Agrometeorological Learning Increasing Farmers' Knowledge in Coping with Climate Change and Unusual Risks

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Enriching farmers' knowledge of the risks and consequences of climate change is the most promising strategy to better assist them. Nevertheless, we have to bear in mind that people filter and absorb scientific knowledge through pre-existing cultural models and aspirations for desired outcomes. The severe pest/disease outbreaks during the La-Niña periods of 2009 and 2010/2011, and the unpreparedness of farmers in many places in Java, was a timely opportunity for many parties to reflect seriously on the deficiencies in our approaches and facilitations.

Our inter-disciplinary collaboration proved successful in strengthening and enriching farmers' knowledge by bringing agrometeorological thinking and knowledge, based on scientific ideas, premises, and methods, to local people who had their own "ethnoscience." This benefits farmers over an extended period and until the public extension intermediaries have been sufficiently trained. Our suggestions are: assisting farmers to discover their own vulnerability issues through continuous dialogues and knowledge exchange in "Science/Climate Field Shops," and the measurement of rainfall and the observation of weather and climate implications for fields and crops in a standardized way as the basis of an improved Climate Field School. To that end the training of public extension intermediaries is necessary.

Keywords: agrometeorological learning, coping better with climate change, strengthening farmers' knowledge, Science/Climate Field Shops, inter-disciplinary approach, trans-disciplinary collaborative research

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Generating a Rural Response to Climate Change: An Introduction

The very heavy rains and the flooded fields everywhere in the hamlets and villages of Gunungkidul, Yogyakarta, were the main topics of farmers' conversations. Finding water standing in their fields after heavy rains was common; that their fields were actually flooded was less so. Their main concerns were the young age of their crops, paddy, and maize, and the already retarded growth due to a long drought in the past three weeks. The farmers, whose fields were heavy black clay soil, feared possible damages to their crops. That turned out to be the case. The roots and stems of the 30–40-days-old maize decayed. Their leaves turned yellow, as did the paddy leaves. Other crops, such as chili, were also badly affected (Winarto and Stigter 2011). These surprising facts were examples of a real risk resulting from an increase of climate variability and climate-related extreme events as consequences of climate change (see OXFAM 2009). The question remains, therefore, how to help farmers respond better to these phenomena, which they are currently unable to cope with. Direct experience and empirical observations are the main means of learning in the local domain of knowledge. Without directly seeing, feeling, and experiencing the phenomena they encounter in daily life, they will not have any confidence or belief in their own or other people's interpretation and sayings (see Winarto 2004; 2010). Phenomena of climate change and variability cannot be observed directly by farmers themselves, and the impact on farmers' lives cannot easily be predicted or anticipated. On the other hand, farmers can rely on their memories and recent experience to develop their expectations of the future, and this shapes their knowledge of climate phenomena and their understanding of climate information (see Roncoli *et al.* 2003, 181). As also argued by Peterson and Broad (2009, 78):

> Our mental models of the world's natural processes are shaped by experience, evolutionary processes, and our daily experiences. As events become spatially and temporarily distant—either forward or backward in time—our ability to tease out relative objectivity vanishes.

Enriching farmers' knowledge and understanding of the risks and consequences of climate change is the most promising strategy to better assist them. We agree with the International Research Institute for Climate and Society's decision to use a science-based approach to enhance society's capability to understand, anticipate, and cope with the impact of climate in order to improve human welfare and the environment (IRI 2011; see also Stigter and Winarto 2011a; 2011b; 2012). Nevertheless, we have to take into consideration that "people filter and absorb scientific knowledge in terms of pre-existing cultural models and aspirations for the desired future" (Roncoli *et al.* 2003, 181). As Crate and Nuttall (2009, 12) argue, "[c]limate change is ultimately about culture . . . ." A deliberate approach to introduce scientific ideas within the existing cultural models and aspirations for the future is thus necessary. This is not an easy task, yet we must respond to the challenge.

Interestingly enough, during our time assisting the farmers in Wareng, Gunungkidul in 2008–9, we discovered that farmers had learned to cite the numerical amounts of rain that had fallen. "In fact . . . when the fields were flooded, on average the rainfall in the points of observation was more or less 120 mm," said Sih. None of the amounts cited by the farmers were below 100 mm (Stigter and Winarto 2011b). How had the farmers learned to use figures? Citing rainfall in numerical form is not part of farmers' culture; neither is relating the quantity and conditions of their crops. But they are good empirical learners, and measuring rainfall trapped in the rain gauges mounted in their fields and observing the fields' conditions every day was what the farmers had been doing. This was the result of a joint production of knowledge based on the farmers' own observations under the facilitation of a group of scholars: an agrometeorologist, a biological-environmentalist, and anthropologists (see Winarto 2010; Winarto *et al.* 2010a; 2010b; 2011d; Winarto and Stigter 2011). An enrichment of farmers' schema of crop farming by incorporating the elements of meteorology through direct seeing, feeling, and experience —the farmers' way of learning—was what we aimed to achieve, with the hope that they would be better equipped to assess their current strategies and be better prepared for similar conditions arising from climate change in the future (see Roncoli *et al.* 2003). That is the "farmer first paradigm" approach we propose: first listen to the farmers concerned, to better understand their vulnerabilities and needs the way they see them (Chambers *et al.* 1989; Scoones and Thompson 1994; 2009; Winarto 2010). We should then be able to generate support from them and for them in facing the consequences of increasing climate variability and climate change in their livelihoods (Stigter 2010a; Winarto and Stigter 2011).

We call this approach and arena in which farmers and scholars meet, discuss, observe, and evaluate farmers' vulnerabilities "Science Field Shops" (SFS) (Winarto *et al.* 2010a; 2011d; Stigter and Winarto 2011a; Winarto and Stigter 2011). If particularly focused on the issue of climate, we may call it "Climate Field Shops" (Stigter and Winarto 2011b). The word "shop" is adopted as a metonymical word of going to a "place" to get something people need. In this case, the "shop" is an arena where farmers can relate stories of their vulnerabilities and obtain proposals for solutions and additional information they need to enrich their knowledge and understanding of weather and climate related to their planting strategies and other decisions. The information could come from various sources: scholars, fellow farmers and farmer facilitators, and extension intermediaries, who themselves make use of many varying sources. Historically "Law Shops" were free for poor people. The Science Field Shops are free for farmers too.[1)]

Such "shops" on farmer vulnerabilities do not contain any formal learning in the fashion of the Climate Field Schools' (State-CFSs) launched by the Indonesian government across Indonesia (Direktorat PerlindunganTanaman Pangan 2007; 2010; Boer 2009; Prakarma 2009; BMKG 2011; Winarto and Stigter 2011). Its flexible format of discussing farmers' problems and questions and generating joint solutions and answers, allows the SFSs to generate material for training extension intermediaries to establish "climate field services" with farmers at a later stage. We argue that these "climate field services" should not have pre-fixed curricula as do the State-CFSs, but that learning situations should be created together with the farmers, based on discussions of their vulnerabilities and other questions on difficulties experienced in the ongoing season (Stigter and Winarto 2011b).

This paper will discuss and examine the ongoing SFS we have been carrying out in collaboration with the farmers in the irrigated lowland rice fields in Indramayu from 2009–12, while also referring to our earlier experience in a hilly dry rainfed karst ecosystem in Wareng, Gunungkidul in 2008–9. We discovered the benefits of such collaboration in the midst of increasing risks and vulnerabilities faced by the farmers in recent years. There were severe outbreaks of pests and diseases in many places in Java as presented in the second and third parts of this paper. Brown plant hoppers (BPHs), viruses brought by this pest (grassy-stunt and ragged-stunt viruses), rats, and rice stem borers infested rice fields over the whole of Java concomitantly with the La-Niña period that started in the usually dry season of 2010 and lasted into 2011, originating from an interplay of complex factors (Stigter 2012a).

The final part of this paper examines the ways in which the inter-disciplinary approach in SFSs was developed, along with trans-disciplinary collaboration with the farmers in improving their agrometeorological learning. Stigter (2010b) and Winarto (2010; see also Stigter and Winarto 2011b) argue that applied scientists cannot carry out the collaboration with the farmers all by themselves, whereas social scientists, such as anthropologists, would not be able to assist farmers in the area beyond their expertise. The collaboration

1) Science Field Shop (SFS) is only a stage (of say, two years) to begin a new extension approach where farmers, scientists, and extension intermediaries interact not only to enrich farmers' knowledge and understanding, but particularly to discover their vulnerability issues as a basis for future climate field services directed to help farmers solve their problems. In the long term, it is expected that farmers can continue learning on their own and that better-trained extension intermediaries, assisted by farmer facilitators, will assume the responsibility of facilitating farmer communities, so as to spread and widen the learning by establishing climate field services with farmers in their fields. Gradually the scientists will withdraw from the local site and hand the learning to farmers, extension intermediaries, and other stakeholders.

between the two is highly needed. Making farmers themselves the main researchers and the scholars' counterpart is a must. This paper presents the story of such a collaboration.

Climate Change and Variability: Risks and Opportunities

Increasing climate variability and continuing climate change do not solely mean greater risks for local people who have adapted to their habitat for generations; they also create opportunities. Risks and opportunities are two sides of the same coin in any (non-polluting) change in people's environment (see Hulme 2009; Crate and Nuttall 2009). How people perceive those risks and opportunities depends on their cultural frameworks. Roncoli *et al.* (2009, 88) detail the ways in which climate change is filtered through the prism of culture:

> . . . how people perceive climate change through cultural lenses ("perception"); how people comprehend what they see based on mental models and social locations ("knowledge"); how they give value to what they know in terms of shared meanings ("valuation"); and how they respond, individually and collectively, on the basis of their meanings and values ("response").

Perception, knowledge, valuation, and response are interlinked to one another in people's minds, feelings, and to some extent, actions, either individually or collectively. In the face of unusual climate change and variability between 2009 and 2011—from La-Niña to El-Niño, and back to La-Niña again in a relatively short period of time—what role did these cultural elements play in farmers' minds, feelings, and actions?

Agricultural production in Indonesia is strongly influenced by the annual cycle of precipitation and its year-to-year variations caused by El Niño-Southern Oscillation (ENSO) dynamics. The combined forces of ENSO and global warming are likely to have dramatic and currently unforeseen effects on agriculture production and food security in Indonesia and other tropical countries (Falcon *et al.* 2011). The ENSO can actually swing beyond the "normal" state to a state opposite to that of El Niño, with amplified trade winds and a colder than normal eastern Pacific. This phenomenon is often referred to as La Niña. When a La Niña period occurs, many Asian regions inclined toward drought during an El Niño, such as Indonesia, are prone instead to more rain.

Both El Niño and La Niña vary in intensity from weak to strong. The interval at which El Niño returns is not exactly regular, but used to range from two to seven years; even this is no longer true. Sometimes an El Niño subsides into a "normal" pattern; other times it gives way to a La Niña. In many ways, the ENSO cold phase is simply the opposite of the warm phase. This often holds true also for the climate impacts of the two.

El Niño (warm phase) tends to bring drought to countries like Indonesia and Australia, at the west end of the Pacific, while La Niña (cold phase) tends to bring more rain than normal to these areas (Metcalf Institute 2000). However, the frequency of these phenomena has changed in recent times, as well as the pattern in which they occur. We are as yet unable to simulate these actual changes with the models that summarize our understanding that apparently is at this moment still very insufficient (ClimateWiki 2011).

These bizarre weather conditions from 2009–11, which were not in line with farmers' local cosmology (*pranata mangsa*) in crop farming, left them confused and unsure of the appropriate actions to take. Wet months in the first dry season of 2009, followed by a prolonged drought in the beginning of the rainy season in 2009/2010, and continuous heavy rains throughout the remainder of 2010 and 2011 up to the cessation of rains in 2011, were very strange sequences for the farmers. For those who had never received any training on climate change issues through CFSs, such strange weather was just referred to as due to "climate change" (*perubahan iklim*), according to what they heard from the media. Their expectations were based only on recent situations, and they acted on a day-by-day basis. As soon as the farmers realized that they were experiencing a prolonged drought, or, on the contrary, a prolonged wet period, they would either fear the risks to their crops or feel grateful for the new opportunities they would get. Yet, the latter could imply consequences beyond their knowledge and create risks more severe than previous ones. Risks and opportunities are intermingled and thus increase the complexity of dealing with the actually occurring phenomena.

Noteworthy too was how some Integrated Pest Management (IPM) knowledge that IPM Farmer Field Schools (FFSs) had passed on to groups of Indonesian farmers, particularly for BPH attacks, had to a large extent become lost over time. Stigter (2009) observed that the IPM/FFS approach first introduced in the Philippines and Indonesia was a success story because it enriched farmers' agroecosystem analyses, improved their self-confidence, solved community problems, and developed a different relationship with local government (see Winarto 2004; 2010; Winarto and Stigter 2011; Bartlett 2005). It was "an educational instrument with the specific purpose of tackling some of the shortcomings of agricultural modernization" (Van den Berg and Jiggins 2007). Nevertheless, with time, relatively few farmers in Java were still able to perform IPM. Due to the lack of institutionalization, most of the skills obtained in that training wore off, and panicked farmers returned to the prophylactic use of pesticides. This was instrumental in inducing a higher number of BPH populations after each spraying (e.g. Stigter 2012a).

On the contrary, farmers, such as some of the IPM FFS alumni, who still relied more on observations, using appropriate pesticides only if necessary (e.g. buprofezin to prevent the growth of BPH in the juvenile stage), applying bio-agents such as *Beauveria bassiana*, reducing chemical fertilizers such as nitrogen or even using organic fertilizers, and selecting the more resistant varieties (including local varieties and farmers' own cultivars such as in Indramayu), were saved from severe harvest failures. Even though BPH populations were migrating to their fields, their plants were not infested too severely. Farmers who managed to fallow their fields for several months after the second harvesting, such as in West Java due to water gate closures, were also spared the continuous BPH infestations suffered in the regions where farmers kept planting paddy without any fallow period in between.

One thing that needs to be considered here is the farmers' ability to stick to their knowledge, confidence, and belief in the sustainable practices they had developed in the past. A number of IPM alumni in Indramayu, West Java, and newly trained IPM alumni in Lamongan, East Java, were not seduced by pesticides promotion by chemical companies. Protecting their fields' ecosystems to sustain good yields was their main aim, despite the increased promotional activities by chemical companies and the government subsidies in the regions with severe outbreaks of BPH. However, things are not so simple. There were also cases in which farmers who started out avoiding pesticides could not withstand the severe outbreaks of BPH, due to the very high population of the pest. This was compounded by the fact that persistent use of pesticides by farmers in neighboring fields caused increasingly bad conditions in their habitat (see NAW [anonymous] 2011; Samejo 2011). To be effective, controlling pests by IPM should be done by all farmers cultivating rice in a certain area, not only by individual farmers in his/her own field. But breaking farmers' habit of the prophylactic use of pesticides is not easy (see Winarto 2004; 2006), especially in the face of intensive promotion of pesticides by chemical companies, shop-owners, and even agricultural extension workers.

These phenomena of different practices and responses throughout Java to risks and opportunities resulting from the La-Niña condition are interesting to follow. Human conditions, the interaction between various actors/stakeholders, influence to a significant degree how risks unfold in people's lives. The cases of BPH outbreaks reveal that rice ecosystems were vulnerable at times when the variability of climate increased significantly and global warming-induced climate change was actually measured (Stigter and Winarto 2011b). Weather conditions were conducive to the outbreak of pests/diseases as concluded by the research team of the Australia-Indonesia Governance Research Partnership (AIGRP). The team argued that the changing climate altered the biology and economic vulnerability of rice production in Indonesia (*Kompas* 2009).

Are Farmers Ready to Cope with Climate Change?

We agree with Roncoli (2006) that because there is a close link between climatic patterns and production outcomes, agriculture stands to benefit in particular from climate information, advisories, and services (see also Stigter 2012b). Climate advisories/services for farmers are indeed necessary. The AIGRP team reported from their 2009 survey of 600 farmers in the north coast of West and East Java that as many as 43 percent of farmers did not recognize the increase of temperature, and as many as 38 percent of them did not know of any changes in the rainy patterns (*Kompas* 2009). Interestingly, the farmers had participated in a Climate Field School (CFS) the season before, but it was only after our group visited the farmers and explained the phenomena to them and assisted them in taking daily measurements of the rainfall in their own fields did they understand the La-Niña condition they were experiencing and what this meant to their rainfall patterns (Stigter *et al.* 2009).

As revealed by the case of BPH outbreaks in 2010/2011, crop farming in Indonesia is complex due to the vulnerability of the ecosystem as a result of farmers' past practices within the highly intensive crop cultivation of the Green Revolution paradigm (see Fox 1991; 1993; Hardjono 1991; also see NAW [anonymous] 2011; Samejo 2011). Farmers were not only trapped into the use of "poisons" introduced as "medicines," but they were also becoming estranged from their new ecosystems. The major changes in their ecosystems and the consequences were not part of traditional local knowledge. They were baffled, for example, by the emergence of new pests and diseases in spite of their regular use of pesticides. "Why the more 'medicines' we use, the more 'illnesses' attack our paddy?" was the question raised by many farmers in West Java (see Winarto 2004). The National IPM Program introduced in the early 1990s had the aim of making farmers aware of the need to grow healthy crops in a more sustainable ecosystem. Yet, how much knowledge they absorbed and applied to their practices, and the extent to which the new paradigm was transmitted to other farmers and the community at large, remains questionable. Changes and their persistence are real (see Winarto *et al.* 2000; Winarto 2004; 2006). It is not easy to shift farmers' cultivation paradigm in a relatively short period of time without providing some sort of facilitation to the farmers in the post-"schooling" period. Unfortunately, extension workers were often absent from the fields for various reasons.

Farmers' learning is based on empirical observations and direct experiences. Assisting them to interpret what is happening in their fields by referring to their recent practices and outcomes, past learning, and their fellow farmers' strategies and crop performances, is a way to enrich their knowledge (see Winarto 2004).

Local traditional knowledge was developed in a context of regular climate variability and commonly occurring extreme events. However, there are three new tendencies in climate change for which local knowledge has not been empirically developed: (i) global warming, (ii) increasing climate variability, and (iii) more (and more severe) extreme events (Stigter and Winarto 2012). Some of the farmers with whom we work in Indonesia, mostly older ones, still believe it is possible to adapt their local cosmology (*pranata mangsa*) to new conditions. We feel it is better that they find out for themselves the new limits of these traditional approaches; however, we can help, for example, by using simple climate predictions available these days for comparisons. Traditional knowledge and indigenous technologies should always be taken seriously, and a participatory approach to test their limitations under today's changing conditions is best. Carrying out experiments together to compare traditional and modern scientific approaches is also a good way to break the ice with local farmers (*ibid.*).

Without any additional knowledge to explain phenomena beyond their empirical learning, it is not easy for farmers to grasp the potential and benefits from a new approach. This was the case with the recent BPH outbreaks. The pest's resistance, resurgence, and fecundity, caused by injudicious pesticides spraying and the killing of natural enemies, are not easily observable (see Bentley 1992). Therefore, without additional information, those phenomena would not become part of farmers' knowledge and understanding. This is also the case with climate change consequences beyond their direct experiences, although they have witnessed uncommon changes in their habitat affecting the growth of their crops.

To help farmers gain some understanding about climate change and its implications for their fields and crops, the Ministry of Agriculture collaborated with the agrometeorologists from Bogor Agricultural Institute to develop a pre-fixed curriculum for a "school," which they called Climate Field School, following the training method developed in IPM FFS (see Direktorat Perlindungan Tanaman Pangan 2007; 2010; Boer 2009; Prakarma 2009). But how efficacious was it?

The CFS was held only once throughout one planting season, with one session of training every 10 days (one decadal period). Unfortunately, due to the late disbursement of funds, the CFS in Wareng, Gunungkidul, was held in a dry season, where rains were rare, rather than in the rainy season. Farmers gained new ideas on climate and weather, rain formation, various types of cloud, categories of rainfall, ways of measuring rainfall and soil moisture, analyzing agroecosystems in relation to weather conditions, and practicing a preparedness strategy towards drought. They were also able to raise questions on the puzzling phenomena they experienced (see Direktorat Perlindungan Tanaman Pangan 2007; 2010; Winarto *et al.* 2008; Boer 2009; Anantasari *et al.* 2011). Unfortunately, once the "school" ended and no further funds were available to pursue any follow-up program, the facilitators from plant protection and extension services did not continue their assistance. Farmers were left on their own, as was the case of the IPM FFS alumni. They did try to implement the drought preparedness strategy and gained better yields in the normal weather conditions of 2007/2008 (see Winarto *et al.* 2011d; Anantasari and Winarto 2011). However, they were not at all prepared for the extreme changes of climate in the following year and were caught unawares by the very sudden La-Niña period in the second quarter of 2010, continuing into 2011. Some farmers actually repeated the same strategy for drought, not for wet conditions (Stigter and Winarto 2011a). Without preparing for a drainage system, which was not part of farmers' culture in a dry rainfed karst ecosystem, the abundance of water in the fields constrained the growth of crops (Winarto and Stigter 2011). Would a one-time training, as was this CFS, really help farmers, especially if they were no longer assisted in the field?

Only a few CFS alumni in Indramayu were motivated to continue applying some of the new skills they had picked up in "school," such as measuring rainfall, observing soil moisture, and understanding the air temperature. With simple but delicate equipment provided by the Meteorology, Climatology, and Geophysics Office in Jakarta, an old farmer in a dry rainfed ecosystem in Indramayu was seemingly able to predict daily weather conditions by measuring air humidity (albeit erroneously) and temperature. He became in turn the source of such information for other farmers in his area. The CFS alumni in Gunungkidul, on the other hand, did not continue measuring daily rainfall since they had no rain gauges after the trainer took back the rain gauges used in "school." Prakarma (2009) discovered from his survey in Indramayu that farmers did not make important changes to their strategies after their training. At the time we were in the field (2008–9 in Gunungkidul, 2009–11 in Indramayu, and 2010–11 in Banyumas-Purworejo, Klaten-Boyolali-Sukoharjo in Central Java), we discovered that farmers did not even receive simple climate predictions for the forthcoming months/seasons. "We have never received any information" was their reply when we asked groups of farmers in Banyumas, Purworejo, and Indramayu in early 2011 (also see *Kompas* 2009).

It is also interesting to note how information was transferred by the Badan Meteorologi Klimatologi dan Geofisika (BMKG) office to those responsible for telling the farmers. In one meeting in Indramayu concerning farmers' observations of daily rainfall in October 2009, at the very beginning of the first rainy season, the leader of the farmers' association (Indonesian Integrated Pest Management Farmers' Alliance, Regency of Indramayu) brought a bundle of written material related to climate change and farmers' cosmology, *pranata mangsa*, he was compiling from various sources. We saw one statement he received from the BMKG office as follows: "If the rains have not reached 15 mm yet, do not start planting." Yet the farmers in question had never learned how to measure rainfall. Unlike the CFS alumni in Wareng, Gunungkidul, who had measured rainfall daily in 2008/2009, the group of farmers in Indramayu had just begun their rainfall measurements in early October 2009. Actually, farmers do have their own taxonomy of rains in lexical form (see Winarto *et al.* 2010a; 2011d). However, without any knowledge of what kind of rain—in their taxonomy—corresponds to the rainfall in quantitative form, they would not be able to interpret the scientific measurement of rainfall as used by scientists and government agencies.

We argue, therefore, that simple weather forecasts and possibly also simple climate predictions for farmers, supported by continuous agrometeorological learning for a longer period of time, are indeed necessary as farmer advisories/services. A number of farmers in Indramayu, who measure rainfall in their own plots every day since October 2009 till the present, benefitted from following the patterns of rainfall and the related problems occurring in their fields. Yet, they argued that without any guidance and explanation from experts or well-trained extension intermediaries, they would not gain much. They would be able to better interpret the data were they in close contact with such people and with one another, sharing their burdens, receiving immediate useful explanations, and obtaining new knowledge. Farmers face problems and have queries that go beyond rainfall data, as seen in the case of BPH outbreaks experienced by farmers in many places in Java. Agrometeorological learning in which both farmers and experts share information, knowledge, and problems is indeed urgent. This must take place in the Science Field Shops discussed earlier in this paper, preceding new CFSs where well-trained extension intermediaries in turn train and facilitate farmers (Stigter and Winarto 2011a).

Endorsing Agrometeorological Learning among Farmers in Java

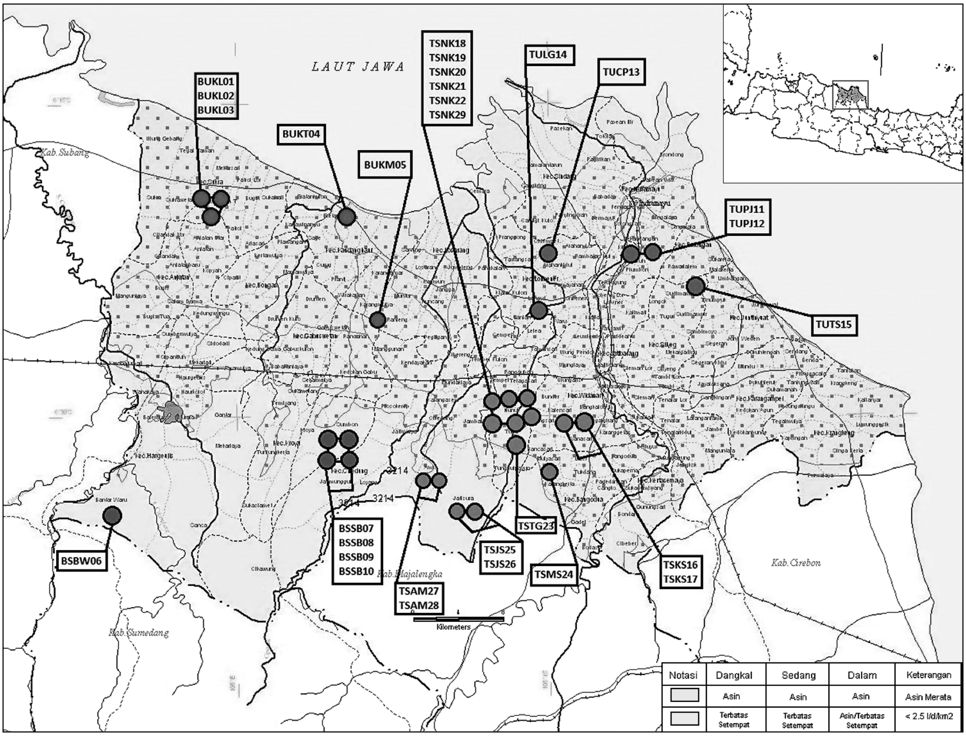
What makes the Science Field Shop (SFS) or Climate Field Shop different from the Climate Field School (CFS)? Both tackle the improvement of farmers' knowledge of weather and climate, but the SFS covers an even wider range of subjects in local agricultural production, and very differently too. Concerning the training of extension officers, we advocate that scholars, officers, and farmers meet in SFSs to prepare for an open curriculum on farmers' vulnerabilities for future CFSs. These better-trained intermediaries will then be able to help farmers in the CFSs with problems of the current season or anticipated difficulties. In some earlier writings, Stigter and Winarto (2011b; see also Stigter 2010a; Winarto 2010; Winarto *et al.* 2010a; 2011d) argue that improving farmers' agrometeorological learning should not begin with a pre-fixed curriculum. Curricula for

CFS trainers (the extension intermediaries) have been proposed (Stigter 2010a) and could be further developed using materials from the SFSs: joint meetings, discussions, knowledge exchanges, and farmers and scholars' evaluations of the former's vulnerabilities and needs. Whilst the CFS was implemented once in one period of planting, our collaboration with the farmers, including trial SFSs, has been going on for a much longer period, enduring several different monsoon seasons with varied weather conditions and the ensuing cropping problems.

In Wareng, Gunungkidul, collaborative work with the CFS alumni, who formed a group called Sedio Mulyo, began in November 2008, following joint visits at the end of 2007 and a preparatory stage in 2008. The 20 members of the group did daily rainfall measurements at 10 points-of-observation spread throughout their rice field areas. This lasted until the cessation of rains in June 2009, covering two planting seasons (see Winarto *et al.* 2010a; 2011d; 2011e). In Indramayu, West Java, an early joint meeting with some representatives of the Indonesian Integrated Pest Management Farmers' Alliance of Indramayu Regency was held in March 2009, followed by a preparatory stage before the rainfall measurements were embarked upon in October 2009. These were Climate Field Shops. Since formal collaboration with the leader of the group came to a halt, the collaboration was terminated after four months of work (Dwisatrio 2010; Winarto *et al.* 2011d). But the group was re-activated by a number of farmers in October 2010, when around 30 of them decided to continue measuring rainfall and observing their fields under a new association—the Indramayu Rainfall Observers Club (see Map 1). This has been in operation till the present (November 2012), spanning four planting seasons and two dry seasons in 2010–12. The farmers agreed to form an informal "club" free from any administrative or bureaucratic procedures.

On the basis of Stigter's experience in West and East Africa, in evaluating the use of farmer rain gauges to measure rainfall in farmers' fields (e.g. Diarra and Stigter 2008), a similar program was organized in Gunungkidul, Yogyakarta, and Indramayu, West Java. This stimulated farmers to measure rainfall in their own plots, following procedures and using equipment described in Stigter *et al.* (2009), and to observe the conditions of their fields and crops. Whereas farmers in Wareng, Gunungkidul, used the wedge-shaped USA rain gauges with an imprinted scale that we purchased to help them in 2008/2009, we urged the farmers in Indramayu to make their own cylindrical rain gauges in 2009 as described in Stigter *et al.* (*ibid.*) (see Photos 1 and 2 to compare the different rain gauges). Since then, farmers have produced cylindrical rain gauges on a commercial basis for their own use and for others who have an interest in measuring daily rainfall in their own plots.

Farmers were not only measuring rainfall and taking notes of the amounts in their



Map 1 Location of 29 Points-of-Observation in Indramayu Regency
Source: Adapted from the map in *Indikasi dan Potensi Air Tanah dan Daerah Irigasi Kabupaten Indramayu, Propinsi Jawa Barat*, 2003.

books—a new task to master—they were also observing the conditions of their fields, the growth of their crops, and other essential information on soils, water, pests/diseases, and crop conditions. Recording the results of these complex observations in a simple written form was also not easy. Herein lies the job of the intermediaries: assisting farmers to do the measurements in a standardized way, helping them in developing and improving their notes, collecting the data and processing them for interpretation by the agrometeorologist, and returning the analytical results to the farmers to enrich their understanding and improve their operational knowledge.

Some anthropologists and a non-social scientist (an environmental biologist) were in Wareng, Gunungkidul, carrying out ethnographic fieldwork and following farmers' learning in the CFS and during the earlier collaboration (2006/2007). Some anthropologists also collaborated with farmer plant breeders in Indramayu in 2006–8. The scholars were thus acting as intermediaries and "cultural translators" between two domains of knowledge—the scientific and the local. Both parties, the farmers and the scholars, were

Photo 1 USA Farmer Rain Gauge in Farmer's Field, Wareng, Gunungkidul
Source: Photo by Winarto, 2009.

Photo 2 A Farmer in Indramayu Measuring Rainfall Using a Cylindrical Farmer Rain Gauge
Source: Photo by Dwisatrio, 2011.

engaged in a continuous dialogue and an inter-subjective relationship in a common aim to improve farmers' agrometeorological learning (Dwisatrio 2010; Winarto *et al.* 2010a; 2011d; Winarto and Stigter 2011). The job of a "cultural translator" is, of course, not a simple one. It is dynamic and requires reflection, and we encountered initial problems. The most challenging tasks were to get the farmers to internalize the habits of (i) going to their fields every day at an agreed time without interruption, (ii) observing their agricultural ecosystems for consequences of the climate, and (iii) recording their observations. As long as the farmers understood the reasons behind these standardized practices and experienced the benefits of carrying them out, the rest was not difficult. Protestations against the standardized ways of measuring rainfall and observing fields came mainly from the leader(s), and not the participants (see Winarto and Stigter 2011). As the "cultural translator" and facilitator in establishing this "game," we also took on the tasks of: (i) informing the agrometeorologist of any existing constraints and (ii) finding a solution together with both the agrometeorologists and the farmers.

As such, the anthropologists were in the end not just carrying out ethnographic fieldwork; they also became the farmers' partners in developing the agrometeorological learning. Roncoli (2006, 82) has argued for a combination of ethnographic and participatory approaches:

> . . . ethnographic and participatory approaches were highlighted as ways of facilitating better integration of farmers' concerns into the development of climate products, and a more realistic appraisal of farmers' ability to use those products to improve their livelihoods.

Farmers' own data were transformed into daily rainfall graphs that were expected to be useful not only for the farmers themselves, but also for other parties. See Fig. 1 for the joint production of knowledge in the form of daily rainfall graphs based on farmers' data (from eight points-of-observation in Indramayu) and processed by the scholars.

It is interesting to note that within only several months of daily observations, the Sedio Mulyo farmers in Wareng, Gunungkidul, were able to develop a new numerical rainfall taxonomy in combination with their existing qualitative one (see Winarto *et al.* 2010a; 2010b; 2011e). In Indramayu, the members of the club also agreed to develop a category of rainfall relating their own taxonomy to the quantity of rainfall, for a standardized category in documenting their measurements (see Table 1).

Measuring rainfall and making agroecosystem observations were only entry points for farmers' agrometeorological learning. Gradually, farmers were able to incorporate the quantitative elements of rainfall, as well as qualitative measurements of other meteorological elements (humidity, soil moisture, temperature, and wind) into their schema of crop farming (see examples of farmers' evaluation of rainfall's implication for the

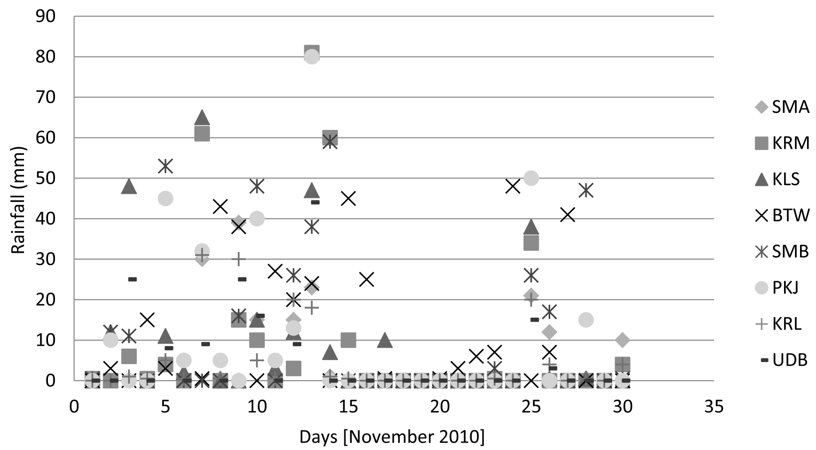


Fig. 1 Daily Rainfall Graph of November 2010 from Eight Points-of-Observation in Indramayu Regency, West Java
Source: Farmers' data, 2010.

Table 1 Indramayu Rainfall Observers Club Rainfall Taxonomy in Qualitative and Quantitative Form

No.	Rainfall Characteristics	Equivalent in Amounts
1	Drizzle	0.5–2 mm
2	Light rain	2–5 mm
3	Medium rain	5–10 mm
4	Big rain	10–20 mm
5	Heavy rain	Above 20 mm

Source: Universitas Indonesia field note, based on farmers' discussion and consensus, 2011.
Note: Consider noting rainfall duration to find out the impact of rain on plants or soil, e.g.: long, medium, short duration of rain.

growth of particular crops in Winarto *et al.* 2011d). This is an example of the advancement of farmers' existing knowledge of crop farming. By carrying out rainfall measurements themselves and noting the impact of different conditions of rain, they were able to assess their present strategies and to think of better measures for the future:

> "If it rains like this in the dry season next year, I may think of not planting tobacco. Probably I will cultivate paddy instead of tobacco," said a farmer in Wareng after experiencing damages on his tobacco plants in the wet dry season of 2009.

That farmer had learned a lesson from having to cope with a La-Niña situation in the dry season. It would be very helpful if special weather forecasts and climate predictions for agriculture could be received by and discussed with farmers, as an agrometeorological service, so that they could prepare themselves better (Murthy 2008; Stigter 2010a; 2010b; 2011). In the absence of such information, measuring rainfall themselves and discussing probable risks or opportunities with either their fellow farmers or with scholars may also be beneficial, as was the experience of farmers in Indramayu:

> After experiencing a prolonged drought (El-Niño) with zero (0 mm) rainfall for almost the whole month of October 2009, which was unusual and a sign of a later start of the rainy seasons than was the case in the past, a group of farmers who joined the rainfall measurements had a discussion of what they were supposed to do to avoid such risks in the near future. From knowledge exchange in the evaluation meeting, the farmers reached a consensus on avoiding the making of wet-nursery beds for rice. Farmers who used to cultivate paddy in a dry rainfed ecosystem shared their experience of making dry-nursery beds (*ngipuk*) and a ground water reservoir/pond (*embung*). They also discussed the need to plant short maturing varieties rather than those with a longer maturing period. Soon after the meeting, a farmer implemented the making of a dry-nursery bed instead of the wet one for the first time in his life, and saved this way his seedlings in the midst of a drought period.

Seeing the need to assess the usefulness of distributing simple climate predictions among farmers, Stigter disseminated the three-months ensemble climate prediction from National Oceanic and Atmospheric Administration (NOAA) (e.g. NOAA 2010) that is updated every month as a simple message. We helped to disseminate the information in simple Bahasa Indonesia through short text messages via mobile phones or through e-mail, and farmers in turn shared the information with their fellows. A number of farmers in Indramayu who used to rely on rainfall for cultivating paddy in the dry season, decided to make the nursery bed in a piece of land in the middle of their fields before harvesting began (*nyulik,* stealing time to start the nursery before harvesting the entire field). They received word that rains could continue to fall throughout the early part of the dry season until June 2011 and decided to build the nursery earlier, so as to be able to harvest their paddy before the forecasted cessation of all rains in June. It worked as planned, and they were happy to gain good yields from the decisions they had taken based on this simple forecast. However, climate predictions can also go very wrong. Low prediction skills and sudden climate changes are the main causes (Stigter and Winarto 2011a). This is why we want to experiment with such simple climate predictions for some time. Even after we explained in our Climate Field Shops that predictions may be erroneous, farmers repeatedly indicated that they still wanted such information, even in such periods of low forecasting skills.

These are examples of creative and adaptive farmers who had learned from their recent experience of measuring rainfall, observing their fields, and receiving simple climate predictions. Preparedness to cope better with increased climate variability and obvious climate change could be enhanced with proper and timely assistance in an appropriate form and language. Stigter and Winarto (2011b) also argue that in Science/Climate Field Shops, farmers and scholars should not only bring up rainfall measurement results and the related observations of crops and soil, but also discuss the background of climate change and its consequences, as well as address farmers' questions, problems, and vulnerabilities. Stigter and Winarto (*ibid.*) further argue that:

> If necessary, the scholars follow up these problems at their institutes (universities, research institutes, weather and other environmental services) with supportive research and teaching to and with their ideas . . . . Ideally, scholars and students should jointly take up to provide an initial overview of answers to vulnerability issues/questions of farmers. Such initial answers should then be discussed with the farmers as to what the possibilities/choices/options are in solving their problems and how they see them from their realities. In that type of discussions should come up whether there is room for and what would be the sense of farmer research on such possibilities/choices/options. Through such research they may find their own solutions but a remaining dialogue with scholars is advisable because cause and effect relationships is what science has to offer to empirical answers sought or found by farmers. (e.g. Stigter 2010a)

This is the ideal collaboration between the two parties to gain mutual benefits from the knowledge exchange (see the Science Field Shops' diagram in Winarto *et al.* 2010a; 2011d; 2011e). Climate Field Shops are limited to weather and climate issues, compared to the wider approach of SFSs, and the Climate Field School comes at a later stage to follow up on seasonal farmer vulnerability issues with the help of well-trained extension intermediaries.

Box 1 is part of a dialogue in a SFS between the members of the Indramayu Rainfall Observers Club and the agrometeorologist on the subject of farmers' queries and problems. Only questions directly related to rainy seasons and actual rains are reproduced here.

Our collaboration and dialogues with the Indramayu Rainfall Observers Club over a long period of time, which also gave the farmers ample opportunities to organize themselves, proved beneficial in consolidating the club's organization and activities. The club grew as an independent body. The leaders did their best to gradually improve the management of their activities by strengthening the rules of standardized measurements and observations and the reporting of data, and through monthly evaluation meetings whereby problems faced by farmers in the fields were shared. It is fortunate that some members are IPM FFS alumni and farmer facilitators who had received special training in facilitating farmers (being farmer facilitator, *petani pemandu*). They also obtained knowledge of pests/diseases (particularly BPH and stem borer) life cycles, prey-predator relationships, sustainable control strategies, plant breeding, and organic farming. The monthly meeting

Box 1 Indramayu Farmers' Questions on Rains and the Agrometeorologist's Answers in a SFS, in 2011

Q: If we do not measure the rainfall, how could we know which rains are good for planting crops?

A: Only qualitatively. In Wareng the farmers had their own terminology for rains and the consequences for the soil and plants. Measuring helps to do this more systematically on a daily and a cumulative basis also for comparisons between different parts of the same season and between the same parts of the season for different years. Once you have a 10-years average, you may call that "normal" and you can day by day take track of whether the cumulative rainfall is above or below that "normal."

Q: Which rains could lead to drought and flood?

A: Below "normal" rains will lead to drought if they continue. Again one must learn to keep track of such conditions quantitatively/numerically. Above "normal" rains can lead to floods. Again this must be "learned."

Q: My areas belong to a dry-rain fed ecosystem, so to enable us to plant in the dry season, we have to catch up with the time. However, if we plant early, we will face the risks of pests/disease outbreaks. How to know in advance the weather condition prior to dry season planting? Are there any conditions of rain that could drive away or constrain the growth of pests/diseases?

A: Basically not possible. Climate forecasting can say something on possibilities for above normal, normal, or below normal rainfall, prior to dry season planting, but these forecasts are general and not location-specific. Moreover, the forecast gives probabilities, and not what will actually happen. Yes, for each pest and disease, research can be carried out to indicate conditions conducive to their outbreak, but this has to be done at research institutes and preferably in farmers' fields. In India and China, some of that work has been successful, in Europe some work is done commercially on such issues. One has to choose the most serious diseases/pests for each crop first!

Q: What responses would researchers carry out when the rain is very high so as cause flood while the drainage canals are not being managed well?

A: Growing crops on ridges might help, or growing crops on raised beds. Some soils may drain better with another top layer or by making holes. Managing the drainage canals well is the best advice to begin with. Making facilities for drainage to non-agricultural land or, even better, into ponds, for later use, is very helpful.

Q: How many years are needed to measure rainfall so that we can define the real problems of rainfall in relation to planting? Can we define the rains for the next three months? How could we do that?

A: Measuring rainfall must become a habit, like eating, drinking, and sleeping. Only then you get to know the real problems, together with the Schooling approach, in a permanent learning process. Only specialized agencies can forecast with a certain probability rainfall chances some three months in advance. But farmers must be prepared for what actually happens by having the techniques mentioned ready, flexible/resilient co-ordination with neighbors in the Schools. Whether this will be sufficient, we have to find out. Perhaps we have to do different things, like growing more than one crop in the same field or having alternative crops on some fields in parts of the year. We have to change our approaches because the climate is changing, otherwise we will lose, but we may expect the government and its institutions/civil servants and NGOs to help.

Q: Would the farmers be able to plant rice 40 years from now referring the changing climate like now? How would the changes in climate be in the future (40 years from now)?

A: As to Indonesia, 40 years from now, the temperatures will be too high in certain parts of the year (particularly the minimum night temperatures) to grow rice with the same yields as possible today, even when we find heat-tolerant varieties. Other crops will have to be tried, soya is one of them, agroforestry systems will have to be developed that lower temperatures for certain crops that can grow with less solar radiation, and the trees will have to produce food as well. So food patterns will have to change, other (preferably higher-value) crops will have to be tried out, rice will have to be imported (and other food products exported). And the population increase will have to become a lot lower if we want people to live on these new food conditions.

Q: If there are continuous rains for one week above 75 mm on black-clayish soil, would it disturb the growth of paddy? What would the effects be on the plants?

A: You can't answer such questions because it depends on available drainage. Are we talking about rainfed rice or irrigated rice? And it also depends on the distribution of those 75 mm over that week. Continuous rain is indeed very different from heavy showers.

Q: What are the effects of climate change on perennial crops like mango? Recently, mangoes have been flowering quite frequently. Is it caused by humidity, or are there some excesses of nutrients?

A: Mangoes do need a long dry season, so when there was no dry season or a dry season that is not long enough, mangoes do suffer a lot. Wet, humid weather favors anthracnose and poor fruit setting. Mango trees require regular applications of nitrogen fertilizer to promote healthy growth flushes and flower production. Micronutrients, especially iron, are also often necessary. Organic fertilizers perform best, since the trees are subject to fertilizer burn. Young trees are particularly sensitive to over-fertilizing. Sandy soils require more fertilizer than loam or clay.

Source: Stigter and Universitas Indonesia research team field note, 2011 (see Stigter and Winarto 2011b).

Box 2 Conclusion of 2010/2011 Rainy Season Planting Strategies

1. Rat population is high due to water abundance.
2. Average yields were 9.7 kw/100 *bata* [0.14 ha] or 7.1 tonne/ha.
3. Damage to the paddy is related to the rainfall condition at each stage of growth of the plants.
4. The average yield of 7.1 tonne/ha is good but it was still affected by damages, this season mainly by rats, and to a lesser degree by other pests and diseases.
5. The lowest yield was 6.0 kw/100 *bata* (4.4 tonne/ha) and the highest yield was 9.9 kw/100 *bata* (7.25 tonne/ha).
   a) The lowest yield was from the south-east zone (Ciherang variety).
   b) The highest yield was from the north-west zone (Borang variety, farmers' cultivar).
   c) The other high yield was from Shogun and Mekongga varieties.
6. Factors affecting the growth of crops: weather, environment, nutrients.
7. Many pests/diseases, but the yields were rather high due to the use of organic fertilizers, plenty of organic matter in the soil, and the practice of water management (irrigation and drainage of the fields).
8. Water management helps.
9. Weeds are a competing factor for the growth of plants.

Source: Universitas Indonesia research team field note, 2011.

became a very fruitful and useful arena to share knowledge and ideas. Examples of these were discussions on BPH and the rice stem borer's life cycle, and judicious control strategies. Such discussions are good examples of how farmers themselves become more aware of their vulnerabilities, not only those caused by the increase in climate variability and change (and the ensuing risks and opportunities), but also vulnerabilities related to their own ill-judged strategies that induced or worsened outbreaks.

> In each monthly evaluation meeting, the discussion focused on the most prominent problem(s) in the past weeks. In the last four meetings, the problems discussed were about the infestation of brown plant hopper, stem borer, and rats. It is interesting to observe that the sharing of information was based on both the "scientific" ideas of the pest's life cycle and the local knowledge of pest outbreaks, and how to develop preparedness strategies to avoid the outbreaks.

Another important product from our collaboration were the conclusions reached jointly by the farmers and the agrometeorologist on the 2010/2011 rainy season planting in relation to farmers' yields, weather conditions, and farmers' strategies (Box 2). This is an example of the very significant lessons obtained by the farmers from the agrometeorological learning processes of the whole 2010/2011 rainy season planting.

Inter-disciplinary and Trans-disciplinary Approach: A Reflection[2)]

The increased vulnerability of ecosystems and people's livelihoods is due to the interplay of various factors: the increasing variability of climate, climate change, more (and more severe) extreme events, and human activities and responses (e.g. Stigter and Winarto 2012). This forces us to reflect seriously on what we have done so far. Have we been able to cater for people's urgent problems immediately, in an appropriate form to be implemented in their habitat? Have we been successful in improving their understanding of the complex situation they are now facing, in a way that enables them to develop their own creative adaptations and improves their social-cultural institutions?

The severe pest/disease outbreaks during the La-Niña periods of 2009 and 2010/2011, and the unpreparedness of farmers in many places in Java, were an opportune moment for many parties to do a thorough reflection on what has been missing in our approaches and facilitations. In this paper we share our experience of building up an inter-disciplinary approach among scientists from different disciplinary backgrounds, including anthropology, agrometeorology, and environmental biology. Each scientist would not be able to assist the farmers based on a mono-disciplinary approach. The agrometeorologist needs intermediaries to help the farmers to improve their agrometeorological learning and analysis for action in the field. The anthropologist cannot facilitate the farmer in his/her fieldwork beyond his/her expertise, and the same applies to other scholars in different disciplines. Our inter-disciplinary collaboration proved successful in bringing agrometeorological thinking and knowledge to local people who have their own ethnoscience, such that we strengthened and enriched this ethnoscience with scientific ideas, premises, and methods (see Ellen 2004).

Nevertheless, without building up a working relationship with local farmers over a longer period of time—if not permanently until extension intermediaries have been sufficiently trained to deal with ongoing increasing variabilities and changes of climate—the collaboration would not benefit the farmers. A trans-disciplinary approach is imperative. Without involving the farmers as active participants in carrying out their own agrometeorological observations and analyses with the scholars' help, guidance, and explanations, and in due course with assistance by extension intermediaries, it is doubtful whether their learning would improve day by day, season by season. Herein lies the great potential to develop farmers' creative climate adaptations and social-cultural insti-

2) An inter-disciplinary approach involves research collaboration across disciplinary boundaries, for example, anthropologists working with agrometeorologists to assist farmers in their agrometeorological learning. A trans-disciplinary approach involves research collaboration with the "subjects," for example, with the local people, the farmers, beyond any scientific disciplinary boundaries.

tutions. In order to face the challenges and constraints of the future, scholars, farmers, and ultimately, extension intermediaries have to jointly overcome field conditions. The vulnerability issues in a particular ecosystem and farmers' unique social-cultural frameworks and aspirations are highly varied. Any collaboration in developing farmers' agrometeorological learning has to be adjusted to the existing field problems and social-cultural circumstances and cannot be uniformly applied across the board.

Some Conclusions

From the above, it may be concluded that it is high time to abandon pre-established teaching and curricula for CFSs addressing farmers in diverse ecosystems. We suggest a reversal in the process of farmers' agrometeorological learning by beginning with farmers articulating their own needs, problems, and vulnerability issues through continuous dialogues and knowledge exchanges in Science/Climate Field Shops. Meanwhile, farmers should be assisted in measuring rainfall and observing the implications of weather and climate for their fields and crops in a more systematic and standardized way. Information and knowledge on basic issues of climate change should also be imparted during sessions at the "shops." On the basis of lessons gleaned from these "shops," an improved CFS could be developed to address particular immediate problems (drought, flood, pest/disease attacks, etc.) in the ongoing growing season. The training of new extension intermediaries and/or refreshing the training of present ones is necessary to that end.

It would not be possible, therefore, to organize such learning on a project basis for a short period only. We understand, however, that it would not be easy to shift the paradigm of assisting farmers without any strong ethics as an underlying foundation. The question is: have we already developed such ethics as proposed by Chambers *et al.* (1989) and Scoones and Thompson (1994; 2009) in their "Farmer First Paradigm?" Stigter (2010c) argues strongly for the need to further develop ethics, policies, and science, in this sequence, in response to climate change. Agrometeorological learning for vulnerable communities is only one dimension of applied science. "Pro-vulnerable" or "people-centered" on-farm climate adaptations in agricultural production have to underlie all policies to strengthen and enrich ethnoscience to better assist those in need of coping with climate change and the inherent unusual risks.

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