INNOVATIONS FOR SUSTAINABLE DEVELOPMENT: THE NEED FOR KNOWLEDGE SHARING

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Abstract

Science is a powerful means to enhance socio-economic development. Many strategies to alleviate poverty involve science. One of the strategies is to build local scientific capacity to generate environment-friendly innovations adapted to the needs and knowledge claims of local communities and institutions. We argue that in order to develop sustainable technologies for local communities, knowledge sharing between science and society should be involved throughout the innovation process. Such a process faces four major challenges; the integration of non-academic and academic knowledge, the methodology, the skills of the scientists, and the institutionalization of the approach within organizations. The objective of this study is to gain greater insight into strategies to realize knowledge sharing throughout the innovation process. We describe a case study on the initiatives of a Bangladeshi NGO to share knowledge between science and society. We analyse the case-study through numerous interviews, informal dialogues and direct observation. The experiences and lessons learnt contribute to the development of strategies for realizing knowledge sharing throughout the innovation process. To achieve knowledge sharing an interactive approach was selected and applied by the organisation for the development of locally suitable agricultural technologies. This led to a fundamental change in how the NGO communicated with the local farmers with regard to technology development. One of the activities was the adaptation of the True Potato Seed technology to the situation of the local farmers. We discuss the achievements and reflect on the challenges faced by this process. An important conclusion is that the key strategy to enhance effective transfer of knowledge is the recognition, of the multiple and pervasive hierarchies that influence interaction, and the identification of specific, local and pragmatic steps to reduce the obstacles that these hierarchies represent to the exchange of ideas and information.

Keywords: Sustainable development, Bangladesh, Knowledge sharing, Science and society, hierarchy

1. Introduction

Scientific advances over the last fifty years have led to revolutionary changes in agriculture, health, nutrition and communication; moreover, the role of science promises to be yet greater in the future because of ever-more-rapid scientific progress. Many strategies to alleviate poverty involve science. Most developing countries, however, lag behind in their local technological development and therefore introduce technologies that have been developed abroad. For example, most developing countries have been pursuing a 'Green Revolution' strategy based on the introduction of high-yielding varieties of rice and wheat, irrigation, chemical fertilizers and pesticides. Although this resulted in considerable yield increases in these crops in many developing countries, the successes achieved were not undisputed, and were sometimes associated with pollution, marginalization of small-scale, resource-poor farmers and other socially less desirable phenomena. Numerous impact studies have shown that the poorest people in developing countries, rarely benefited from these technologies, because they were not appropriate for application under their living conditions [1].

One of the strategies to address this problem is to build local scientific capacity to generate environment-friendly innovations adapted to the needs and knowledge claims of their communities and institutions. It is generally acknowledged that in order to generate appropriate technologies it is necessary to incorporate knowledge of socio-economic and cultural aspects in the innovation process. To this end, a whole range of participatory approaches to technology development have been developed, which actively involve local communities. However, in most projects information on needs and constraints is only collected and integrated during the planning stage of the project. Next, the technology is developed at the research centers without involving the local communities. During the dissemination phase, the local communities can give their opinion. Technologies developed in this way still often fail to benefit the target group [2,3,4,5].

We argue that in order to develop sustainable (agricultural) technologies for local communities, knowledge sharing between science and society should be involved throughout the innovation process. However, such a process faces four major challenges. Firstly, the integration of non-academic knowledge and academic knowledge needs specific attention. Non-academic knowledge usually is subjective, concrete, individual and often implicit, whereas academic knowledge claims to be abstract, universal and explicit. Part of the non-academic knowledge is embodied in people and the ways they are interacting in socially organized forms. This so-called tacit knowledge is highly personal and hard to formalize, making it difficult to communicate or to share with others. It is deeply rooted in an individual's action, experience and ideals, and can be segmented into two dimensions: "the technical dimension, which encompasses the kind of informal and hard-to-pin-down skills or crafts captured in the term 'know-how', and a cognitive dimension, which consists of schemata, mental models, beliefs and perceptions so ingrained that we take them for granted" explanations [7: 8]. However, despite the differences, non-academic knowledge may not differ that much in characteristics from academic knowledge. In non-academic knowledge production the same types of explanation are used as in some scientific disciplines, such as psychology or anthropology, namely hermeneutic[1] and narrative explanations [6,7].

Since non-academic knowledge and explanations are context and use-dependent, its validation is one of the most challenging aspects. It includes additional criteria, besides consistency and empirical adequacy, such as applicability and contextual adequacy. This ensures the 'objectivity', or rather inter-subjectivity, of research results and thus their scientific validity. Continuously evaluating the research process on these criteria requires a continuous dialogue with feedback loops between the parties for cross-checking of previous assumptions, insights and demands. Meeting these criteria might give rise to interpretations or innovations that are also appropriate to the specific context of application and to the needs and demands of end users [8].

The second implementation challenge is the lack of a well-defined general procedure to share knowledge between science and society throughout the innovation process. In general, it is undertaken regularly, although mostly in a rather implicit and ad hoc way. Based on these experiences, we can formulate some common procedural elements: an interdisciplinary team is established, societal actors are active participants in the research process, data collection methods from broadly differing scientific disciplines are used (as a kind of tool box), a continuous dialogue between the parties involved is established, various feedback loops for cross-checking of information are included, and knowledge from various academic and non-academic sources is collected and integrated. In this way an iterative and interactive process emerges with the aim to 'solve' practical problems. It is, however, neither possible nor desirable to develop a generic detailed procedure. The context dependent nature of the research is not compatible with the development of some kind of blueprint research manual. In every concrete situation a specific procedure will need to be developed.

Thirdly, the researchers need various skills that are not all learnt in regular science curricula. These skills are, for example, social skills such as openness, reflexivity, modesty, flexibility, and the ability to listen to others, to build relationships and to deal with (or have tolerance for) ambiguity. These skills are needed to build the "capacity to cooperate with experts from other fields and to come to see problems in a complementary way, which rests upon the capacity to assume multiple cognitive and social identities" [10: 139]. Besides these communication skills, researchers need organizational skills for e.g. organizing workshops and discussion meetings, and specific scientific skills for gathering, translating, analyzing, weighting, valuing, structuring and synthesizing academic and non-academic information and knowledge [9,10, 11].

The fourth implementation challenge is the institutionalization of knowledge sharing within existing organizations. Since many organizations are structured according to strong disciplinary lines, a certain degree of reorganization is likely to be necessary in order to facilitate this type or research. Organizational change is, however, a complicated process. Several attempts to initiate change within more traditionally structured organizations have started with the establishment of separate, innovative, pilot teams, before other parts of the organization are affected. The challenge is to develop strategies to address the tensions that will arise between the innovative group and the larger traditional organization [12,13].

Due to the aforementioned challenges knowledge sharing is often conducted in an implicit way, and restricted to certain phases of the innovation process, particularly the diagnostic, planning and evaluation phases, while other phases remain more or less monodisciplinary. The objective of this study is to gain greater insight into one of the challenges, the methodology to realize knowledge sharing throughout the innovation process. This was achieved by analyzing a case study on the initiatives of a Bangladeshi NGO, the Grameen Krishi Foundation (GKF) to share knowledge between science and society. An interdisciplinary team consisting of ten staff members of GKF, the Technology Assessment unit (TA unit), applied the Interactive Learning and Action (ILA) approach (see box 1 for a description of the approach) as a methodology for sharing knowledge between science and society. The strength of this methodology lies in the structured way in which consultation and collaboration methods are combined and in the explicit focus on stimulation of knowledge integration [14].

The case-study was undertaken within the framework of a larger project; 'Iteractive Strategies for Generating Innovations for Resource-Poor farmers'. The project was executed by the Grameen Krishi foundation (GKF), a non-governmental agricultural organization in the North Western part of Bangladesh. The study took place from 1997-2003 and was executed in collaboration with the Athena Institute of the Vrije Universiteit which had previous experience in knowledge sharing between science and society. The project was financed by the Dutch Directorate General for International Cooperation (DGIS) with some additional support form the Mondial Institute for Social development. The study presents experiences and lessons learnt of the Bangladeshi NGO in realizing knowledge sharing throughout the innovation process by applying the ILA approach.

Box 1. The ILA approach

The ILA approach consists of four phases. The objectives of the *first phase* are to establish (and train) a team of trans-disciplinary researchers and to become familiar with the socio-economic, ecological and political setting as well as the local community in a selected area. The *second phase* involves gathering information and knowledge, the issues concerned, and the perspectives and views of actors. Participants need to formulate their own perspectives, needs and ideas, but also to reflect on those of others in order to obtain a basic understanding of important issues and of each other's views. In a more or less spiral-like way actor perspectives are alternated, each time building on previous information and knowledge in an increasingly sophisticated way. At the end of this phase the preliminary findings are laid down in an intermediary document. In the *third phase*, participants are brought together in interactive workshop settings to review and discuss the intermediary findings in order to achieve wide dissemination, criticism and legitimization and to allow for the incorporation of new ideas and perspectives. These workshops are characterized by close interactions between the participants, facilitating mutual feedback and the development of shared constructions. The plan of action, which resulted from the previous phase, forms the input to the *fourth phase*, in which specific projects are formulated and implemented. Project formulation and implementation can be undertaken at any level and may focus either directly on the local community or on research institutions or policy-making bodies, or any combination of these. As in the previous phases, it is essential that formulation and implementation should be interactive, exploring the options in close collaboration with all concerned.

2. Methodology

From 1997 to 1999 we assessed and analyzed the case study. Informal dialogues, group discussions, individual and group interviews were held with the staff members of GKF to explore all the successes, the difficulties faced and strategies to overcome these difficulties. Subsequent interviews were held with participants in the process, amongst others local community members, farmers and scientists. Validity of the data was gained by asking similar questions from a different perspective in one interview and by conducting various interviews in which the same questions were posed. In addition, most activities conducted by the TA unit members were directly observed by different members of the research team. The research team consisted of: (a) four staff members (including the authors) who were responsible for the analysis of the whole process, (b) two MSc students who assisted in the process as trainees.

2.1 Group discussion

From 1997 – 1999 the research team organized weekly and monthly group discussions for the TA unit members. Each group discussion included a summary of the progress so far, individual input of all team members, and a discussion on the individual inputs. A monitor observed the group dynamics and recorded notes of the proceedings. During the first part of the group discussions the team members summarized the difficulties they faced. In the second part of the sessions, the team members collectively prioritized the problems and discussed strategies to deal with the constraints. Notes of the discussions were recorded in a book which was available for all team members. Group discussions were analyzed by the research team. All problems, causes and mutual relations mentioned were logically analyzed.

2.2 Interviews

In order to assess the individual experience of the team members, the farmers and the scientists, in the progress of sharing of knowledge, various interviews with individual team members, farmers, community members and scientists were conducted. All interviews were semi-structured, thus leaving room for interviewees' narrations. Interviewees were purposively selected. Interviews were extensively reported from minutes directly afterwards.

2.3 Direct observation

Most of the activities of the TA unit in a village named Radhakrishnapur were directly observed by members of the research team. Direct observation of the activities increased insight into the difficulties faced by the TA unit members and increased understanding on the effects of the different strategies developed to deal with the difficulties. Observation schemes were prepared and depended on the findings of the group discussions. However, all observations recorded the participation of the participants (silent presentation, non-dominant active participation, dominant participation).

3. Results

From 1997 to 1999 the case study was assessed and analyzed. Informal dialogues, group discussions, individual and group interviews were held with the staff members of GKF to explore all the successes, the difficulties faced and strategies. The ILA approach consists of four phases. The results of each of the phases are subsequently discussed.

3.1 First phase

3.1.1 Establishing an interdisciplinary team with a flat structure within a hierarchical organisation

The staff members of the interdisciplinary team – the Technology Assessment unit (TA unit) – consisting of seven male and three female staff members of GKF were selected by the managing director of GKF. Next, this team was trained in the Interactive Learning and Action (ILA) approach. Initially the team was just a set of solitary individuals with a strong hierarchy based on education previous, position within the organization and sex (all males were higher in hierarchy than the females). It took a lot of time and effort to reduce the hierarchy and to build the team. The transition was made gradually. Exercises in couples, such as 'interview your partner' made them listen to each other.

In order to reduce the hierarchy a red ball was introduced. Only the person holding this red ball was able to speak or had to speak. The trainer threw the ball to one of the team members when he or she was allowed to speak. This ball worked extremely well. The ball and it status was accepted by all team members (also the higher educated team members). It allowed the very shy team members to speak up. Discussions were possible with the ball thrown back and fort over the table.

Another important contribution to team building was the establishment of a group culture. For example, the unit members initially often blamed each other for being wrong (especially those of 'lower status' were frequently held to be at fault). This considerably reduced the creativity of the trainees and resulted in the failure of brainstorming sessions. In Bengali the word 'wrong' is expressed by the word *buhl*. Every time the word *buhl* was used, the facilitator immediately responded with *buhl na*, which means something like 'there is no wrong'. The unit members took over this habit of saying *buhl na* and the expression became a private joke for the team. Another group 'rule' introduced was the use of the first names instead of family names. In general everyone having a higher status is spoken to by using the title mister, sir or madam, followed by the family name. People of lower status are addressed by their first name. By doing this, however, a hierarchy in the TA unit was enforced. This problem was put before the unit members and the solution was found in the exclusive use of first names.

Next, the team needed to become familiar with the socio-economic, ecological and political setting as well as the local community in selected area. However, initially, according to the unit members, there was no need to go to the field and interview farmers about their constraints. The Managing Director (MD) of GKF was supposed to know everything (by definition since he is highest in the organizational hierarchy) and, thus, he was also expected to be familiar with the constraints of the resource-poor farmers and the ways to solve these constraints. All the trainer had to do was ask the MD. This barrier was taken by inviting the MD in the training session, and by asking him to explain that some constraints are very complicated and need to be addressed in an interdisciplinary way. The conclusion of the unit members was that, if the MD said so, they would go to the field and interview farmers.

The MD and the team together selected Radhakrishnapur as a suitable village, since few developing organizations were working in this village. However, talking to farmers is a very low status job. Especially, the higher educated team members were not really motivated to talk to the farmers. Moreover, the members of the TA unit were made fun of by their colleagues of the wider organization. They were sitting on the floor with farmers and made drawings in the sand. Team members with a higher education were conducting the same (low) activities as the lower educated team members. This reduced the status of the unit. To increase their status the team was placed directly under the Managing Director. In addition, the MD explained to the rest of the organization the aim of the unit and that he had initiated this project.

3.1.2 Making hierarchies visible – and using them positively

The research team applied participatory Rural Appraisal (PRA) Gender Analysis (GA) tools for analyzing the problems and livelihood strategies of local communities of Radhakrishnapur. Most PRA / GA tools resulted in a visualisation on the ground. During May – July 1997 team was in the village almost every day. Participatory approaches were conducted with individuals, with different groups of community members and with separate groups of male and female farmers, to provide gender specific information. Most participatory activities lasted several hours. Therefore, most activities conducted with groups of people had differing amount of participants. Even the individual activities including males resulted often in a community activity. The participants were selected at random. Most participants belonged to the age group: 16-30 years. See figure 1 for an example of a village map.

The participants were highly enthusiastic about the methods. Their reaction was that for the first time, a development organization took the time to really listen to them. They were more than willing to sit with the team and discuss issues of their village. Most participatory activities ended in a lively discussion amongst community members. One male farmers said: "This is the first time that I do not feel embarrassed that I cannot offer you a nice chair, you are sitting in the same way as we are". Separate activities were conducted with the women. The women were initially rather shy, however they became really enthusiastic and talkative later in the process. Copies of the maps produced by farmers (see figure 1) were supplied to the farmers that produced the maps. Farmers were very proud of these maps and they decorated their houses with various maps produced.

During the participatory activities community members were asked to discuss their livelihood in general. The team members learned amongst others that Radhakrishnapur is a village consisting of 137 households, that the village has one school and a medical facility and one paved main road, which runs right through the village. On the road side is the local market. Almost all community members are poor and in general both men and women are engaged in crop farming and in herding as a secondary activity. Rice is the main crop. All farmers cultivate rice in two summer seasons. In the winter time they cultivate either another rice variety or a winter crop such as wheat, maize, potatoes. The produce is used for home consumption and the surplus is sold in the market. Vegetables are mainly cultivated in the homestead and are mostly the responsibility of the women.

The TA unit members were surprised that the participatory methods worked so well and that farmers had so much information and moreover that they could visualize this. Whereas the team was highly unmotivated to go to the field on the first day, they were extremely motivated after the second day. Initially it was not an option for the team members to work beyond office hours, however after the first day the team members convinced the trainer that they really needed to go to the field much earlier and that they had to stay in the field till dark (otherwise the farmers would not have time for them). Although all teammembers were enthusiastic about the methods, it showed that local community members felt more at ease in the presence of the lower educated teammembers. Therefore the higher educated team members decided that they dressed like the lower educated team members on field days, for example no had and no jackets only shirts.

Figure 1 the village map of Radhakrishnapur

3.2 The second phase

During the second phase more specific information and knowledge on specific (agricultural) issues, and the perspectives and views of the different actors -such as; local farmers, community members, scientists, governmental officials- was gathered with the help of in depth interviews and participatory approaches. Participants formulated their own perspectives, needs and ideas, but also reflected on those of others in order to obtain a basic understanding of important issues and of each other's views.

3.2.1 Recognising and using hierarchies (again)

The TA unit collected information about constraints and opportunities faced by the farmers with the help of participatory approaches and in depth interviews. In total 105 participatory activities were conducted. The farmers were asked - collectively or individually- to prioritize the (agricultural) problems. The main purpose for this prioritization exercise was to generate discussion and elicit explicit arguments that underlie each problem. In addition, the prioritization generated gender differences. The TA unit members did not face difficulties collecting information of the farmers and the farmers were very willing to explain their constraints. However, remarkable was that an higher educated male team member was required to interview a large rich or old farmer, lower educated team members were able to collect more detailed and or sensitive information of the farmers with a lower status (for example about bribes which the farmers have to pay to richer farmers) and of course the female team members were required to interview the female farmers. By collecting information of different sources by different team members the TA unit was able to understand the whole picture. Thus outside the office the team functioned according to hierarchy, however behind closed doors the team had a flat structure and was able to integrate the information obtained from various actors.

From the small and medium scale farmers the team members learnt that, amongst others potato is a very important crop for the local farmers. Especially the local red variety is extremely popular, since according to the female community members it is very suitable for cooking and has a very good taste. Farmers commonly cultivate potatoes by planting seed tubers of the previous season. Seed tubers are easy to plant and potato plants grow quickly and vigorously. Despite these apparent advantages, seed tubers are often carriers of diseases and pests, which can either reduce yields considerably, as farmers do not have the money to apply significant levels of various pesticides and fungicides. This is the complaint of the large scale and rich farmers, they have to apply more fungicide since the plots of the other farmers have a lot of insects. In addition, they mentioned the lack of cold storage facilities in the region. All farmers expressed an interest in alternative high-quality and environment-friendly potato planting materials that could be obtained and cultivated at a reasonable price.

Initially the TA unit members were hesitant to interview the local governmental officials, because of his high status. In addition, the government official made clear that he was interested in an interview with the leader of the TA unit but not with the lower educated team members nor a female. Since it was of utmost importance to keep the relationship with the local government official good (otherwise it is impossible to conduct any activity in the village) the highest educated team member interviewed the governmental official and asked him about the potato crop. The government official recognized the popularity of the potato and the lack of quality planting material. According to these officials the outputs from potato seed programs are not able to fulfill the national demand of high-quality potato planting material. Moreover, seed tubers are perishable, bulky and, hence, difficult to transport to distant production areas. There is also a lack of refrigerated storage facilities.

The TA unit members needed to collect information from the scientists. Scientists in Bangladesh have a very high status therefore it was only possible for the highest educated team members to visit the scientists in order to collect information. The TA unit members visited the Agricultural University Mymensingh and Dhaka. One of the team members previously studied in Mymensingh which seemed to smoothen the interview. Some scientists were not at all interested in views of the farmers, whereas some other scientists really showed their interested in the view of the farmers and in the activities and aims of the TA unit. In response to the constraints of the potato crop, two interested scientists indicated that True Potato Seed (see box 2) is a quality and environment-friendly potato planting materials that can be obtained and cultivated at a reasonable price. They referred to another research institute which was worth visiting. These scientists organized the appointment for the TA unit. These visits to the scientists increased the status of the TA unit members within the wider organization considerably.

Box 2: True Potato Seed

The TPS is produced sexually by crossing male and female flowers. The seeds are then used either for direct field sowing or for raising seedlings. The seedlings are used either for transplanting to the field to grow a normal crop, or for the production of seedling tubers to be used as planting material in the subsequent growing season. The main advantage of TPS is that it reduces the use of potatoes, which then become available for consumption. Moreover, TPS can be stored inexpensively in warm and humid areas. Therefore, it reduces the need for specialized storage facilities. Another advantage is that TPS is almost disease free and, thus, reduces the need for pest control. Since 1950, work on TPS is initiated at various public research institutes conditions [15,16,17].

The TA unit provided the information on TPS back to the local community members in a workshop. All community members who joined the participatory activities earlier were invited, also the females. Most of the males were interested to come to the workshop which was held at a central place in town. However, the females were interested but needed permission of their husbands. Therefore, the husbands were asked permission. Three husbands allowed their wives to go, under the condition that they were escorted by the females of the team. Therefore, before the workshop started the female team members collected and escorted the three females to the workshop and at the workshop they were seated in a special separate place surrounded by females of the unit.

In this workshop about 100 participants were present. The workshop included a plenary introduction, a visual presentation on flap-over of the findings of the participatory activities and the information collected from scientists. During the first part of the workshop the participants were asked to discuss the intermediary findings in order to achieve wide dissemination, criticism and legitimization and to allow for the incorporation of new ideas and perspectives. In the second part of the workshop the participants were asked to collectively prioritize the listed problems by negotiation and distribution of urgency points and to prioritize the listed technological innovations. The main purpose of this prioritization exercise was to generate discussion and elicit arguments that underlie each problem and technological innovation.

The participants reflected on the information collected. The red ball was used to guide the discussion during the workshop. The ball and its status were accepted by the community members and the community members listened to the one holding the ball (even it was a female). The TA unit members allowed the ball to rotate. The farmers expressed their interest in TPS and therefore a next workshop was planned with scientists present. The TA unit wrote these findings in an intermediary document, this document was also sent to scientists.

3.3 Phase 3

During the third phase the farmers and the scientists were brought together in an interactive workshop to review the results and to discuss a plan of action. Few scientists were interested to come to Radhakrishnapur for a discussion with farmers. None of the scientists of the major research institutes had time, was willing or had the possibilities to come all the way to this village (distance 200 km). Therefore a local scientist working in the next village was invited. For this scientist it was important that he was able to give a speech. In addition, the setting should be ‘nice’ (inside, chairs tables etc.). Therefore the TA unit members found a suitable location and organized the workshop. They organized exactly the same chairs and tables for all participants (not only the scientists) (in Bangladesh people of higher status sit on more impressive chairs if available). The decorated the walls of the room with copies of the maps produced by farmers, material of the scientists and the TA unit.

At the workshop were 17 participants were present among 15 farmers (amongst them three female farmers), 1 scientist, 1 governmental official. The workshop included a plenary introduction, a presentation of the scientist on TPS and a plenary discussion of a plan of action. At the end of the workshop, a plan of action was developed, in which specific projects were formulated. The workshop was characterized by close interactions between the participants, facilitating mutual feedback and the development of shared constructions.

From the discussion during the workshop it became apparent that the TPS technology was not economically interesting for small-scale resource poor farmers, because the environment friendly methods were not appropriate under their circumstances and they lacked the cash to purchase chemical inputs. For example, to apply TPS in an environment friendly way, soil from a depth of at least one meter should be used. However, these farmers claimed to have sand at one meter depth. In addition, the farmers were interested in other varieties of the TPS. Currently, the major crops were available as TPS. However, the farmers preferred to have the local varieties. Moreover, TPS was only available in bags of 5 grams. This amount of seed is enough to cover 20 sq meters of land, the farmers did not have this amount of land. The farmers were interested in an adapted version of the TPS technology and in a new variety of TPS (the deshi variety, name). Together the farmers, scientists and TA unit members made a plan.

3.4 Phase four

In response, different projects were implemented at three levels; the farmers land, the TA unit land and at the research institute. First of all, the TA unit started to supply TPS to the farmers in bags of one gram. In addition, several experiments were conducted with TPS on both farmers' plots and the TA unit's plot to adapt the cultivation protocol. Scientists started experiments with production of TPS from the local variety (not further discussed in this article). The ideas for experiments mainly came from the farmers. This resulted in the following experiments:

• Different fertilizer doses. Different institutes have different recommendations for TPS cultivation (for the same variety of seed). The farmers have much knowledge about their soil. Integration of farmers' and scientists' information led to three different fertilizer schemes for TPS cultivation. Experiments were needed to show the optimum dose for the region.

• Appropriate depth for digging soil for seedbed preparation. As mentioned before, the practice of digging soil from a depth of one meter to prepare a seedbed not needing pesticides, was not suitable for small-scale, resource-poor farmers. The farmers found sand at that depth, and also did not understand the need for this practice. In a dialogue between scientists from TCRC and farmers, the farmers better understood the potential advantage of digging soil and a decision was made to compare the use of soil for seedbed preparation from a depth of 1.0, 0.5 and 0.3 meters, as well as soil from 0.3 meters depth mixed with soil from the surface (1:1).

• Different sowing distances of the seed. In the protocol it was mentioned to sow seeds at a distance of 10:10 cm, and two seeds per hole. However, most of the farmers faced difficulties with this practice; the size of the seeds is very small and it was extremely laborious. When the TA unit members tried it, they faced the same difficulties. This proved to be an advantage in the subsequent discussions with scientists, who tended to trivialize the difficulty. It was decided to conduct experiments with a sowing distance of 10:10 and 25:4, and line sowing.

The lower educated TA unit members and the female TA unit members monitored their own experiments as well as the farmers' experiments. The farmers monitored their experiments with criteria of their interest. (From experiments with other crops it was learnt that farmers often have different criteria than the academically trained TA unit members.) Since most poor farmers cannot write, they used drawings to monitor their experiments. The farmers had weekly meetings with the TA unit members in which they discussed their experiments. Every week the experiment could be adapted and changed according to the comments, needs and knowledge of the farmers. Farmers' knowledge was continuously integrated into the research process. In order to stimulate the discussions the weekly meetings took place around an experimental plot of one of the participating farmers. At these discussions more TA unit members were present. The farmer could show his / her experimental plot to the other farmers and it stimulated discussion. Photograph 1 shows an experimental farmer which demonstrates his irrigation system for the plantlets, instead of a(n expensive) sprinkler he is using his toilet-can and a movement of his hand in other to disperse the water.

From the experiments, it was concluded that the higher fertilizer doses did not significantly increase yields (not even after growing the crop the same way in subsequent growing seasons). It also turned out that, in comparison with soil from a depth of one meter, soil from a depth of 0.3 meters did not increase the pest attack significantly, but was much less labor intensive and had a positive impact on yield due to better soil quality. Furthermore, the farmers adapted the technology in a new sustainable and environment-friendly way. For example, the bamboo fence was too expensive for farmers; instead they used jute sticks (with the positive side effect of eliminating the need to cut bamboo trees).

During the experiments the higher educated TA unit contacted the scientist at a regular basis to ask for advice and inform them about the findings. The comments of the scientist were then discussed with the farmers by the lower educated TA unit members. By establishing these explicit feedback and feedforward mechanisms, they achieved transparency. Finally, the TA unit produced reports on the various experiments, which were sent to relevant research institutes, governmental departments, donor agencies, and interested actors.

The scientist started experiments to assess the options to produce TPS seed of local varieties. Years later it became possible to produce more local varieties.

Photograph 1: Farmer demonstrating his irrigation system

4. Conclusion and discussion

In this study we aimed to gain greater insight into realizing knowledge sharing throughout the innovation process by applying a specific methodology, the ILA approach, in order to generate environment-friendly and appropriate agricultural technologies for small-scale, resource-poor farmers. The case study shows that the ILA approach can be considered and provide a practical and effective methodology for generating environment-friendly and appropriate technologies for small-scale, resource-poor farmers. The local farmers adapted an existing technology to their local situation and at the same time they influenced the research agenda's at the research institutes. However, in our case-study it was of utmost importance to continuously find strategies to cope with the differences in hierarchy.

Various strategies to deal with the differences in hierarchy had to be developed. First, strategies to deal with the hierarchy within the interdisciplinary team establishing of a group culture and the introduction of the red ball seemed to work. Second, the hierarchy in the wider organization, careful explanation by the managing director and conducting activities of high status improved the status of the TA unit. Thirdly, the hierarchy outside the organization, different actors in the process, such as local community members, various types of farmers, governmental officials and scientists expect behavior according to hierarchy. If behavior is not according to hierarchy people feel either insecure (lower educated farmers) or they refuse to collaborate (scientists). In the case study numerous strategies have been developed to include people of various hierarchies for example in a workshop; the seating arrangements, same seats for all participants, dress codes for the team members dependent on the activities of the day, enclosing women by female team members during the workshops. However, the most important strategy was that the interdisciplinary team consisted of team members of high and low education and that this team developed two 'faces'; outside the office, the team members behaved according to the organization's formal hierarchy, and behind closed doors they adopted a non-hierarchical structure and culture.

Whereas hierarchy structures are quite strong in Asian countries, it is still present in other countries including the West. Therefore, most likely that the ILA approach is suitable in other projects and regions, but that also in these projects hierarchy during all phases of the approach and during all levels of implementation is problematic. It is therefore argued that the key strategy to enhance effective transfer of knowledge is the recognition, of the multiple and pervasive hierarchies that influence interaction, and the identification of specific, local and pragmatic steps to reduce the obstacles that these hierarchies represent to the exchange of ideas and information.

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