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CHALLENGES AND LESSONS WHEN USING FARMER KNOWLEDGE IN AGRICULTURAL RESEARCH AND DEVELOPMENT PROJECTS IN AFRICA

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SUMMARY

Farmer participatory research (FPR) approaches are now considered mainstream and are especially applicable for developing appropriate technology options in complex, diverse and risk-prone regions, where local adaptations are crucial. Although the advantages of using farmer knowledge to guide scientific research are numerous and well documented, the challenges and potential pitfalls that befall biophysical researchers, in particular, when using FPR approaches have received much less attention, especially in sub-Saharan Africa. Our experiences show that in certain cases, the methods used to collect farmer knowledge are flawed, leading to inaccurate or incomplete information being gathered. This potentially leads to the development and promotion of unsustainable, unprofitable or socially unacceptable technologies. This paper uses a series of examples to illustrate that discrepancies between farmer and researcher observations may occur because (i) farmers and scientists may not have sufficient insight into the systems complexity, (ii) farmers and scientists use different reference frameworks, and (iii) methodological errors may lead to farmers intentionally or unintentionally providing false or 'desired' information to achieve (short-term) benefits. This paper concludes by providing guidelines to improve the integration of farmer and scientific knowledge in order to develop appropriate technology options that are both environmentally sound and adaptable to local conditions.

INTRODUCTION

Over the past 15–20 years, farmer participatory research (FPR) approaches have become increasingly mainstream for researchers and extension workers in developing countries (see Ashby *et al.*, 2000; Okali *et al.*, 1994; Richards, 1985). FPR is especially applicable for developing appropriate technology options in complex, diverse and risk-prone regions. In such areas, farmers have developed their own coping strategies over time and understanding local adaptations is crucial. An important advantage of applying FPR is the incorporation of indigenous technical knowledge (ITK) in the technology development process. Using ITK seems especially relevant for biophysical research areas that were traditionally considered as food for technocrats. In the mid 1980s, it became clear to an increasing number of agricultural scientists that the traditional top-down research approach was not leading to satisfactory solutions (e.g. Richards, 1985). The involvement of farmers in the research domain has been useful

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in guiding research towards acceptable solutions to practical problems (e.g. Barrios *et al.*, 2006; Brokensha *et al.* 1980; Chambers *et al.* 1989; Thrupp 1989). These authors observed that most African farmers have a thorough knowledge of their cropping systems and that this knowledge is dynamic, rather than static. There are good examples of how researchers used farmer knowledge to guide scientific research and develop solutions that better fit the needs of African farmers (e.g. Defoer *et al.*, 2000; Quansah *et al.*, 2001; Steiner, 1998; van Asten *et al.*, 2004; Veldhuizen *et al.*, 1997).

However, involvement of farmers in agricultural research does not automatically put the FPR process on the right track. Farmer-led research without sufficient scientific rigor and triangulation of data can sometimes lead to wrong conclusions. Many agricultural projects involving farmers in Africa are carried out by teams of biophysical scientists without the input of social scientists, as biophysical researchers have more and more become generalists during the last 10 years. This has led to continued challenges and mistakes in implementation and interpretation of research programmes, as the use of inaccurate information or misunderstandings between farmers and scientists may result in the development and extension of unprofitable, unsustainable or inappropriate management recommendations. Several challenges and pitfalls of FPR have been identified by various authors working outside Africa. In this paper, we classify the different challenges and pitfalls mentioned in previous studies into the following broad categories:

(1) *Insufficient insight into systems complexity*: There is evidence (Bentley, 1989; Grossman, 2003; Moller *et al.* 2004; Thapa, 1994) that farmers and scientists may have insufficient insights into systems complexity, i.e. the different dimensions of, and interactions within, a system (e.g. farming system, soil–plant–pest interactions). For example, Grossman (2003) found that farmer's knowledge of complex soil biology in decomposition was restricted to organisms farmers could see. Farmers had knowledge gaps regarding phenomena that they could not see.

(2) *Differences in reference frameworks*: Farmers tend to use their farm and immediate surroundings as the reference framework for observations, whereas scientists mostly use universally accepted reference frameworks, measurement units (e.g. S.I. units) and classifications. Briggs (2005) argues that local knowledge often tends to be site specific and may not have much value beyond the particular location. On the other hand, scientists can interpret their findings through comparison with studies outside their own research site(s), yielding broader generalizations. Homann and Rischkowsky (2001) maintain that differences in reference frameworks between scientific and indigenous knowledge is rooted in the fact that scientists search for knowledge of universal significance, which is not context related, whilst indigenous knowledge is a social product closely linked to a cultural and environmental context.

(3) *Methodological errors*: The methods used to involve farmers in research can lead to the collection of inaccurate and/or misleading information. The use of leading questions by the research team, resulting in biased answers, is a well-known source of errors (Ashby, 1990). A second source of methodological errors may result from

> the lack of matching project objectives between farmers and researchers. This is often the case when farmers wish to attract a project to their community but do not attach the same importance to its objectives as scientists do. Farmers may thus 'bend' the truth by giving 'desired or leading' information to obtain short-term benefits for themselves or their community. Peters and Peters (1998) found that farmers are not concerned whether research results can be replicated, extrapolated or generalized. If scientists are not aware of this and do not sufficiently take farmers' objectives into account, then this will inevitably affect their experimental results. For example, farmers would add extra feed to the prescribed pig diet if they were not satisfied with the pig growth (Bentley, 1994). Other problems associated with such methodological errors have been given by Briggs (2005).

This paper uses examples from FPR experiences from different farming systems in sub-Saharan Africa to (i) demonstrate some of the challenges and potential pitfalls that may hamper FPR and the use of farmer knowledge, (ii) to classify FPR challenges and pitfalls into three different groups, and (iii) to provide some suggestions to improve the FPR process so that these challenges and potential pitfalls can be avoided. Most of our examples originate from research projects carried out by biophysical scientists (e.g. agronomists, soil scientists, entomologists), who lacked extensive input from social scientists, a situation that arises in many research stations across Africa. Therefore, most of the examples will highlight errors that could have been avoided if the process had been better thought through. Without providing absolute answers or suggesting that all possible challenges have been addressed, the authors wish to highlight some of the major challenges and pitfalls that affect the quality of data collected in farmer participatory and farmer-led research. The aim of this paper is to raise awareness, especially amongst biophysical scientists, that FPR approaches have to be well thought through in order to maximize benefits of combining farmers' and scientists' knowledge.

INSUFFICIENT INSIGHT INTO SYSTEMS COMPLEXITY

Farming systems are complex due to their many dimensions (e.g. social, economic, physical, chemical), each consisting of a large number of, and interactions between, components. Farmers and scientists alike often lack sufficient overview of the whole system to be able to correctly judge problems or the impact of changes on the system. This may be due to a lack of training or experience or to the sheer size of the system. Several authors have pointed out the consequences of scientists not fully understanding the whole system (e.g. Nederlof and Dangbegnon, 2007; Sutherland, 1999). Here we give several examples of African farmer communities that lack a sufficient understanding of their production systems to make the best corrective decisions to overcome major production constraints.

The cause of low productive spots in irrigated rice fields of the Sourou Valley, Burkina Faso

In the Sourou valley, Burkina Faso, rice farmers in a 3000 ha large irrigation scheme observed steadily declining yields a few years after the inauguration of the scheme in

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the mid 1980s. The yield decline was related to the appearance of many large (2–20 m^2) low productive spots in their fields. A full description of this case study can be found in Van Asten *et al.* (2004). In summary, agronomists from the national agricultural research institute in Burkina Faso (INERA) and the Africa Rice Centre (WARDA) jointly developed a project to address the decreasing yields. At the start of the research project, farmers were asked to explain the cause and importance of the low productive spots during an initial meeting of farmers and scientists. This was followed by a formal survey using open-ended questions on the same topic with 69 farmers. Farmers clearly indicated that they associated the spots with the presence of calcareous nodules at the soil surface and excessive amounts of earthworms. The farmers hypothesized that earthworms reduced plant tillering, as they deposited casts at the base of young rice plants. After a series of soil and plant sampling campaigns and farmer-managed and researcher-managed trials, the researchers showed that the low-productive spots were related to zinc deficiency. This problem was particularly severe at sites where the soil pH was high due to the presence of calcareous nodules. However, high earthworm numbers were not related with the appearance of low productive spots, nor did earthworms influence plant growth negatively. On the contrary, tiller number showed a positive linear relation ($R^2 = 0.57$) with the log-transformed earthworm number; i.e. plant performance increased with increasing amounts of earthworms, contrary to the farmers' hypothesis. Farmers were able to identify low productivity spots in their fields and correctly link the presence of these spots to calcareous nodules. However, they lacked knowledge on the soil chemical processes required to identify the actual cause of the problem (i.e. zinc deficiency) and develop workable solutions for this.

Rice production in the Bignona valley in the Casamance, Senegal

In the Bignona valley in south Senegal, rice is the most important food crop. Large acreages are grown in the wide valley bottoms of tidal rivers that used to be covered by mangrove forests. Rice production was mainly limited by salinity-related stresses until production problems increased after the onset of regional droughts in the 1970s. To reduce salinity problems and increase rice production, a large anti-salt dam was constructed in 1987. The construction of the dam stopped the inflow of saline river water into the valley during the dry season. Contrary to expectations, rice yields decreased after the construction of the dam. Farmers raised concerns about this during a participatory rural appraisal (PRA) exercise in 2000 organized by FDPPE – a local non-governmental organisation (NGO) – in collaboration with an agronomist of the Africa Rice Centre. Consequently, a research project was initiated to understand and help address the rice production problems. Detailed soil surveys carried out by the scientists showed that the combined effects of droughts and dam management had led to a 0.6–0.9 m drop of the groundwater table. This resulted in the oxidation of (potential) acid-sulphate soils in the lowlands, leading to severe acidification (i.e. topsoil pH $<$4.5) and iron toxicity problems in large parts of the lowland rice fields. Results from village mapping and time line exercises carried out in PRA workshops in three villages showed that farmers (especially women and youth) rightly recognized the magnitude of the changes that had taken place (i.e. decrease in rice production and area) and could accurately identify degraded soils in their rice schemes (Fermont, 2001). However, farmers did not have sufficient chemical knowledge to understand that their fields were no longer saline, but had acidified due to continuous oxidation of the soils. Consequently, farmers still managed their fields as if they were saline (e.g. flushing and draining of the soil to wash out salts) instead of adjusting their management to appropriate practices for acid-sulphate soils (e.g. permanent flooding of fields in order to prevent or reduce soil acidification). Farmers were not the only ones who lacked understanding of soil chemical processes. Most extension and development workers in the region had not understood the changes in soil properties that affected rice production and were thus not able to give appropriate advice to farmer communities.

DIFFERENCES IN THE REFERENCE FRAMEWORK

Farmers judge their farming system, its components and its problems within their own reference framework, which is often not larger than their own field, village or parish. Farmers may call something big or small depending on previous observations within their reference framework. Farmers also do not always use universally convertible measurement units – they often use local units that do not necessarily have a standard conversion factor (e.g. the weight of medium-sized banana bunches in Uganda varies per region and farmer). Scientists, on the other hand, learn to use a much wider reference framework. Through books, internet, communication and travel, they may acquire knowledge over a much larger range of farming systems to which they can compare observations made in a specific field or village. When reporting results, most scientist are trained not to classify observations in qualitative terms (e.g. big, small) only, but to rely on quantitative terms and tools using universal standards (e.g. S.I. units). In the section below, we show several examples that bring out the difference in reference framework between farmers and scientists.

Identifying yield loss factors in banana systems in Rwanda

In 2001, scientists from the national agricultural research organisation in Rwanda (ISAR) and the International Institute of Tropical Agriculture (IITA) conducted a study in Rwanda to identify major socio-economic, and pest and disease constraints for banana production systems at 12 sites in four major production areas. Results were published by Gaidashova *et al.* (2005) and Okech *et al.* (2005). In brief, during PRAs farmers were asked to identify and rank production constraints by raising their hands. At the same time, biophysical scientists visited farmers' fields and quantified the importance of weevil damage (*Cosmopolites sordidus*), root necrosis due to root-burrowing nematodes and the percentage of plants infected by Fusarium wilt (*Fusarium oxysporum cubense* spp., also known as Panama disease). In 2004, all survey sites were revisited, and soil and plant samples were taken to study the presence of possible soil fertility problems. Scientists quantified plant nutrient concentrations and soil fertility parameters, such as total N, exchangeable K, pH, and Mehlich-extractable Zn. The importance of pests and diseases and soil fertility problems were ranked using scientist's

Table 1. Ranking of the importance of major banana production constraints by farmers and scientists for 12 sites in four banana growing areas in Rwanda. Farmers' ranking is based on their perception, while scientists' ranking is based on plant and soil measurements, and in comparison with international standards and regional variations (Gaidashova and Van Asten, unpublished data).

Site†	1	2	3	4	5	6	7	8	9	10	11	12
Pest and disease pressure												
Farmer ranking‡	1	2	3	2	2	1	3	1	2	2	1	1
Scientist ranking‡	3	2	3	3	2	2	1	3	2	1	3	3
Soil fertility problems												
Farmer ranking	2	1	1	3	1	2	2	2	3	3	2	3
Scientist ranking	2	2	1	3	3	2	2	2	1	1	3	3

†Names of the sites: 1 = Karengera, 2 = Bugarama, 3 = Gishoma, 4 = Kayonza, 5 = Rukira, 6 = Rusomo, 7 = Bicumbi, 8 = Kanombe, 9 = Rubungo, 10 = Gitesi, 11 = Nyamyumbe, 12 = Rubavu.
‡Ranking scale: 1 = most important; 3 = least important.

expert knowledge, based on international and regional literature on the effect of the different stresses on crop yield. Table 1 clearly shows that, although farmers' and scientists' rankings correspond in several cases, there are also numerous cases where farmers and scientists have contrary rankings, e.g. pest and disease rankings at sites 1, 7, 8, 11 and 12, and soil fertility rankings at sites 5, 9 and 10, differ distinctly. The explanation may be that the importance of a constraint only becomes visible to farmers through spatial and temporal variations of production at plot, farm and village level. Consequently, constraints that show little spatial or temporal variations, but that are homogeneously affecting yields, will be much harder to detect for farmers. When farmers were asked to rank constraints, they considered pest and disease pressure as the major constraint, because they could easily observe their visual symptoms and could easily relate them to temporal and spatial yield variations within their site. Constraints that were more uniformly suppressing yields in space and time were less visible to farmers, but could relatively easily be identified by the scientists when comparing analytical results with international and regional standards. Hence, farmers use a more qualitative and local reference framework, scientists use a more quantitative and universal reference framework.

Rice production in the Bignona valley in the Casamance, Senegal – II

Following the identification of production problems affecting rice production in the Bignona valley described above, a WARDA agronomist proposed several on-farm trials to the farmers during feedback workshops. The proposed trials included variety, fertilizer and soil tillage technologies. In total 53 farmers volunteered to carry out a trial in the growing season of 2000, with a large preference for trials on problem soils, i.e. acidic lowland (55% of farmers) and drought-prone upland (27%) soils, compared to the more productive non-acidic lowland zone (18%), as they reasoned that a 'sick' soil like a sick person needs to be cured. Participatory evaluation of the trials showed that use of new varieties and fertilizer were only profitable on non-acidic lowland soils (Fermont, 2001). In the subsequent season (2001), 59 farmers volunteered to carry out trials, with a large preference for non-acidic lowland (54%) soils, and much less interest for the acid soils (36%) and drought-prone upland soils (8%) (Fermont, 2002). The change in on-farm trial choice showed that farmers rapidly gained insight into potential crop response to fertilizer × varieties technologies. However, the example also showed that farmer participation may not always lead to the selection of a broad range of technologies (e.g. no testing of tillage practice) in a broad range of environments (e.g. large preference for a specific environment), which eventually may slow down the development of appropriate technologies. Hence, although scientists and farmers had discussed the trials in detail and agreed on the main objectives, the farmers were focused on maximizing individual benefits in the short term, while the scientists preferred activities that would provide insights in a larger range of biophysical and socio-economic environments, which would help to develop and extrapolate recommendations more easily.

Indicators for change as perceived by farmers and scientists in East Africa

The International Center for Tropical Agriculture (CIAT) in partnership with national agricultural research and extension services (NARES) and NGOs has been testing and evaluating an action research project that aims to empower rural communities to develop their own monitoring and evaluation systems in Malawi, Uganda, Kenya and Tanzania (See Kaaria *et al.*, 2008 for full description of the project). All communities were guided through an initial visioning process to help them develop a common vision about the results they hoped to see once the project had been completed successfully. The most common expectations or objectives for communities participating in research and development (R&D) projects were improved food security, increased incomes and knowledge, and empowerment. In most communities, community objectives tended to focus more on the livelihood outcomes rather than outputs. For example, common community objectives were 'to have enough food in our homes', 'increased food self sufficiency', 'sufficient food at household level', 'earn money from livestock (pigs) and crop sales' and 'increased incomes'. On the other hand, objectives of project staff objectives were: 'improved soil fertility', 'soil fertility management options adopted by farmers', 'identify the best bean variety to grow in the area for food and sale' and 'increased livestock feed'. Project staff objectives focused on short-term project results, whilst community objectives focused more on the long-term outcomes beyond the life of the projects. For example, community indicators for improved soil fertility management were more often related to increase in yields, while the project staff's indicators focused on improved soil fertility parameters. Hence, community indicators combined both qualitative and quantitative measures with a non-specific time frame, while scientists' indicators were more quantitative, generic and related to a specific time frame. Njuki *et al.* (2008) showed that involving farmers in evaluating change led to broadening of how researchers viewed project impacts. For example, scientists focus had been mainly on project outputs (e.g. number of technologies they developed, number of farmers who adopted them, number of papers published from their work), while the communities viewed the results in terms of the extent to which these would improve their livelihoods. This meant that researchers had to extend their results chain to go beyond the direct outputs to look at the implications of these outputs for farmers' lives and livelihoods. This provides a good example of how a better understanding of what farmers view as indicators of change in their livelihoods can make a research programme more effective in measuring its own impact.

METHODOLOGICAL ERRORS

Although FPR methods have been widely promoted and adopted by scientists, much less attention has been given to problems associated with some of the methodologies used. This may include problems with the interpretation of scoring or ranking exercises. But perhaps the most dangerous threat to the quality of data collected in FPR is when farmers produce 'false' or 'desired' answers, or alter the management of on-farm trials, with the aim of maximizing the short-term benefit or minimizing any negative repercussions. Such behaviour is entirely logical from a farmer's perspective, but when scientists are unaware of this, it may negatively affect their research results. The reasons why farmers provide 'incorrect' information to the researcher or extension officer may include the following:

(a) the question is improperly formulated or posed, which leads the farmer in a certain direction
(b) farmers hope that certain answers will increase their chances of getting (financial) benefits through the development/research project
(c) farmers provide a 'correct' answer, to show that they are knowledgeable or out of politeness
(d) farmers wish to avoid an answer which is culturally unacceptable, or which will lead to a certain chastisement
(e) farmers' objectives no longer coincide with the researchers' objectives, leading to changes in farm management practices.

In the following examples, we would like to highlight cases where scientists have obtained erroneous results due to their poor choice in the methods used, and/or due to insufficient triangulation of data.

Under-reporting access and ownership of farm resources

Our experiences in rice-based cropping systems in West-Africa, as well as in cassava and banana-based cropping systems in East Africa, demonstrated that in certain instances farmers under-report access and ownership to resources (e.g. farm size, off-farm/on-farm income, the number of cattle) in surveys and PRAs. The reasons for that could be (i) to attract more project assistance as the village is 'poor', (ii) fear that data may be used by authorities to collect/increase tax contributions, or (iii) due to a general culture of not showing off wealth for fear of theft (e.g. parts of Uganda).

On-farm irrigated rice trials in the Senegal

In irrigated rice systems in the Senegal Valley, Haefele *et al.* (2002) installed trials in farmer fields, with one part of the field functioning as control (i.e. traditional farmer practices), and with other parts of the field used for testing the researcher-introduced technologies. The authors observed that after the first season, farmers started to mimic part of the introduced technologies in the control plots. Besides improving their own production, farmers took pride in showing the researchers that under their 'own' management, yield differences with researcher-proposed management were minimal. Researchers should realize that farmer 'control plots' are highly dynamic and that their interventions can rapidly alter farm management practices with the aim of increasing farm revenues. In fact, use of an absolute zero (i.e. banning the use of external inputs) as a control plot should not be promoted unless farmers are fully aware of, and in agreement with, the objectives and possible low yields that may occur in such plots. Rather than an absolute zero as a control plot, a farmer practice control plot could be used that can be revised each season as farmers adapt different components of improved technologies.

On-farm banana research in Uganda

Similar to the previous example of on-farm rice trials in the Senegal river valley, van Asten (unpublished data) observed, in on-farm banana research in Uganda, that farmers intentionally tried to improve the management of bananas in control plots/mats, because farmers anticipated a higher remuneration from selling the banana bunches to the research project, than from selling the bunches at the farm gate. Furthermore, farmers wanted to show the researchers that they were capable of producing large bunches because in Uganda the pride of a man is often determined by the state of his banana garden. Similarly, Taulya (2005) observed that farmers tried to tamper with bunches from plants monitored in their field for research purposes, because the research project gave premium bunch prices compared to the farm gate prices. The use of payments or other benefits associated with trials should therefore be carefully thought through as they are likely to negatively affected research results. In addition, scientists will have to put more efforts into co-developing with, and communicating to, farmers the objectives and possible outcomes of on-farm trials, so everyone has a similar view of what the trial results should be.

The importance of finger millet and bananas in southwest Uganda

Based on farmer responses in their survey on shifts in banana production in Uganda, Gold *et al.* (1999) hypothesized for southwest Uganda that (i) bananas became an important crop after the 1970s when yields dropped in central Uganda, and (ii) that bananas then replaced finger millet as the traditional food crop. However, production figures and maps from McMaster (1962) show that banana was already an important staple crop in southwest Uganda in the 1950s, with all of Masaka and most of Ankole districts having 30% or more of the agricultural land under banana by 1958, and with finger millet just being a minor crop. Part of the discrepancies between the farmer survey results and the historic literature were related to the way questions in farmer interviews were formulated, e.g. when the researchers asked farmers to indicate which was the most important food crop before the 1970s, farmer referred to finger millet, not because it was most important in terms of production or calorie intake, but because it had an important traditional and cultural value. Farmers and researchers therefore had a different interpretation of 'important' in the question about finger millet.

Crop surface area estimations in cassava research in Kenya

In the context of a research programme on cassava agronomy in Kenya, individual on-farm surveys were carried out with 60 farmers in three sites in western Kenya (Fermont and Gonzalez, unpublished data). Each farmer was asked to carry out scoring exercises to evaluate the importance of the various crops grown in the survey year in terms of (i) the acreage and (ii) the importance for total crop income. Each farmer was given at least 20 beans, depending on the total number of crops grown, to illustrate their scoring. Results of the scoring exercises were cross-checked with the farmer; i.e. if the farmer allocated twice as many beans to crop *x* than to crop *y*, the interviewer asked the farmer whether he/she meant that crop *x* occupied twice the acreage of crop *y*. Changes were allowed if the farmer had not properly understood the exercise. Field data on the actual acreage of all crops were obtained for the survey year by visiting all fields of the farm with the farmer and recording field size and crop allocation in the current and past season. In another part of the survey, farmers were asked to give detailed estimates of crop income for each crop in the survey year, which were cross-checked against acreage, and production and consumption levels. Both sets of data (scoring exercises, and detailed crop acreage and crop income data) were used to calculate the percentage of cropped land and the percentage of crop income obtained from cassava and maize. These crops represent the two main starchy staples grown in each site. Comparison of the two data sets shows that farmers tended to overestimate smaller (<20%) crop acreage or income and underestimate larger (>20%) crop acreage or income (Figure 1a and 1b). Errors seem to be larger with estimations of crop acreage than with estimations of crop income. People are generally prone to systematic overestimation of small quantities and underestimation of large quantities. This was also shown by Dildy *et al.* (2004) for visual estimation of blood loss by medical students and physicians and by Lindbo *et al.* (2001) for the determination of the percentage of organic-coated sand grains by soil scientists. Hence, this example illustrates the inevitable error associated with the type of scoring exercises often used in PRAs and (in)formal interviews when scoring results are presented as quantitative figures. Rather, results from these exercises should be presented as rankings.

SUGGESTIONS FOR ADDRESSING IDENTIFIED CHALLENGES AND PITFALLS

Participation of farmers at different stages of agricultural research is, without doubt, indispensable for researchers who wish to develop technologies that are both environmentally sound and socio-economically acceptable. However, the examples presented in this paper clearly indicate that biophysical researchers have to be more rigorous in their interaction with smallholder farmers and in their use of farmer

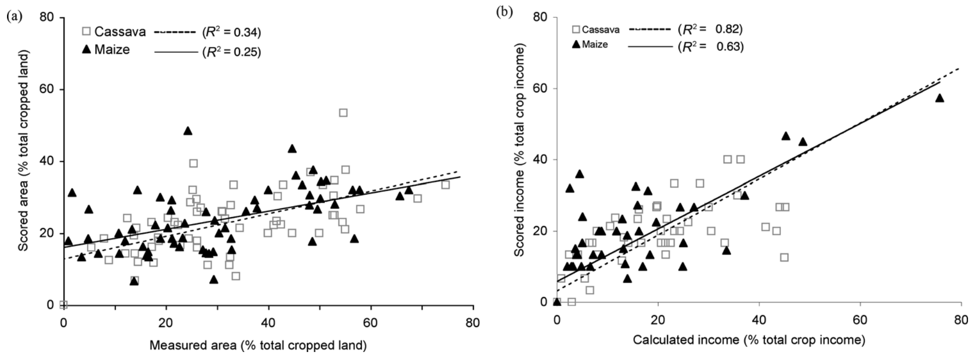

Figure 1. The percentage of cropped land (a) and percentage of crop income (b) generated by cassava and maize as estimated by farmers in scoring exercises for the survey year (y-axis), compared to actual crop acreage from field data and calculated crop income from detailed and triangulated survey data for the survey year (x-axis) (Fermont and Gonzalez, unpublished)

knowledge to guide their research. It should be very clear in this respect that scientists should not only be very conscious about FPR pitfalls related to limited farmer knowledge and farmer bias, but scientists should also be very careful and conscious about their own weaknesses in FPR approaches.

Suggestions for preventing FPR problems related to insufficient insight in system complexity

- Combine FPR with a strong research component into problems identified by farmers to improve the understanding of the underlying causes. This is especially important if production constraints are related to processes that are not easily visible with the naked eye (e.g. soil chemistry, certain pests and diseases) or when the constraints entail numerous interactions between different farming system components (e.g. intercropping systems). The research should aim to understand farmer perceptions about the spatial and temporal distribution of the studied problem, while also trying to understand the socio-economic dimension of the problem.
- Regularly provide feedback on research findings to farmers and extension workers in a format they understand (e.g. use local language and local units). This will allow them to indicate research gaps, to correct possible incorrect findings and to provide feedback on the socio-economic dimension of the problems studied. Through regular feedback meetings, farmers and researchers can help each other to better understand the systems complexity and correct wrong interpretations at early stages of the research process.

Suggestions for preventing FPR problems related to differences in reference framework

- Use results of farmer identified production constraints with care and substantiate findings with a quantitative diagnostic survey, before a whole research programme is started on the basis of farmer perceptions only.
- Cross-check farmer estimates with quantitative measurements (e.g. verify the conversion from local to universal measurement units with several farmers).

- Ask farmers to be as quantitative (e.g. time, mass, number, volume, surface area, monetary value) as possible when expressing their resource use, problems and objectives, and use qualitative (e.g. rankings) data only to better understand farmers' perceptions in their local context.
- Even if the farmers' hypotheses on the causes and dynamics of agricultural problems seem unlikely at first, it is recommended that the scientists include testing of farmers' hypotheses in order to (i) better understand the systems complexity and (ii) better understand farmers perceptions.
- Before starting a series of on-farm activities (e.g. agronomic trials), scientists and farmers should thoroughly discuss and agree on the objectives of the activities, and clearly spell out individual versus general interests.

Suggestions for preventing FPR problems related to methodological errors:

- Put minimal emphasis on the objectives of questionnaires to prevent farmer bias.
- Use knowledgeable resource persons to cross-check information which is less easy to triangulate, such as number of cattle or non-agricultural sources of income.
- Train project staff to cross-check and triangulate data at several stages, such as (i) during the interviews, (ii) soon after the interviews (e.g. in the evening) and (iii) during data entry.
- Repeatedly visit farmers to gain their trust in order to 'solve' inconsistencies in earlier answers; e.g. some farmers in Uganda were pleased when scientists made the effort to revisit them when the data they supplied were not consistent.
- Prevent or temper farmer expectations on short-term (financial) benefits by clearly spelling out the project objectives and benefits.
- Develop research protocols that avoid ambiguity about the cause of the observed treatment effects.
- In order to avoid farmers changing their management practices, researchers should not pay premium prices for the produce from research plots, unless there are very clear agreements between farmers and researchers on the objectives and requirements of their joint activities.
- If researchers wish to test technologies that are likely to reduce farmers' incomes (e.g. when they prevent farmers from early adoption of tested technologies in 'control' plots, or when they ask farmers to harvest too late in their view), then the researchers will need to consider compensation of anticipated yield losses with farmers. Such agreements would have to be made before the start of the technology testing, in order to avoid a conflict of interests. Both scientists and farmers have to clearly express their expectations and needs before starting joint technology testing.
- Use a healthy dose of scepticism.

CONCLUSION

Over recent decades, FPR approaches have been extensively adopted in agricultural research in sub-Saharan Africa. However, there are a number of challenges and pitfalls in FPR that participants should be aware of. Several of these pitfalls had already been identified by various authors in Latin America and Asia. In this paper challenges and pitfalls reported previously have been validated for the African farming context, and grouped in three distinct classes, namely: (i) insufficient insight into systems complexity, (ii) differences in reference frameworks and (iii) methodological errors.

All development and research actors know about the importance and power of FPR approaches when working with smallholder farmers, but the capability and skills required to fully utilize these approaches are still lacking in most of us. This is due to (i) insufficient training of researchers who interact with farmers (e.g. facilitation skills, gender analysis), (ii) a general move to producing 'generalist' biophysical scientists rather than specialist scientists, who work in multi-disciplinary teams with social scientists, and (iii) the lack of social scientists in many research teams.

Unfortunately with the renewed interest we are seeing in agriculture development at the end of 2007 and early 2008 (e.g. World Bank, 2007) and with increasing investments in agricultural research, the rush now is to achieve numbers. Whose numbers, which numbers and what these numbers mean, could be completely lost on us if we do not ensure rigorous approaches to interactions with smallholder farmers. FPR tools will remain key to guide research for technology development, adaptation and adoption, but users of these tools should also be aware of the challenges and pitfalls of these tools if they wish to make significant and sustainable impact.

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