison to 2010 and in contrast to control group farmers.

3.1.3. Individual surveys on benefits resulting from involvement (2013 and 2014)

There was much repetition in the issues farmers mentioned in response to our questions. Participants often made reference to project related technologies. In other cases, however, participants referred to specific technologies that were not directly related to the project (Table 5). Other recurrent responses related to human–social aspects (sharing ideas, co-operation).

In evaluating their involvement (question 1) farmers rated gaining knowledge as being important (Fig. 3). When looking more specifically into the way farmers evaluated benefits of their involvement (question 4) we observed that acquiring specific technical knowledge and sharing ideas were considered important by them.

One farmer commented on the issue of obtaining knowledge: "*We got a clear understanding of fertilizers and manure but the most important gain is that we now know how to do research by ourselves, although it is not scientific.*"

The knowledge obtained can be related to both project and non-project sources and possibly resulted in a change of agricultural practices during the last five years. Clear project related issues were for example the adequate use of fertilizers and row sowing. Of the non-project specific matters, the use of selected seeds and irrigation was mentioned by the farmers. The use of selected seeds was by some farmers associated with the project. However, in a strict sense this did not apply since the farmer groups came up with this issue themselves.

Farmers often highlighted such technology related achievements: "*I did an experiment of sowing in rows, the difference was 2.5 quintal*", "*Learning about selected seeds from the experiment brought change*", "*I learned what the soil needs*".

When more specifically looking at co-operation (question 5), sharing ideas was considered important (Fig. 5). In an indirect view on their involvement (question 6) farmers frequently mention jealousy (on them) and the aspect of learning.

Farmers commented accordingly to their learning: "*You learn from each other a lot and from what you see in the experiment, it would be nice to try this also in our individual fields*", "*We share ideas and add*

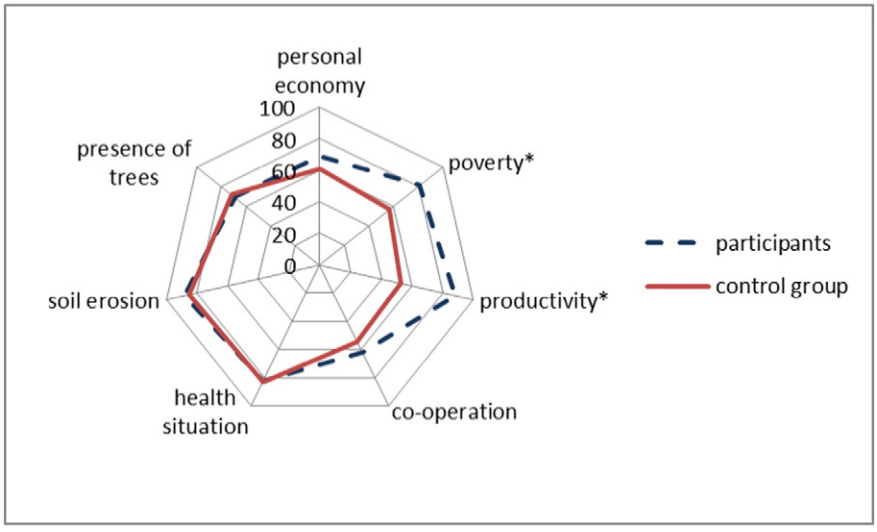

Fig. 1. Improvement of livelihood aspects between 2009 and 2013 (in %) as perceived by participants (n = 74) and the control group (n = 59). Significant difference with control group (Chi-square, p = 0.05) is indicated by an asterisk (*).

Table 4
Questions and categorized responses used in our evaluation of social aspects (shaded responses are used in our comparison).

No	Question	Aspect covered	Response categories	Corresponding number of the response axis in Fig. 2	Example responses
1	What will you do to stop grazing of animals on your fields (Final interviews phrasing: What will you do to stop travelling through your fields?)	Changing attitude	Direct approach		Tell him to stop
			Indirect approach		Ask others to discuss
			Involve officials	1a	*Tabia* police
			Allow		No problem
			Own action		Fencing
2	What will you do in relation to the advice given by a development agent ?	Changing attitude towards officials	Discuss and reject	2a	
			Accept	2b	
			Reject without discussion	2c	
3	Mention 3 persons with whom you frequently discuss issues related to agricultural practice ?	Changing network	Family	3a	Uncle, wife, son
			Friends/neighbours	3b	
			Officials	3c	Development Agent (DA), tabia administrator
4	What would you like to learn ?	Personal reflection	Formal education		Reading, writing
			General agriculture		Getting productive
			Specific agriculture	4a	Beekeeping, growing fruits
			Specific non agriculture		Nursing
			Nothing	4b	"I am too old"

learning to our traditional knowledge which is passed to the young generation", "*We learned a lot and are ready to teach others.*"

In general they considered that outsiders perceived their participation to be worthwhile. Explicit financial benefits were only mentioned in few cases.

3.2. Treatment selection

At the start of the research farmers selected mainly traditional and recommended treatments: 38 and 23 % of the experimental treatments fell in this category (Table 6). During the course of experimentation there was an increase in percentage of advanced practices (i.e. combination of treatments). An important change was that groups started including controls (data not presented), perhaps an indication that they learned and appreciated systematic experimentation. Initially groups adopted recommended and introduced treatments but left them out later. Interestingly, the inclusion of "out-of-the-box" treatments, such as the application of ash (Fig. 5), was relatively constant. Farmers indeed seemed to experiment with curiosity-driven treatments despite their unknown and therefore risky outcomes (Okali et al., 1994).

3.3. Factors motivating involvement in participatory experimentation

In contrast to our expectation that groups would over time become less committed because of limited material incentives from the project, we found that commitment persisted: after four years all 16 groups still were involved in participatory experimentation. Outcomes obtained in the experiments were considered important. The Inticho-groups, for example, mentioned that they considered out-scaling of findings essential and urged upon us the need of reporting these to BoARD-officials. In the final workshop (April 2014) all groups indicated that they would continue on their own and already had made decisions about the design

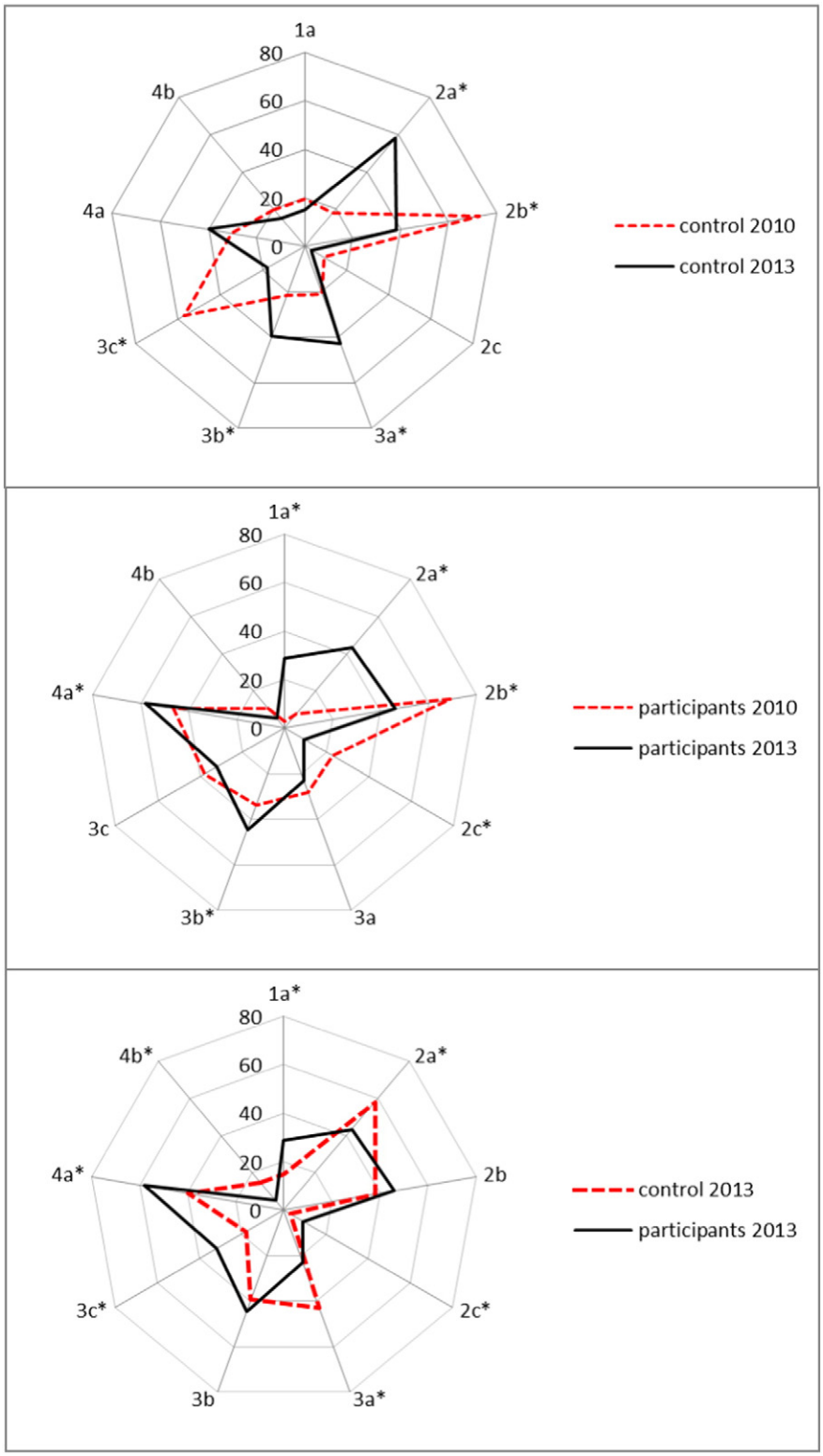

Fig. 2. Categorized responses (%) of: control group farmers in 2010 (n = 66) and 2013 (n = 60); participants in 2013 (n = 76) and 2010 (n = 78); and participants (n = 76) and control group farmers (n = 60) in 2013. Responses refer to 4 questions: (1) "attitude in relation to solving problems" (corresponding response: (1a) "involve officials"), (2) "discussion with extension workers" (corresponding responses: (2a) "reject with discussion", (2b) "accept", (2c) "reject without discussion"), (3) "discussion on agricultural issues" (corresponding responses: (3a) "with family members", (3b) "with neighbours and friends", (3c) "with officials"), (4) "on learning ambitions" (corresponding responses: (4a) "specific agriculture", (4b) "nothing"). Significant difference (p = 0.05) between groups is indicated by an asterisk (*).

and responsibilities for the experiments in the coming growing season. Out of 16 groups, in October 2014, about five months after our involvement had formally ended, 12 groups indeed had continued their group-experimentation. Of the four groups that not conducted an experiment in 2014, two indicated that they lacked facilitation. The two other groups indicated that they considered sorghum, which they planted in 2014 in most of their fields, not suitable for experimentation.

Table 5
Evaluation of involvement: response categories and examples.

No	Question	Category[a]	Examples
1	What was important with respect to the experimentation for you?	Technical project knowledge (specific)	Using compost, mixing fertilizers
		Technical non-project knowledge (specific)	Using selected seeds
		General knowledge (non-specific)	Gaining knowledge
		Sharing ideas (collectivity)	Sharing ideas
2	What did you learn the last 5 years with respect to agriculture?	Technical project knowledge (specific)	Use of fertilizer
		Technical non-project knowledge (specific)	Terracing, selected seeds
		General knowledge (non-specific)	Practical knowledge
3	What changed for you the last 5 years with respect to agriculture?	Technical project related changes (specific)	Use of fertilizer
		Technical non-project related changes (specific)	Irrigation
		Other	Becoming independent
4	What was the most important benefit from being a member of the research group?	Technical project related knowledge (specific)	Learning to develop productivity
		Technical non-project related knowledge (specific)	Constructing stone bunds
		General knowledge (non-specific)	Getting education
		Sharing ideas	Share ideas, it is good to discuss about the experiments
		Co-operation in general	To help other people if there is a problem
		Other	To be progressive, we learn how to do research, understanding how to solve problems, getting payment
5	What were benefits resulting from co-operating as a group?	Sharing ideas	Share ideas, learn from each other to select the progressive one
		Saving time	Saving time
		Community	Creating community, getting peace
6	How do others see you being involved in the research?	Jealous	"Why are we not involved?"
		Learning benefits	"They think we learn a lot"
		Financial benefits	"Some think we get a lot of money"

[a] As used in Figs. 3 and 4.

The results in Table 7 show that the only factor that was present in all but one group was perceived benefits (with yield responses for farmer-selected treatments above 50%). All other factors were distributed variable over the 16 groups and absence of a single specific factor (i.e. leadership, coherence, etc.) apparently did not lead to less involvement. Perceived benefits in the form of responsive treatments might thus have had an overriding importance in keeping the group experimentation going on. The other factors considered were either irrelevant, supported participation only occasionally or were compensated for by other factors present. In the final, informal, stage of our involvement, farmers mentioned that facilitation was important for them in relation to their experimentation.

3.4. Synthesis

3.4.1. Analytical framework

In the course of our research we collected and used different sources and types of information. To systematize our exploration of the relation between observed and farmer-reported change and involvement in participatory experimentation we included the outcomes of the interviews and observations in our analytical framework (Table 8). This overview outlined in what way the dimensions of process, outcomes and impact and both functional and human–social aspects were interconnected and consequently allowed us to refine our exploration. Systematic experimentation was, for example, an important process component that enabled farmers to obtain experimental skills, which likely increased their confidence. In a similar way, the possibility for the farmers to include their own preferred treatments in the experimental design allowed them to use combinations of traditional and formal knowledge and to become more self-determined.

To arrive at a more integrated synthesis we first will focus on the dimension of impact/change, which was relatively easily to monitor and then will embark on an explanation by considering the two remaining dimensions: the process in which the farmers were involved and the outcomes generated by this process. In addition, researcher experiences, functional and human–social aspects and implications for rural development processes will be commented.

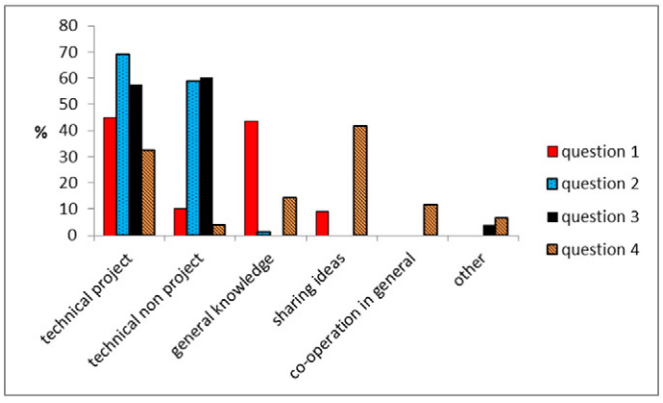

Fig. 3. Categorized responses to questions relating to involvement in participatory experimentation (as a % of respondents, n = 78 for all questions except n = 76 for question 4). Responses refer to 4 questions: (1) "what was important in the project", (2) "what did you learn about agriculture", (3) "what practices did you change", (4) "which were the benefits of being involved". Categories refer to the main concerns of the responses.

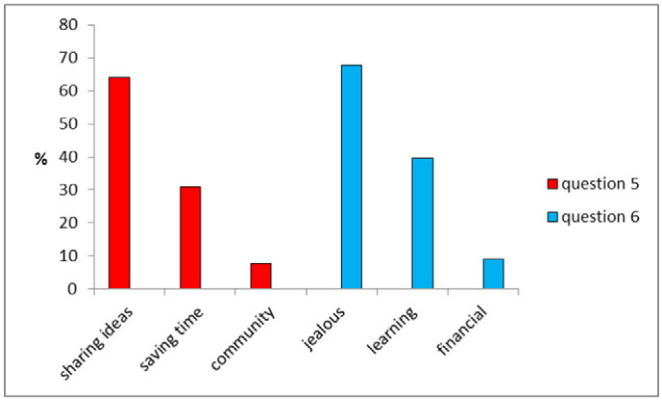

Fig. 4. Categorized responses to questions relating to involvement in participatory experimentation (as a % of respondents, n = 78). Categorized responses refer to 2 questions: (5) "what were benefits of group co-operation", (6) "how do other people see your involvement". Categories refer to the main concerns of the responses.

Fig. 5. Out-of-the-box treatments in an experimental field in 2013: the whitish plots are treated with ash.

3.4.2. Impact—what changes?

The results of this study pointed to a range of changes that took place in farmer-reported and observed attitude during the course of four years of group experimentation. Farmers indicated that they had gained knowledge and had become confident with respect to agricultural practices like, for example, the correct application of fertilizers in their fields. They also reported to be more confident in systematic experimentation. In line with this they indeed considered outcomes of previous years and included progressively more advanced treatments and controls.

Achieved crop yield responses of the selected treatments exceeded in most cases 50%, indicating that their selections indeed led to increased productivity. Over all groups we found for the period 2011–2013 responses (significant at $\alpha = 0.05$) for the "*best three*" farmer-selected treatments between 65–84 % and 32–52%, respectively compared to zero-input controls and current farmer practice on the same field (see for more details: Kraaijvanger and Veldkamp (2015a); Kraaijvanger and Veldkamp (2015b)). In retrospect the farmers themselves also perceived an improved crop productivity.

Our data showed that participants started to involve outsiders, i.e. not family members, more in their discussions about farm management. At the same time, they addressed officials more to solve problems in the neighbourhood. Farmers also started discussions with extension workers in relation to farm management more easily than before and they became more specific in their ambitions to learn about agriculture. All in all, such observations pointed to a clear change in attitude.

3.4.3. Process—were changes a result of involvement in participatory experimentation?

With respect to involving officials in discussions about farm management, involving officials in solving neighbourhood problems and the responses given in relation to learning ambitions, differences between participants and control group were significant. In retrospect over 80% of the participants indicated clear positive changes with respect to the incidence of poverty and the productivity of the lands. The contrast with the control group with respect to these issues was significant, suggesting that these changes were related to involvement in the participatory experimentation. In interviews farmers indicated that sharing knowledge through discussions was an important benefit for them. The workshops supported such discussions by providing the topic and the data required. They also frequently indicated that they had learned through their involvement in experimentation (sharing ideas, observing and taking the best, seeing in practice, experiencing opportunities). Responses of participants with respect to questions on involvement, benefits and actual changed practices appeared consistent. Whether these changes were a result of learning remains to be seen. However, they might give indications of the impact of four years of collaborative involvement.

Table 6
Type of treatments as selected by the groups in the years 2010–2014.

Year	n	Traditional %	Recommended %	Advanced practice %	Out of the box %	Introduced %
2010	60	38.3	23.3	8.3	30	0
2011	200	19.5	19.5	11.0	32	18.0
2012	173	19.7	19.1	12.2	29.5	19.6
2013	209	12.4	14.8	18.1	28.7	25.9
2014	135	9.6	15.6	32.6	31	11.1

3.4.4. Process—what kept farmers involved?

Answering the question why participants continued to be involved in the group experimentation over a period of more than four years cannot be answered clearly. Outcomes of our evaluation of a set of factors, that we assumed being important for continuation of group experimentation did not indicate pronounced single factors, except the factor "*benefits*", that explained farmers' motivation and participation in a consistent way. Also authors like Islam et al. (2011), Mapfumo et al. (2013) and Ndekha et al. (2003) found that benefits appear to be very important in motivating participants to continue with their experimentation. However, at the same time these benefits were outcomes of the process of experimentation. Consequently, "*benefits*" were not only a source of motivation but also an intrinsic part of the process. This suggests that more complexity is involved in the process than is provided by a simple cause–effect rationality. In addition to that, participatory approaches are assumed to be context-dependent (Martin and Sherington, 1997). Implementing participatory experimentation, therefore, requires the use of approaches sufficiently flexible to address both complexity and context-dependency.

What other specific sources of motivation are required to initiate and maintain the process cannot be indicated based on our data. Factors probably compensated each other to some extent, as was also suggested by Islam et al. (2011) in his study of farmer-led extension groups. Lacking leadership might, for example, be compensated by coherence, lack of embeddedness in networks probably might be compensated partly by group-diversity. Had several groups dropped out, we might have had more lessons on this point.

Involvement in participatory experimentation requires transaction costs (Home and Rump, 2015; Morris and Bellon, 2004). For the farmers that participated in our research opportunity costs (Butler and Adomowski, 2015; Neef and Neubert, 2011) due to participation in the workshops were most important; these costs were covered by providing a *per diem*. In addition, yield losses on the host fields were compensated; other costs were limited since the farmers involved managed their fields in the usual way.

Hoffmann et al. (2007) commented that meaningful collaborative research requires specific attention for the following aspects: (1) user orientation, (2) farmer involvement, (3) farmer inclusion in experimentation, (4) diffusion of farmer knowledge and (5) fairness with respect to opportunity costs. Comparing these five points, in retrospect, with our set-up of participatory experimentation, we regarded them as fairly respected.

In his overview of collaborative research in Kenya, Ramisch (2012) indicated that collaborative efforts in the end became somewhat "institutional" and that associated social functions ensured community embedding. This coincides to some extent with our observations that the group contributed a "*something*" that we tried to capture as "*group quality*". This "*something*" probably is not only a factor supporting involvement but also an output of participatory experimentation. Although such denominations might appear as a "*black box*", our

Table 7
Factors motivating involvement of the 16 groups of farmers over a period of four years, using different criteria. (0 = standard, + = above standard).

Group	External factors	Group quality				Benefits	Institution	Facilitation
	NGOs, BoARD	leadership	coherence	composition	networks	Treatment responses (0 ≤ 50%, +≥50%)	Involvement local leaders, accountability, external interest	Inputs field assistants
Tikuz	+	+	+	0	0	+	+	0
Adigudat	+	+	+	+	+	+	0	0
Endamariam	+	+	+	0	+	+	+	0
Munguda	+	0	0	0	0	+	0	0
Mymisham	0	+	0	0	0	+	0	+
Biherawi	0	+	+	+	0	+	0	+
Machalawi	0	0	0	0	0	+	0	+
Zonghi	0	0	0	0	0	+	+	+
Zalaweni	+	0	0	0	0	+	+	+
Mayzagra	+	+	0	0	0	+	+	+
Awadu	+	0	0	0	+	+	+	+
Siluh	+	+	+	0	0	+	+	+
Adikolagol	+	+	0	0	+	0	+	+
Dingelat	+	0	0	0	+	+	+	+
Adowro	+	+	0	0	+	+	+	+
Gudowro	+	0	0	+	+	+	0	+

expectation is that the compound factor "*group quality*" is essential in gaining and keeping momentum. Consequently, "*group quality*", which is actually an aggregate of different and variable aspects, is important in participatory experimentation. In addition, facilitation (of participation) also involves affective factors, like for example enthusiasm and attention, that likely played a major role in motivating participants (Patrick et al., 2000; Wentzel et al., 2010).

3.4.5. Outcomes—what were direct results?

Outcomes and impact appear two sides of the same coin, differentiating between them was in some cases challenging. In our analysis we considered outcomes being direct results from involvement, whereas impact related to change observed, for example, in relation to functional or human–social aspects. Having impact therefore meant that outcomes had materialized into actual change.

In relation to human–social aspects farmers indicated that they acquired technical knowledge and skills. In addition, they highlighted that sharing ideas took place, not only between farmers and researchers but also between farmers themselves; the experimentation became a platform for discussion and exchange of ideas. Sharing ideas in this way is considered an important output of sound participatory experimentation (Akpo et al., 2014; Mayoux and Chambers, 2005; Ramisch, 2012). With respect to functional aspects farmers made progress in their experimentation and achieved average yield-responses of about 76% in their best treatments as compared to control experiments and some 44% higher than responses achieved on farmer fields (Kraaijvanger and Veldkamp, submitted for publication). All groups continued their involvement and the groups included more and more treatments that bore their own signature.

3.4.6. Did learning occur?

Learning implies that change takes place, for example, in knowledge, in skills, in attitude, in behaviour or in worldview (Jarvis et al., 2003). Some specific changes seemed related to involvement in participatory experimentation. Farmers mentioned, for example, improved technical skills, deeper knowledge on the application of fertilizers and sharing ideas.

When taking a meta-perspective on the outcomes of interviews and observations some general comments can be made. If learning was indeed responsible for the changes in farmers' practices and attitudes, such learning then might be referred to in terms of both single and double-loop learning (Argyris and Schon, 1974). The experimentation itself, resulting in confidence and competence in using practices that resulted in higher productivity, could be labelled as single-loop learning. However, considering the series of experiments, we observed that groups explored new types of experiments. They shifted from a more traditional to a more advanced orientation in the selection of their treatments in which now combinations of traditional and modern practices were included. Also others involved in participatory experimentation observed comparable shifts (Fujisaka et al., 1994; Ramisch et al., 2006; Vandeplas, 2010). Such a fundamental change in farmer behaviour could be considered as a (modest) form of double-loop learning (Armitage et al., 2008). Recently, also Cornish et al. (2015) observed in line with this that farmers not only acquired functional knowledge but at the same time started managing their own learning. Considering the outcomes of their responses in relation to perceived benefits of involvement we see that farmers not only appreciated the technical benefits but also valued the process in which they had been involved, they had learned how to learn together. Such a reflection on learning then even might point to third-order learning in the sense of Bateson (1972).

3.4.7. The researcher side: process, outcomes and impact

In participatory experimentation learning should take place for all participants involved, in our case farmers and researchers. This learning, depending on objective and context, however, does not need to be the same (Faure et al., 2014; Kaufman et al., 2014). We, for example, did not involve directly in farmers' (functional) learning at field level but instead took a meta-perspective at a more general (human–social) level. In retrospect, we applied a specific tool (participatory experimentation) to learn about it in terms of process, outcomes and impact. At the same time, our involvement in participatory experimentation with 16 farmer groups resulted in better understanding complexity at field-level: what worked in one site often had no effect in another site and the other way around.

Considering the process from a functional point of view our involvement was restricted primarily to facilitation of the experiments and workshops. To obtain, however, at meta-level insights and understanding, we observed and monitored farmers' involvement and achievements. With respect to human–social aspects of the process we supported commitment, ownership and confidence of the groups.

With respect to (functional) outcomes we found that differences between high input treatments and farmers' fields were often limited and that, at the same time, the combined treatments the farmers proposed, were quite effective. Therefore, we sometimes appeared to be "*bad farmers*" (see also Ramisch (2014). An important human–social outcome for us was the observation that, unexpectedly, all 16 groups continued their experimentation.

Table 8
Analytical framework including summarized research outcomes. Examples and data sources are included within brackets.

Dimension	Functional aspects	Human–social aspects
Process	Systematic experimentation conducted (experimental blocks, controls, replications)	Farmers kept participating (observed)
	Experiments conducted within farmer fields	All groups continued (observed)
	Exact yield data for grain and straw were collected	Power relations: not clearly visible (observed)
	Farmers used the available quantitative data (observed)	Leadership was important for momentum (observed)
	Farmers selected treatments according to their ideas (observed)	Farmers operated as a group (observed)
		Gender representation in the groups about 10% (observed)
		Open and transparent process during workshops (observed)
		Farmers considered their involvement worthwhile (farmer reported)
Outcomes	Adequate responses of specific treatments (measurement)	Learning (farmer reported, observed)
	Farmers selected effective combinations of treatments (observation)	Farmers combined traditional and formal knowledge (observed)
	Farmers rejected ineffective treatments (observation)	Farmers were selective in using knowledge: they only used knowledge that was relevant
	Farmers demonstrated experimental skills (observed)	Co-operation (farmer reported, observed)
		Learning (agricultural knowledge, experimental skills, farmer reported, observed)
		Empowerment (farmer reported, observed)
		Sharing ideas important (farmer reported)
Impact	Natural capital increased (crop productivity, farmer reported)	Social capital increased (co-operation, farmer reported)
	Using systematic experimentation (including controls, observed)	Increase of knowledge and skills (farmer reported)
		Increased confidence (farmer reported, observed)
	Change in financial capital (less poverty, farmer reported)	Farmers wanted to acquire specific agricultural knowledge (farmer reported)
		Farmers expanded their networks (farmer reported)
		Farmers became more self-determined in experimentation (observed)

Impact with respect to human–social aspects was achieved at a meta-level in the form of an increased understanding and insight in the process of participatory experimentation. Observations made throughout our involvement, for example, with respect to continuation of the groups and the performance farmers achieved, resulted in an increased confidence and belief in the potential of farmer experimentation. In addition, our involvement resulted in being more socially accepted and becoming less outsider and more insider. Identifying functional impact is difficult; arriving at more general recommendations with respect to farm management, which is often an overlying objective of researchers involved in participatory experimentation (Arévalo and Ljung, 2006; Martin and Sherington, 1997; Sturdy et al., 2008), might have been one, however, this was not achieved.

Insights and understanding in relation to participatory processes directly resulted from our involvement: this points to single-loop learning. At the same time, double-loop learning occurred for the researchers. We observed, for example, that the farmers were quite effective in their experiments and on their own fields; also the contrast between controls and farmer fields was striking. At the same time, we were surprised by their commitment, the fact that they continued their involvement and the very effective treatments they often proposed. All this changed our view; not only our initial presumptions with respect to the low performance of farmers' practices eroded, also our confidence in delegating responsibility for experimentation with the farmers increased.

3.4.8. Addressing functional and human–social aspects in participatory experimentation

In our participatory experimentation change was demonstrated with respect to both functional as well as human–social aspects. Still, in evaluating participatory processes the primary focus often is on the more tangible functional outputs, leaving the equally important human–social aspects unaddressed. As a consequence attention for human–social aspects of the process will be limited (Martin and Sherington, 1997).

For example, in processes that are more controlled by scientists a shift in focus to functional aspects is likely for reasons of accountability with respect to project outcomes (Baskerville and Wood-Harper, 1996; Martin and Sherington, 1997). Achieving change/impact with respect to human–social aspects, however, requires purposive involvement of farmers in all phases (Ashby and Pretty, 2006; Campbell and Vainio-Mattila, 2003; Hellin et al., 2008; Nederlof et al., 2004).

Long-term evolutionary processes are required to achieve (sustainable) change with respect to human–social and functional aspects (Douthwaite et al., 2003; Hellin et al., 2008; Misiko, 2009). Still, as was reported also by Ramisch (2014), we initially felt some frustration about not achieving quick visible functional changes since we were not in full control of the process (and context). In the course of our involvement, however, it became clear that even with complete control such changes are not likely and that on a long term, changes with respect to human–social aspects were equally rewarding and most likely more sustainable.

3.4.9. Implications for the use of participatory experimentation in rural development processes

Participatory experimentation processes are in the spotlight of rural development processes. At the same time, outcomes of these participatory processes are heavily debated, for example with respect to effectivity and type of impact (Bentley, 1994; Farrington, 1997; Farrington and Nelson, 1997; Kapoor, 2002). The interaction we outlined between process, outcomes and impact indicated that to achieve functional and human–social impact requires purposive adjustment of processes in order to secure involvement of farmers. In line with this we recommend the level of control executed by the farmers to be as high as possible. Only in this way self-fulfilling prophecies of process-outcomes-impact will not materialize.

In participatory processes context is the "*alpha and omega*". However, this context should not only relate to functional aspects related to outcomes but also to human–social aspects associated with the process. The finding that identification of a clear set of single success-factors in our case was not possible indeed pointed to context-dependency of the process. In designing participatory processes we therefore recommend, in agreement with, for example, Butler and Adomowski (2015), Duraiappah et al. (2005), Kaufman et al. (2014), Misiko (2009), Raymond et al. (2010) and Rocheleau (1994), to adjust the process in an adaptive way in accordance with the context in which groups operate. A major concern in this is process facilitation and especially the availability of trained facilitators (Bentley, 1994; Butler and Adomowski, 2015; Mayoux and Chambers, 2005). In addition, user-defined constraints clearly should be the point of departure in participatory experimentation if benefits are to be perceived later on (Galabuzi et al., 2014; Sumberg, 2005; Van De Fliert, 2003).

Participatory experimentation in an agricultural context serves different (but connected) objectives: developing and adapting technology, learning, finally adoption of technology and empowerment (Choudhary and Surf, 2013; Duraiappah et al., 2005; Hassenforder et al., 2015; Hellin et al., 2008). At the same time, benefits of participatory experimentation in relation to costs are often questionable (Martin and Sherington, 1997). Development of technology and its adoption is important for public organizations, learning and empowerment are important concerns for NGOs (Farrington, 1998). In implementing and out-scaling participatory experimentation it makes sense to combine efforts and expertise of both public organizations and NGOs (Hellin et al., 2008). For, example, the (costly) development of effective approaches in both functional and human–social terms, could be the mandate of NGOs, whereas public organizations in a more cost-effective way might cover further outscaling. Such interaction and co-operation then will serve as a first step in establishing networks and innovation platforms comprising different levels in the context of Agricultural Innovation Systems (AIS) and Agricultural Innovation and Knowledge Systems (AKIS) (Biggs, 2007; Röling et al., 2014; Wood et al., 2014), addressing in this way also non-technical components of innovation.

4. Conclusion

Participatory experimentation with 16 farmer groups in Tigray (Ethiopia) resulted in our case in a continuation of their involvement in this experimentation during the whole four year period. At the same time, major changes relating to agricultural practice, experimentation and attitude were observed.

When comparing responses of participants to those of an independent control group, we observed that some of the attitudinal changes were significant. Also reported changes in livelihood aspects were significant and matched with involvement in participatory experimentation. In addition, congruency between responses relating to agricultural practice, learning and perceived benefits suggested that changes reported might be related to involvement in participatory experimentation.

Participants indicated that their motivation came mostly from benefits in the form of obtaining technical knowledge and probably also from sharing knowledge. Generally speaking, participants considered their participation worthwhile and highlighted learning as being important.

In evaluating a set of factors that might be influencing involvement we only found technical benefits in the form of reasonable yield responses being overall important. All other factors were highly variable among the groups and appeared to be trade-offs rather than knock-out factors. In designing processes of participatory experimentation it is, therefore, important to take such non-uniform sets of impact factors into careful consideration. Given the diversity of groups and the context in which they operate, blue-print approaches are not likely to sufficiently address associated variability.

Including process characteristics, outcomes and impact of the participatory experimentation in our analytical framework highlighted that change took place and that process, outcomes and impact were connected. At the same time we found functional and human–social aspects of agricultural systems affected in a positive way by participatory involvement. As a consequence, well-managed processes are required to achieve impact of participatory approaches in rural development. In other words participatory experimentation is not a *panacea* but requires instead careful adjustment and fine-tuning with local context and stakeholders to achieve the impact required for transformation of agricultural systems.

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