Towards Effective Participatory Decision-Making on Climate-Smart Agriculture Practices and Technologies

A Case Study of Rohal Suong Climate-Smart Village, Battambang Province, Cambodia

Working Paper No. 241

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

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Abstract

Under the Climate-Smart Village (CSV) program of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), the village of Rohal Suong in Battambang Province was selected to be the first CSV in Cambodia. This provides the local community with an opportunity to identify and enhance existing practices, which can be classified as climate-smart agriculture (CSA) interventions, and to test new technologies that it can adopt. Those that were deemed appropriate as climate adaptation measures could then be out-scaled and upscaled in other places and in various levels. In this regard, a series of activities to support the participatory prioritization and selection of CSA technologies and practices (CSA T&P) was organized and participated by various stakeholder groups in Rohal Suong. These activities helped the community representatives identify the CSA T&Ps that could best improve their lives and meet their needs. As part of the CSA prioritization process, the representatives ensured that technologies and practices are relevant to the local context and are publicized for review and revision. The community workshop sessions considered the various issues within the community, especially those that affect different genders and people of lower socioeconomic status. Using Rohal Suong as an example of effective participatory priority setting, the researchers propose a procedural guide for the participatory prioritization of CSA T&P, which can guide the scaling process in other rural communities of Cambodia.

Keywords

Climate-smart agriculture, participatory decision-making, Cambodia

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Contents

Acronyms

AS	Aphivat Strey
AWD	Alternate wetting and drying
CABI	Centre for Agriculture and Bioscience International
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CFi	Community Fisheries
CFR	Community Fish Refuge
CSA	Climate-smart agriculture
CSV	Climate-Smart Village
EBRM	Ecologically-based rodent management
GHG	greenhouse gas
IPM	Integrated pest management
MAFF	Ministry of Agriculture, Forestry, and Fisheries
NGO	Non-Government Organization
PDAFF	Provincial Department of Agriculture, Fisheries and Forestry

Introduction

As part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) in Southeast Asia, WorldFish has partnered with government agencies and local non-government organizations (NGOs) to apply the concept of Climate-Smart Villages (CSVs) in Cambodia. Rohal Suong in Battambang Province was chosen as the first CSV in the country. The farming systems in Rohal Suong are considered as well-adapted to the natural conditions and climate variability, providing the opportunity to identify and enhance existing technologies and practices that can be classified under climate-smart agriculture (CSA). They could then be promoted on larger scales to increase the general awareness on the importance of CSA in agricultural development and climate change adaptation and mitigation.

The term, 'CSA', first introduced by the Food and Agriculture Organization of the United Nations in 2010, aims to adapt agricultural practices that reduce climate change impacts and decrease GHG emissions. The official definition of CSA is any practice that: i) sustainably increases productivity; ii) reduces climate vulnerability (enhance adaptation); iii) reduces emissions that cause climate change (mitigation); while iv) protecting the environment against degradation; and v) enhancing food security and improving the livelihood of a given society (FAO 2010). CSA, however, does not refer to new set of practices. Rather, it includes any change to current agricultural activities that addresses both food security and climate change.

WorldFish organized a series of activities, including a village workshop with all relevant stakeholders in Rohal Suong for the participatory prioritization and selection of CSA T&P for testing in the village. In the case of Rohal Suong, participatory prioritization was used to identify the CSA technologies that could best improve the lives of villages and meet their needs. To ensure a fair assessment of CSA T&P selected for potential implementation in Rohal Suong, they were judged based on their relevance to local context. They were also made public and open to criticisms and revision. WorldFish organized the sessions while considering the many different issues within the community, especially those affecting different genders and people of lower socioeconomic status. With Rohal Suong serving as an example of effective participatory priority setting, the team developed a practitioner's guide for participatory prioritization of CSA T&P.

This can be used to guide future prioritization processes of CSA practices and technologies in other CSVs. The steps to achieve an effective participatory priority setting of CSA T&P are as follows:

- understand the environmental context of the study site
- conduct a literature review and feasibility analysis, and specify the budget
- conduct a stakeholder analysis
- ensure stakeholder knowledge management
- develop a ranking system and selection criteria for CSA practices
- convene a dialogue session to rank and select CSA technologies
- validate and finalize the list of priorities

Guidance for Participatory Decision Marking on CSA Technologies

I. Understand the environmental context of the site for the CSA participatory prioritization

The first step is to collect all information needed to understand the national and local contexts where the participatory prioritization will be applied.

A. National Context

A nationwide Knowledge, Attitudes and Practices (KAP) study found that Cambodians have witnessed and believed that the climate is changing. However, most respondents from the study lack a deep understanding of the causes of weather changes, and only associate climate change and global warming with local deforestation, diseases, farming difficulties, water shortages, and an increase in temperature (MOE 2011).

Cambodia's economy is predominantly based on agriculture, the biggest consumer of water in the country (Wokker et al. 2011). This sector, however, faces the threats of climate change. More frequent natural shocks such as droughts, floods and cyclones, have already affected crop production. Based on climate prediction models, Cambodia is ranked as one of the most at-risk countries in Southeast Asia (Yusuf and Francisco 2009).

The availability of water will be affected by climate change as well. Shifts in seasons and rainfall patterns have changed the hydrological system of the Mekong River, the groundwater cycle, and the frequency and intensity of droughts and floods (Daze et al. 2013). This led to water instability and shortages among the farmers and consequently, rising conflicts among water consumers (Nang et al. 2011). The fishing industry also faces the major impacts of climate change in Cambodia, as shifts in seasons and rainfall affect fish breeding patterns. Moreover, both freshwater and coastal fisheries are vulnerable to declines in fishery productivity and to a stiffer competition over fish resources (Daze et al. 2013). This may lead to serious consequences for food security and nutrition. The implementation of CSA can help Cambodia adapt to and mitigate the impacts of climate change.

B. Local Context

Information on the local environment of the CSV must be gathered. In the case of Rohal Suong, a baseline study and situational analysis were conducted a year prior to the CSA prioritization session. The local baseline study and situational analysis found that climate change impacts will intensify in Battambang Province over the next few years. The results also provided a better understanding of the village in terms of use of resources, perception on climate change, as well as climatic hazards and vulnerabilities. The village highly depends on crop cultivation (rice, maize, mung bean, watermelon, cucumber, etc.) and agriculture-related activities. Before the 1990s, Rohal Suong was mainly covered by seasonally inundated forests (locally called flooded forests), which provided habitat and feed for fish, water birds and reptiles. However, the flooded forests quickly disappeared over the past 20 years due to agricultural expansion. Most rice farmers have switched from growing a single crop to two crops per year, with new rice varieties introduced to the villagers by dealers, NGOs and governmental projects. Rice yield may have been higher than previous years, but the crops still require intensive inputs, such as chemical fertilizers, pesticides, and more water (Try et al. 2015). The Sangke River and the Tonle Sap Lake, which reaches the village almost every year during flood season, are the main sources of water and fish for villagers. The villagers noted that their catches declined rapidly after the flooded forests and natural water bodies were converted into agricultural fields. As a response, authorities established several community fisheries (CFi) in 2002 to use and preserve fishery resources.

A national study conducted by the Ministry of Environment in 2011 found that the local population noticed weather and environmental changes, including an increase in frequency of natural disasters and extreme weather events. These changes are believed to be caused by the widespread deforestation and rapid industrialization in the country. Local community groups identified flash foods, droughts, crop diseases, and insect outbreaks as the impacts of climate change that they have experienced. As the weather becomes unpredictable, information regarding meteorological and hydrological patterns in the village is needed. A meteorology station exists at the provincial level, but not at the district level. Villagers of Rohal Suong identified increasing agricultural productivity, profitability, and restoring natural resources mainly fisheries as the priorities in the village. They also hope to improve water distribution and management, which includes irrigation infrastructure, water storage, and ponds, among others.

Figure 1. An elder shares his experiences related to changes in the weather, climate, and environment at the project launch event in Rohal Suong village. Photo: WorldFish/Eam Dyna

II. Conduct the Literature Review and Feasibility Analysis

A. Literature Review

A literature review must be conducted to identify existing CSA T&P that could potentially be implemented in the CSV. The literature was reviewed based on the baseline study, the situation analysis, and the community-defined areas of priority. Also considered were various CSA T&P that already exist elsewhere in Cambodia and could be replicated in the CSV. The review contains information on the history of each CSA T&P, what each technology is and what it entails, whether the practice or technology has been implemented in Cambodia previously, and whether the practice was successfully introduced. The climate-smart technologies reviewed for Rohal Suong were those that would address the following climate change concerns: rice productivity, fish productivity, dry season water supply, and pest control. The practices and technologies considered in the literature review for Rohal Suong are found in *Appendix A.*

B. Feasibility Analysis

The CSA concept was developed to support efforts on sustainable agricultural systems and to ensure the food and nutrition security of all people at local and global levels. It also aims to preserve and protect environment and natural resources and integrate practices necessary for climate change adaptation and mitigation. Implementing CSA requires a comprehensive approach considering the technical, social, and financial implication of each technology and practice. CSA T&P must be contextualized based on the local landscape and community needs, and must also be in line with governmental priorities.

Following the literature review, a simple feasibility analysis was conducted, outlining the benefits and risks or costs associated with each CSA T&P. The criteria considered in the feasibility analysis were based on a document developed by the CCAFS team for prioritizing CSA T&P in Southeast Asia (Vernooy et al 2015). The technologies and practices described in the literature review were assessed based on numerous criteria to provide an overall picture of their benefits and costs, as well as their enabling and hindering factors. WorldFish also researched the monetary costs and potential income benefits of the listed CSA T&P and compared their costs against the others. The factors considered in the feasibility analysis are listed in *Table 1*.

Table 1. Factors considered in the feasibility analysis of the CSA practices and technologies.

Factors considered when judging the feasibility of each CSA	In-depth considerations for each factor
History	Is this intervention new to the village? Have other projects previously tested this intervention in the same village or in the same district/ province? If the intervention is not new to the village, has it worked before? Why or why not? Are there any constraints for this technology to be tested in this village because of the history? What can we do to remove the constraint?
Resources/Assets	What biophysical conditions and natural resources are needed for this intervention? Are there any constraints for this technology to be tested in this village because of the resource access/asset issues? What can we do to remove the constraint?

Social and gender norms	What is the level of inputs required from women/men, and what are the implications on their time/labor, capacity/skill needs? Are there powerful individuals in the village who may create constraints/incentives for the intervention? If there are any constraints for this technology to be adopted in this village because of social relations/gender issues, what can we do to remove the constraint?
Market, value chain/extension services	Does this intervention meet market demand? Are the necessary inputs and outputs and value chain established to support the intervention? Are technical services available to support farmers in implementing this intervention?
Women empowerment/equity	Does this intervention negatively or positively affect women's empowerment and equity within the village?
Food security	Is this intervention expected to have positive or negative results in terms of food security?
Poverty reduction	Is this intervention expected to have positive or negative results in terms of income generation and household asset accumulation?
Financial resources and capacity of CSV team	What are the other resource needs in terms of capital investment, operational cost, and human resources?
Climate-smart criteria	Is this intervention climate-smart? Which climate-related issues does this intervention address, and how?
Policy/Law	Are there government policies and regulations that promote/constrain the intervention? If there is a policy constraint, what can be done to remove the constraint?
Sustainable resource use/conservation	Does this intervention affect the environment or natural resource base?

An overall assessment was completed for each technology and practice. After considering their pros, cons, possible risks, and contribution to community needs, the team made a shortlist that would be proposed to the community.

III. Conduct a Stakeholder Analysis

The next step is stakeholder identification, analysis and engagement. It must be decided who can participate during the priority setting process. The importance, influence, and interest of each stakeholder in relation to the issue must also be decided. The layers and levels within a stakeholder institution must be broken down, as well as the level of involvement of each stakeholder. Also considered were the potential conflicts, conflicts of interest, risks, opportunities, resources and relationships of stakeholders.

Stakeholders refer to any individual, group or institution with an interest in the prioritization process. In the case of Rohal Suong, all relevant stakeholders, the dynamics among them and between them, and their environment were identified and analysed. The WorldFish team facilitated a brainstorming session to identify all stakeholders and specify how each stakeholder influences CSA practices in Rohal Suong. Stakeholders identified as influencing or being influenced by CSA practices in Rohal Suong were:

- CCAFS/WorldFish
- Aphivat Strey (AS)
- Local farmers
- All villagers
- Women and children
- Village Chief
- Commune authorities
- Community Fisheries group
- Community water user group
- District Agriculture Office
- Provincial Department of Agriculture, Fisheries and Forestry (PDAFF)
- Ministry of Agriculture, Forestry and Fisheries (MAFF)

A Stakeholder Influence vs. Interest grid was also created to visualize relationships between stakeholders, and the influences between and among them *(Figure 2).*

Figure 2. CSA Rohal Suong Stakeholder Influence vs. Interest grid

IV. Ensure Stakeholder Knowledge Management

While classifying and identifying stakeholders, it is important to recognize that stakeholders have different knowledge levels and means of expression. Before the process of prioritization begins, organizers must ensure that all stakeholders have access to information while considering relevant language and education barriers. This is important to enable stakeholders to fairly and accurately rank the CSA practices and technologies.

In Rohal Suong, WorldFish used posters to ensure that all stakeholders were aware of the pros and cons, economic costs, and gender implications of each technology and practice (*Appendix B*). During the prioritization session, the posters were presented to the participants, who then asked questions and clarified information regarding each technology. The posters provided information about the interventions, which climate issues they tackle, their potential benefits, the resources needed, and the possible risks when implementing them.

V. Develop Selection Criteria and Ranking System

Afterwards, a scoring system and a list of selection criteria for ranking the CSA T&P were created. In Rohal Suong, the selection criteria and a ranking system were adopted from Vernooy et al's (2015) manual, *Testing climate-smart agriculture technologies and practices in Southeast Asia: a manual for priority setting*. Criteria also considered whether the intervention was sustainable and if it can ensure food security, generate economic improvement, benefit women, foster community development, or improve the adaptive capacity of the village to climate change. Both input and output variables were considered. Risk factors were also considered in ranking the interventions, whether these were affected by either social factors or climate change.

The scoring system used was a scale of one to five, with ***5*** indicating high dependence of a CSA T&P on a particular factor and ***1*** for low dependence. During the prioritization session, participants ranked the technologies from ***1-5***, based on whether the technology required outside financial support, labour (including whether the technology was more dependent on male or female labour), outside technical support, or cooperation among the villagers.

After the interventions were ranked according to these criteria, participants completed an overall assessment and decided whether to accept or reject a new CSA T&P. Participants were asked to depict their decision as "☺**"** or *"happy to accept a practice/technology,"* "☹**"** or *unhappy to accept a practice/technology* or "😐**"** *"so so" (not sure whether they should accept or not).*

The scoring system and criteria used in Rohal Suong were written on small scoring cards, which were provided to the participants during the prioritization session (*Table* 2). The ***Remark*** column was included for participants to record the reasons for their rankings.

Table 2. Scoring system for CSA Technologies used in the Rohal Suong CSV

INPUT VARIABLE	SCORE	REMARK
Financial capital needed		
Labor needed		
Degree of dependency on female labor		
Outside technical support needed		
Amount of cooperation needed among villagers		
TOTAL SCORE		
OUTPUT VARIABLE		
Sustainable resource use and conservation /environment improvement		
Food security		
Income generation/ economic improvement		
Benefits for women (gender equity and women's empowerment)		
Community development		
Respond to improved cc adaptive/ resilience capacity		
TOTAL SCORE		
RISK ASSUMPTION		
What other social factors are considerations?		
How will this technology be affected by changing climate/weather factors?		
TOTAL SCORE		
OVERALL ASSESSMENT		

VI. Convene a Deliberative Dialogue with Stakeholders and Rank CSA Technologies and Practices

The participatory workshop was held in a primary school located at the center of the community. Elders, farmers, community group leaders, village headman, representatives from commune office, the district office of agriculture, and other key stakeholders were invited to select potential pilot CSA T&P. Gender is deemed as a key factor in CSA prioritization, leading to a gender-based grouping during the activity. The time and place of the workshop was also made suitable for both women and men. The overall objectives and methods of the workshop were presented to the participants, which were achieved by following the four key steps below:

- **Step 1: Presentation of CSA practices and technologies:** The CSA practices and technologies were presented to the participants through posters, presentations and video clips. Presentations included a general overview of the practice or technology, its potential to address climate change, its costs and benefits, and any implications it may bring to the women's workload.

- **Step 2: Participatory Analysis/Technology Fair:** Participants were divided into smaller groups and viewed the CSA posters, with a research team member standing next to each poster to answer queries. The small groups rotated for them to see all the posters. This "gallery walk" method allowed the participants to discuss among themselves and interact with the research team members.
- **Step 3: Scoring and Ranking:** Once the participants had familiarized themselves with each CSA T&P, the scoring system was introduced to them. Villagers had the opportunity to discuss and choose which practices and technologies they considered the most suitable to be piloted in their village. They not only scored on each intervention, but also provided the reasons for their scores. After all the participants had rated the CSA T&P, the results were consolidated and used to make the decision regarding the acceptance or dismissal of each CSA practice or technology. The results of the discussions for each CSA T&P are listed in *Appendix C*; the agenda of the priority setting workshop in *Appendix D*.
- **Step 4: Finalizing and Validating Results:** After the interventions were ranked, the results were synthesized, aggregated, and analyzed. The results of scoring and ranking were reported back to the participants during the plenary session, which was then followed by an open forum to allow the participants to discuss the results with other stakeholders and with the research team. Their questions and ideas were mapped before reaching a consensus of which intervention would be implemented in their village. After the results were approved by the participants, these were presented to the Provincial Department of Agriculture, commune leaders and authorities, WorldFish, Centre for Agriculture and Bioscience International (CABI), CCAFS and AS representatives for review and revision.

Figure 3. CSA practices and technologies are presented by a team member in the CSA technology fair.
Photo: WorldFish/Eam Dyna

Figure 4. Farmers and key stakeholders are scoring and ranking the CSA practices/technologies. Photo: WorldFish/Eam Dyna

Conclusion

This guide note indicates the principles and key steps to develop a participatory decision-making process on CSA T&P that will be implemented in the CSVs. The main objective of the principle and the entire process is to avoid a top-down and rushed selection of agricultural options. This approach provides enough space and time for discussions and reflections among key stakeholders in the CSV. Furthermore, the sessions ensured that they include all relevant stakeholders and considered the many different issues within the community, including those that affect different genders and people of lower socioeconomic status.

The case of Rohal Suong on CSA implementation shows that CSA interventions that respond directly to the needs of the community are readily accepted by local farmers. For instance, climate stress-tolerant rice varieties introduced by the project have reduced crop loss significantly. Community Fish Refuge (CFR), a CSA practice, improves fish production in rice fields, providing more food supply for rural households. These CSA interventions increased the farmers' incomes and ensured food security in the community, particularly in the poor and vulnerable households.

Farmers, community committees, and local authorities, however, must revisit those CSA T&P every three to five years to ensure that they are still appropriate to the community setting. New CSA interventions must be discussed by that time to respond to the ever-changing climate, environmental, economic, and social landscapes.

Appendix A: Climate-Smart Agriculture Review

Climate-stress tolerant rice varieties

The increasing frequency of extreme weather events such as drought, floods and higher temperatures will affect rice growth and cultivation in Cambodia. Plant breeding can address these damaging effects, which is why rice breeding has been a very successful activity in the past few decades. The International Rice Research Institute (IRRI) has been developing rice varieties that can withstand climate stress such as drought, flood, heat, and cold, as well as soil problems such as high salt and iron toxicity. IRRI scientists use a method called marker-assisted breeding, where breeders can integrate specific traits that are desirable into new varieties with a better accuracy. For instance, they can cross traditional drought-tolerant varieties with modern high-yielding varieties that are not immune to drought to make them drought-tolerant as well.

The introduction of new stress-tolerant rice varieties has enabled rural poor farmers to adapt to the current weather events and overcome some of the challenges to their rice production. One of the new rice varieties is the short duration rice seeds, which allows a much quicker growth of rice on land, requiring only 90 to 115 days to mature compared to the minimum 150 days for traditional varieties. This helps the farmers avoid risks such as pests or flash flooding, which could lead to crop loss (Feed the Future 2014). These innovations yield transformative results in agriculture in Bangladesh. The use of new seeds and fertilizer technologies led to 20% increase in rice yields and raised farmer income from an average of $426/ha in 2012 to $587/ha in 2013. Aside from improved crop management, support from national institutions and the use of relevant technology will enable climate-stress tolerant rice varieties to demonstrate positive results to the lives of poor farmers.

Climate-stress tolerant rice varieties should be selected based on time of maturity and on relevance to the local landscape, including weather, soil, water and climate. Farmers should also choose to plant rice varieties with good market value; are pest-resistant; and produce high yields. The Ministry of Agriculture, Forestry and Fisheries of Cambodia has introduced 38 rice varieties, each of them being suitable for specific conditions (Sam & Ouch 2015). In 2011, the Royal Government of Cambodia recommended 10 varieties from the 38 released varieties to increase rice growth and promote rice exports (Ouk 2011). Among the varieties released by the government, several of which are resistant or tolerant to biotic and abiotic stresses such as flood, drought, brown plant hopper, heat, pest, and striped stem borer (Ouk 2011). In terms of maturity, the rice varieties can be classified into three groups: Early Maturity Variety (EMV), Medium Maturity Variety (MMV) and Late Maturity Variety (LMV). Based on the study conducted by Sam & Ouch, modern rice varieties used by farmers include IR66, variety 504, and variety 85; improved traditional rice varieties include Raing Chey, Phka Rumduol, Somaly and Phka Malis; and traditional varieties include Kronhol, Neang Khon and Neang Tom. To adapt to climate variability, farmers switched from late maturity to early maturity varieties, but they did not choose the ten recommended varieties. They said that those varieties did not have a good market value and some of them are even not suitable for their conditions (Sam & Ouch 2015).

Promising rice varieties include drought tolerant seeds such as Sahbhagi Dhan (IR74371-7-1-1), which has been launched in drought-prone areas and has performed well so far, providing about 1t/ha yield advantage under severe drought stress (Verulkar et al. 2010). Other promising varieties are flooding-tolerant varieties through the use of the SUB1 gene during breeding (Neeraja et al. 2007, Septiningsih et al. 2009). These varieties have a high submergence tolerance, and because they retained the desirable features of the original popular varieties, they were easily accepted by farmers in flood-prone areas. However, no variety showed tolerance to submergence during the flowering or later stage (Mackill et al. 2010).

Alternate Wetting and Drying

More than 10 years ago, IRRI and its partners developed a water-saving technology for rice production called Alternate Wetting and Drying (AWD). It allows farmers to reduce their irrigation water use in rice fields without decreasing their yield. The practice has been known to save 15-30% of irrigation water throughout many rice producing regions in Asia (Sheinkman et al. 2015). Recently, AWD has also been recognized as a good greenhouse gas mitigation technology, encouraging policy makers to favor its promotion and implementation. AWD can indeed reduce methane emissions from rice fields by around 48% without decreasing yields (Richards & Sander 2014; Sheinkman et al. 2015).

AWD, also known as controlled irrigation, can be implemented in irrigated lowland rice fields where soils can be drained in five-day intervals. However, high rainfall is a risk as it can hinder the good functioning of AWD if the field is unable to dry during the rice-growing period and if rainfall exceeds water lost to evapotranspiration and seepage (Richards & Sander 2014). With this risk, AWD in rainfed rice is not recommended due to uncertain water accessibility when fields will be re-flooded. Currently, AWD is widely recognized as one of the most promising practices to reduce methane from irrigated rice paddies, showing a potential to reduce GHG emissions and water consumption from rice culture while maintaining yields. When using AWD, the rice field is alternatively flooded and drained, where the soil can dry out between 1 to 10 days after the disappearance of ponded water, depending on the soil type, weather and crop growth stage. An effective way to implement

AWD safely is to use a 'field water tube', also called 'pani pipe', to monitor water depth on the field. Farmers were taught to supervise the depth of the water table in the field using a perforated water tube. This practice starts at 1 to 2 weeks after transplanting and requires field drainage until the water level reaches 15 cm below the soil surface. Instantaneously, the field is being re-flooded to a ponded depth of 5 cm before being re-drained again. The threshold of water at 15cm below the soil surface is considered as 'safe' for AWD because this should not cause any yield decrease with the roots of the rice plant still able to absorb water from the saturated soil (Lampayan et al. 2009).

According to literature, AWD demonstrates three main benefits for rice farmers:

i. it can reduce water consumption by up to 30% as required number of irrigation events is reduced, thus helping farmers cope with water scarcity and gain control over water usage.
ii. The 2006 IPCC methodology found that AWD can reduce methane (CH4) emissions by half compared to continuous flooded fields. The mitigation aspect of AWD mainly depends on its proper execution, and incomplete drainage can lead to negligible reductions of GHG emissions (imperative for water table to drop to 15cm below soil surface).
iii. 'Safe' AWD does not reduce rice yields compared to continuous flooding, and it could even reduce labor costs by improving soil conditions, as well as help farmers who use irrigation pumps to save money on irrigation costs.

To benefit from AWD, farmers, irrigation authorities, and local government, as well as appropriate design of irrigation schemes must coordinate with one another. Based on the lessons learned from the Philippines' experience, incentives for farmers to adopt AWD vary greatly depending on the irrigation scheme in place. In areas where farmers pay a flat irrigation fee regardless of the volume of water consumed, there was little private incentive for adopting AWD. However, in rice areas where canal water is scarce and irrigation schemes are lacking, farmers often use pumps and usually buy their own fuel to operate the pumps. In this case, implementing AWD allows the farmers to save money by irrigating less frequently or for a shorter period. Once farmers were certain that AWD would not reduce their yield, they used it as an opportunity to improve their rice culture and irrigation system. Still, AWD implementation requires a well-functioning irrigation system and funds for proper technology transfer and training (Richards & Sander 2014).

Community Fish Refuges

The community fish refuge (CFR) was first introduced in Cambodia in 1995 through the Aquaculture and Aquatic Resources Management Project (Meusch & Viseth 2001). From 1995 to 2013, the Fisheries Administration (FiA), JICA, DFID/DANIDA, and FAO funded and set up 779 CFRs around the country. However, only 54% of those CFRs are functioning, which means that the CFR committee is managing the areas through regular patrolling, meetings, law enforcement and fundraising activities. Those that are not functioning are either dried out or none of the activities cited above is being carried out. FiA, through interconnecting channels and habitat conservation, aims to establish 1200 CFRs in 75% of all communes by 2019 to increase fish productivity in wetlands and rice fields (RFFEP 2015).

A CFR is a natural or artificial fishpond of a certain size and shape, which must not dry up during the dry season and meant to conserve aquatic fauna (mainly fish). FiA established the CFR concept as a national policy in 2005 to promote fish production and increase fish yields of the surrounding rice fields, in addition to preserving fish biodiversity and other aquatic animals of the wetlands and Tonle Sap floodplain (Brooks et al. 2015). The CFR can be an enclosed area within a larger body of water or it can be an entire community pond, in which case the pond becomes disconnected from the floodplain during dry season. It is strictly prohibited to fish in these bodies of water all year round and they are managed by local community members with technical assistance from FiA staff (TWGF 2006 in Thuok 2009). CFRs and the surrounding water areas are mostly multiple-use water resources, where community ponds are also selected as water storage areas for irrigating rainfed rice-growing fields during the early wet season, for watering vegetable gardens, and sometimes, even for domestic use for local households.

The rice field fisheries (RFF) agro-ecosystem is made up of three domains: the rice fields, the CFRs and the connecting channels (rivers, creeks, canals). All of them are habitats for fish and other aquatic animals (OAAs). Based on a series of workshops among FiA, local NGOs and local authorities, the Rice Field Fisheries Enhancement Project (RFFEP) has defined the rice field fisheries ecosystems, including CFRs, into four different categories:

1. CFRs in upland irrigation reservoirs
2. CFRs as community ponds not prone to flooding (usually outside the Tonle Sap Lake road boundaries - highway 5 and 6)
3. CFRs as community ponds prone to flooding (typically inside the road boundaries)
4. CFRs as demarcated areas in a larger water body within the floodplain of the lake

The RFF channels facilitate fish movement to and from the CFR, and they can be up to 300m long or be a few meters connecting the CFR pond to the rice fields. Depending on the landscape setting, the CFR can also only be connected to the rice fields via a culvert or sluice with no channel. Once rice fields are flooded with about 25-50cm of water, especially after rice transplanting, fish use the fields as breeding, spawning, foraging and growing habitats (Thuok 2009), where rural farmers can use it as a fishing ground (Gregory 1997). Most of the rice fields around CFRs are planted with medium- or long-term maturity rice varieties in the early rainy season, while short-term rice varieties are planted during dry season.

CFRs are valuable as fish conservation habitat when a minimum water volume and depth is maintained throughout the seasons, which is why, due to meteorological conditions, a CFR that dries out more frequently within a 20-year period is considered poorly located. The use of CFR water for irrigation immediately reduces the fixed water quantity after the rainy season, but an effective way to monitor the water volume by committees is to use a marker pole planted in the CFR for all to see. Once the water level has dropped to the red color, committee members and households should stop any further water extraction as this will harm the fish populations. Another benefit of the marker pole is to maximize the amount of stored water available for topping up small-scale aquaculture or irrigating vegetable gardens (Brooks et al., 2015). During the period of six to nine months where the CFR is disconnected from the rice fields and the surrounded water bodies, fish stock is confined to the CFR water volume, which is why it is important to monitor water quality and ensure that the conditions of the CFR are optimized for growth and breeding.

Ideally, healthy CFR water is of green color and one’s hand appears visible even if it is 30 cm deep. Conversely, it should not be of brown color, which indicates heavy mineral turbidity that hampers sunlight penetration and plankton growth (Brooks et al. 2015). In CFR, the concentration of important nutrients for plankton is determined by the concentration of elements in the incoming channel water or run-off. Agricultural land with heavy fertilizers will be nutrient-dense, but often, CFR water in Cambodia has low concentration of the essential nutrients. A solution, in the form of a fertilizer, could be made to add the necessary elements, but this practice is expensive and its returns are unknown and unqualified (Brooks et al. 2015). A common problem in Cambodia is mineral turbidity in CFR water due to frequent heavy rainfall and flash floods that lead to soil erosion. The soil must be stabilized as much as possible by vegetation, which entails managing flooded forest and plant bushes when necessary.

Agroforestry

The concept of agroforestry involves a thoughtful process of integrating tree species and shrubs with crops cultivation, livestock production and other farm activities. This land management approach is practiced in both tropical and temperate regions, specifically in about 46% of all agricultural lands, by more than 1.2 billion people across the world (Chavan et al. 2015). Records also show that agroforestry currently supports 30% of all rural populations (Zomer et al. 2009). Planting trees on farming fields is widely practiced in Southeast Asia and in Central and South America (Lipper et al. 2010). Dawson et al. (2013) explained that agroforestry systems range from open parkland assemblages to dense imitations of tropical rainforests, and from planted mixtures of a few tree species to trees planted on boundaries of farms, involving different levels of human management. Among women, low-input agroforestry activities are often preferred as financial constrains keep them from affording expensive technologies (Dawson et al. 2013).

Many aspects of agroforestry are beneficial to the farmers and to the environment. Trees and shrubs on farm can provide essential ecosystem services, including soil fertility and moisture (increased organic matter), watershed protection, animal and plant biodiversity conservation, and carbon sequestration and storage, which ultimately would benefit food and nutritional security (Garrity 2004). Moreover, appropriate combinations of crops and trees can also increase farm yields and diversify production, thus increasing farmers' income and reducing risk of market failures. Since agroforestry helps in tackling the challenges of mitigating and adapting to climate change effects, and securing food and nutrition of smallholder farmers, the approach is seen as an important component in climate-smart agriculture (Dawson et al. 2013). Trees and shrubs can also reduce the impacts of extreme weather events such as droughts, heavy storms and rains, especially in rural and vulnerable areas in Cambodia. They also serve as important sources of livelihood and food for farmers; thus, taking the pressure off of the country's declining forests (Steele 2007).

Although agroforestry is recognized as an important leverage for climate change mitigation and adaptation in agriculture, the practice is still constrained in many regions due to local customs, institutions, and national policies (Lipper et al. 2010). Opportunities to develop agroforestry further include seeking support and engagement from private sector to increase partnerships (carbon credits being an incentive for private companies), building capacity, and researching and identifying species that are a good fit for the local ecological zone and agricultural practices. The Lengale Consulting Company for ActionAid (2013) reported that agroforestry must be applied such that shading effect or light competition between trees and crops is avoided. A careful selection of tree species is crucial, and trees can be planted in farming zones that are fragile and vulnerable to soil degradation such as near water sources, soil bunds of terraces, steep slopes etc.

In Bangladesh, UNDP piloted a project named the Triple F model, which stands for Forest, Fish and Fruit. The model introduced an innovative way to rejuvenate a barren coastal land into a productive zone. The project established mounds and ditches where fruit and timber trees can be planted and grown, and fish can be cultivated. Moreover, between the fruit and timber trees and along the banks of the ditches, vegetables can be cultivated, generating even more production outputs for farmers. The Triple F model can produce enough fruit, vegetables and fish to complement a household's nutritional requirements and generate more income from the sales of any extra produce. The project was launched in areas with coastal mangrove forests to protect crops and ditches from tidal surges and storms. Moreover, the mangrove forests and fruit and timber trees can be used for the fuel needs from villagers, and timber trees can even be cut down after they have matured to be sold. In Bangladesh, this Triple F model offers a great potential for coastal families to improve their food and income security (UNDP 2011).

In Rohal Suong, Cambodia, the village was largely covered by flooded forest before the 1990s, which generated high-value benefits to local villagers and the environment. Unfortunately, the land area of flooded forests diminished over the years due to agricultural expansions and high demand for firewood. Similar with Bangladesh, CCAFS could pilot an intervention based on the Triple F model contextualized to the Cambodian landscape and needs. A combination of rice field fisheries, CFR, flooded forests and fruit and timber trees can potentially be implemented in the village, maximizing production outputs from farming, fishing and trees, while adapting to and mitigating the impacts of climate change. More research and consultation with local communities and authorities are required to ensure the viability and feasibility of implementing such a model in Cambodia, but this could represent a great opportunity for a successful climate-smart practice and technology for the country.

Rainwater harvesting

Rainwater harvesting has been practiced over the millennia, especially in the water-scarce regions of the world. Based on IISD[1]'s definition of arid and semi-arid regions, their average annual rainfall is only up to 350mm and 700mm respectively, which qualifies Southeast Asia, including Cambodia, as a water-abundant region with a cumulative average annual rainfall of more than 1,500mm. However, with climate change, rainfall patterns are becoming more erratic during wet season, and periods of drought are becoming more persistent. In Cambodia,

[1] International Institute for Sustainable Development (IISD)

rains usually fall as heavy showers and are lost to run-off, and there is a high potential for evapotranspiration. Eighty percent of the Cambodian rainfall occurs during the six-month wet season (May to October) with less than 300mm of rainfall during dry season (November to April), which presents the same water scarcity in an arid region. Because rainfed rice production is underperforming as market demand grows, the farming system requires more input and a more secured water supply throughout the year to cope with unpredictable and prolonged drought periods, even during the wet season. To ensure that many farmers can use rainwater harvesting technologies in a durable way, these technologies should be affordable during and after implementation, manageable and easy to set-up with materials available locally, and adaptive to the needs of the communities (Sheinkman et al. 2015).

Rainwater harvesting is a practice of collecting rainfall runoff for different purposes. In agriculture, there are two main concepts and several technologies to harvest rain water (cf. figure below): macro- and micro-catchments. The former involves collecting and storing water in reservoirs (ponds) or pits or earth dams, while the latter involves trapping and storing rainwater in the soil profile (in-field), but it can also be harvested by redirecting water runoff into the field from outside.

In-field rain water harvesting (IRWH) is considered a climate-smart approach as it increases the access and availability of rainwater through the capture and retention of rainwater runoff within the fields, allowing enough time for infiltration. By using this technology, rainwater is collected over a short distance and stored in basins running along crop rows that will allow a deep infiltration into the soil. The basins can be covered with mulch to maintain soil moisture for a longer time, ensuring water supply for crops, fruit, and vegetable production (Sullivan et al. 2013). The benefits of using IRWH include:

- conserving limited rainfall water for longer periods enabling crop growth despite sporadic rainfalls,
- using water beyond the normal wet season,
- conserving almost 10% more carbon than traditional tillage methods,
- reducing soil erosion and nutrient depletion due to runoff,
- and supporting adaptation and mitigation of climate change strategies (Sullivan et al. 2013).

IRWH technologies have been used quite successfully in other countries in Asia and Africa. Bunds are one of the most common technologies used to collect surface runoff and increase water infiltration. They are built along field contour lines, where rainwater is slowed down, leading to an enhanced water infiltration and soil moisture. Bunds can have different designs to be suitable to the local grounds, although mainly two types are being used (contour bunds and semi-circular bunds), and they can be built either with soil or stones (Waelti & Spuhler 2012).

Integrated Pest Management

Integrated pest management (IPM) is an approach in agriculture where a set of practical pest control techniques is applied to avoid pest outbreaks in crops and to keep the use of pesticides and other interventions to the minimum due to their risks for human health and the environment (Kimkhuy & Chhay 2014). The objective of IPM is to grow healthy crops with the least disruption possible to agricultural ecosystems and to encourage natural pest control methods (FAO 2013).

In Cambodia, the first national IPM program was initiated in 1993, but the Ministry of Agriculture, Forestry and Fisheries (MAFF) officially made IPM one of the country's key crop production strategies in 1998. As of July 2002, MAFF established the National IPM Programme (NIPMP) to facilitate the coordination of all IPM interventions in Cambodia, with the main goal of promoting food security and food safety through sustainable intensified farming systems, including the promotion of integrated pest and crop management at farm level (Kimkhuy & Chhay 2014). Since its creation, the NIPMP has collaborated with various key institutions in 19 provinces to implement capacity building programs (farmer field schools) and participatory action research to provide farmer education at local levels. The implementation for IPM activities in Cambodia has showed successful results so far. Ngin (2004) stated that NIPMP achieved 15-35% increase in rice production, 15% increase in vegetable yields, 43% reduction in pesticide application, and 64% reduction in volume of pesticide use. At the end of 2013, the Cambodian IPM program has reached and trained 918 IPM trainers (38% women), 2797 farmer trainers (36% women), and 198,895 farmers (46% women) in rice, vegetable and crop cultivation (NIPMP 2013). IPM keeps the ecological balance in farming systems, while empowering farmers through informed decision-making and education. There has been a reduction of chemical pesticide use, soil and water pollution, pest resistance, and loss and damage of crops in areas where successful IPM methods were implemented (Kimkhuy & Chhay 2014).

Rodent management

Based on a recent study carried out for the research program CCAFS in Cambodia, farmers who were part of the focus group discussions identified rodents as the most important pest problem they have been facing. Mice and rats that attack rice crops at tillering and booting stages can cause large devastation of rice fields overnight. In fact, rodents are generally considered one of the major problems on rice farming in Asia during both pre-harvest and post-harvest stages (Singleton 2003). In Cambodia, no official national estimate of the losses of crops caused by rodents are recorded, but according to Singleton (2003), most farmers estimated that losses attributed to rats were greater than 20%. The common solution used by farmers to tackle a rodent infestation is through the use of chemical rodenticides such as zinc phosphide, which are also toxic and harmful to humans, animals and the environment (Palis et al. 2015).

The Australian Center for International Agricultural Research (ACIAR) developed an ecologically-based rodent management (EBRM) approach to tackle rat infestation in farming fields by combining cultural and physical rodent management practices. EBRM is a holistic system involving the participation of the whole community (not only farmers) in implementing rodent management activities, which include synchrony of rice cultivation, implementing short two-week campaigns on rodent control at key periods (before transplanting and after), reducing the width of irrigation banks in rice fields to less than 30cm to prevent rodent nests, improving general hygiene around the village and gardens, promoting synchronous fallow, and showing the use of community trap barrier system (CTBS) (Palis et al. 2015; Singleton et al. 2005; Brown 2006). To implement a CTBS, farmers must plant early 'trap crops' to lure rodents to these areas, which should be placed in surrounding rice fields and put in place about two weeks before the actual crop is planted. The trap crop is generally 20 x 20m, surrounded by a plastic barrier that carries at least one multiple-capture live-trap along each side (Palis et al. 2015; Singleton et al. 1999). The CTBS does not use poisons, and rodents that get trapped in the trap crop should be monitored daily. However, management and labor costs of using a CTBS seem higher than other typical baiting systems.

EBRM projects were implemented in Cambodia in the early 2000s by CARDI. The activities under EBRM included capacity building (for trainers, scientists and technicians), participatory research, production and distribution of training materials, annual project meetings, and dissemination of activities. The training activity was mainly focused on rodent biology, ecology of rice-field rodents, rodent control methods, taxonomy, and rodent identification. Capacity building exercises extended to training research staff and extension workers to transfer the skills necessary for them to pilot CTBS in the field and conduct community interventions, increasing the ability of government staff to implement EBRM in Cambodia (Palis et al. 2015). Farmers at the project sites also gained good knowledge and skills to rodent management, and became confident in selecting zones for the construction of CTBS. However, project reviews revealed that adoption of these practices was high only during the life of the project, and farmers could not continue applying them afterwards due to the high cost of materials used and lack of incentives. No evidence of EBRM scaling in Cambodia were recorded since then. In an unpublished report in 2003, Brown reviewed the results of the rodent management projects and found no significant impacts at the community level as a three-year period wasn't long enough for farmers to absorb the new techniques. A couple of aspects can be taken into account in order to improve farmers' adoption of new practices (Palis et al. 2015):

- Authorities influence the farmers' decision-making – introduction of innovations is easier and more accepted when done by an authority figure. To sustain the innovation at the community level, a strong and trustworthy leader must be present.
- Culture in Cambodia makes its population superstitious, and religious beliefs could influence their adoption or rejection of a new technology. Harming animals or people are believed to bring bad karma, and since Cambodians generally believe in reincarnation, they tend to be skeptical even on killing rodents.

Insect and disease management

In rice farming, there are various types of weeds, insects, and diseases attacking the crops, which can lead to massive production loss. Many rice pests are known, including the brown plant-hopper, armyworm, casework, leaf folder, stem borer, and gall midge. Cambodian rice is specifically sensitive to hopper attack, causing the plant leaf to turn brown (hopper burn). The golden apple snails have also become a pest on rainfed lowland rice (Jahn et al. 1997). Diseases emerge often but their effects vary depending on the crop variety, the climate, and the management practices in place. Even though major disease outbreak is rare, most rice crops experience attacks of blast, brown spot, sheath rot and blight (fungal), bacterial leaf streak, and tungro (Sarom 2007).

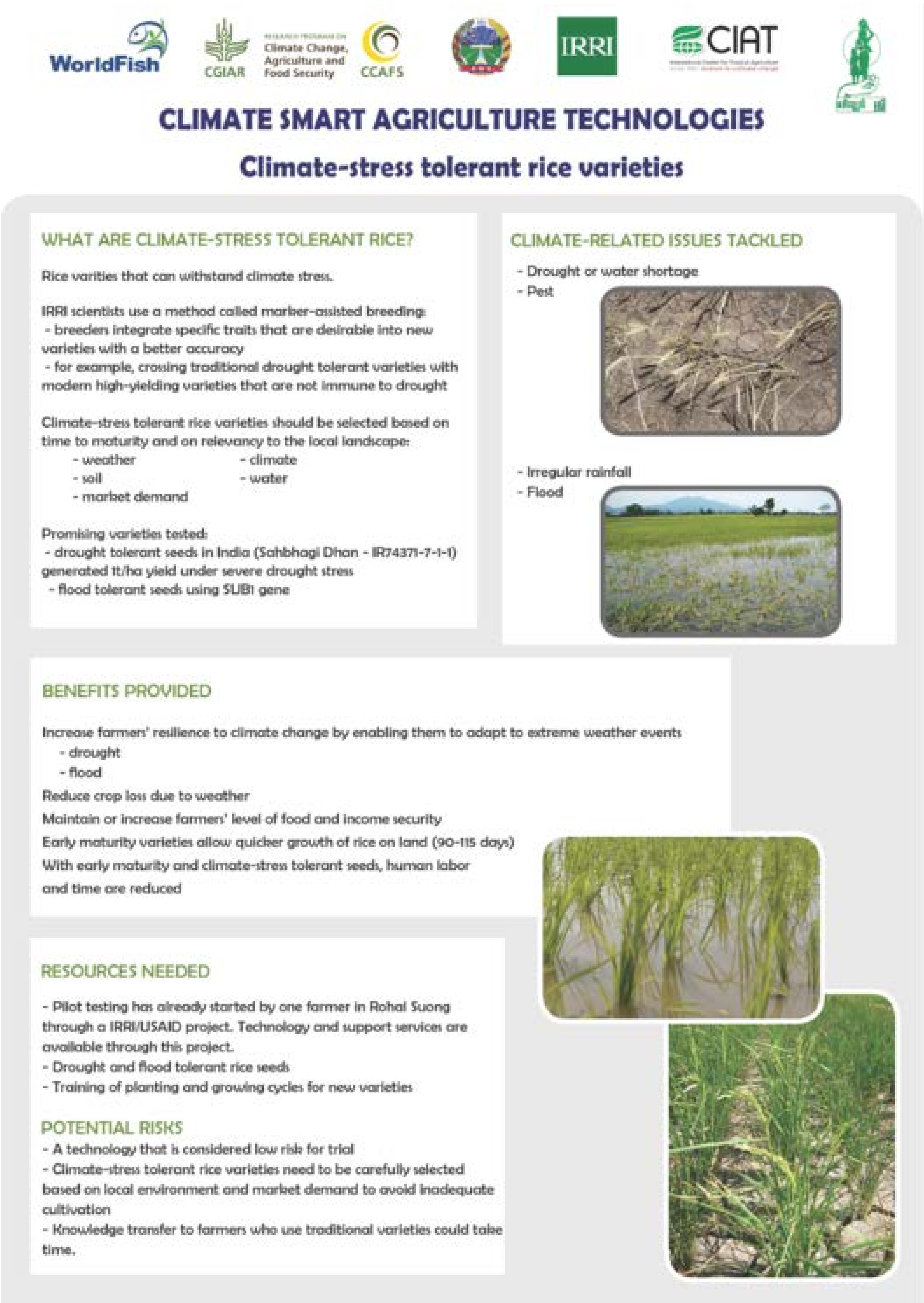
A basic IPM training program is also known as the Farmer Field School (FFS), where farmers learn and implement pest control activities on conditions they need to face on their fields. Teaching the farmers about ecological principles on their own fields is empowering and fulfilling as they have the chance to improve their own learning ability (Pontius et al. 2002). The basic educational model of FFS is based on the farmers' discovery-learning path and process, which serves as the launching pad for institutionalizing IPM at the community level (Pontius et al. 2002). Through CARDI's research work in Cambodia, national rice yield has increased significantly. Farmers were also trained to distinguish rice pests from rice-friendly insects and to learn pest control measures, including planting at appropriate times and growing pest-tolerant and disease-resistant varieties of rice (Sarom 2007).

As mentioned before, IPM entails a whole package of eco-friendly practices aimed to reduce or control pests in the farming system, while maintaining or increasing crop yields. The first principle of IPM is to create a healthy soil and crop through proper soil management, healthy seeds, and appropriate varieties; a robust crop displays less chances to develop pests or can recover better and easier from pest damages (Gallagher et at. n.d.). The second principle of IPM decision-making is to have a wider observation of the whole field, understanding patterns related to soil, water, plant, pests, natural enemies, and weather. All these are discussed during IPM training courses, and with this type of knowledge, farmers can better compare the costs of potential losses against management cost required to implement IPM practices, helping them make economically-sound decisions while understanding ecological and toxicological factors (Gallagher et al. n.d.).

Introducing new methods and getting farmers to fully adopt the IPM approach is not an easy task. Several strategies have been defined and tested at various levels of information and completeness. Most agricultural extension workers are aware of the importance of identifying pests and natural enemies, but promoting insecticides, herbicides and fungicides remains a common practice. Heong et al. (1998 & 1999) promoted IPM by developing radio messages to reach a large scale of farmers, teaching farming communities that early spraying of insecticides is not necessary and in fact increases the risk of higher pest populations later during crop cultivation. In Cambodia, farmers who have been trained or exposed to IPM courses can distinguish “good insects” from “bad insects”, and by learning about their life cycle and the nature of infestation, farmers are given a basis to design and implement the best pest control strategy that applies to their own situation.

Appendix B: Posters Developed for the Workshop

Climate-stress tolerant rice varieties



Alternate wetting and drying (AWD)

CLIMATE SMART AGRICULTURE TECHNOLOGIES

Alternate Wetting and Drying (AWD)

WHAT IS AWD?

A water-saving technology for rice production
Developed more than 10 years ago by IRRI and its partners

AWD can be implemented in irrigated lowland rice fields where soils can be drained in 5-day intervals
When using AWD, the rice field is alternatively flooded and non-flooded

An effective way to implement AWD: use a 'field water tube', also called 'pani pipe', to monitor water depth on the field: threshold of water at 15cm below the soil surface is considered as 'safe' because this should not cause any yield decrease.

"Poly pipe and alternate wetting and drying"
U.S. Department of Agriculture. Photo by Adam Chambers

CLIMATE-RELATED ISSUES TACKLED

- water shortage
- drought
- greenhouse gas emissions from rice culture

BENEFITS PROVIDED

Allow farmers to reduce their irrigation water use in rice fields without decreasing their yield
Practice has been known to save 15-30% of irrigation water
Help farmers cope with water scarcity and gain control over water use (better management of water resources)
Reduce labor costs by improving soil conditions
Help farmers who use irrigation pumps to save money on irrigation costs

AWD can reduce methane emissions from rice fields by around 48% without decreasing yields
AWD is one of the most promising practices for greenhouse gas emission reduction from rice culture

RESOURCES NEEDED

- Appropriate design of irrigation schemes is essential
- Need of knowledge and technology transfer to implement this technology
- Training activities for farmers, CSV team members and extension service.

POTENTIAL RISKS

- High rainfall as it can hinder the good functioning of AWD:
  - if the field is unable to dry during the rice-growing period
  - if rainfall exceeds water lost to evapotranspiration and seepage
- AWD in rainfed rice is not recommended due to uncertain water accessibility when fields have to be re-flooded

Community fish refuge (CFR)

CLIMATE SMART AGRICULTURE TECHNOLOGIES

Community Fish Refuge (CFR)

WHAT IS CFR?

First introduced to Cambodia in 1995

CFR is a natural or artificial fishpond of a certain size and shape, which never dries up throughout the year and use to conserve aquatic fauna.

CFR can be a delimited area within a larger water body or it can be an entire community pond, where it is strictly prohibited to fish all year round.

Rice field fisheries agro-ecosystem is made up of three domains:
1. CFR 2. Connectivity 3. Rice fields

CLIMATE-RELATED ISSUES TACKLED

- Water shortage or drought
- Disappearing habitat of fish and other aquatic animals
- Irregular rainfall in rainy season

Marker pole installed in CFR to monitor water level

BENEFITS OF CFR

Improve fish catch and productivity of rice field fisheries
Conservation area where aquatic fauna is enhanced
Multiple-use water resources:
- watering vegetable gardens
- domestic use for local households

RESOURCES NEEDED

- Require long-term collective work by setting up a CFR committee to manage the CFR
- Investments needed in terms of capital, operations, time, and human capacity and skills.
- Need regular maintenance and monitoring, or else it will dry up or lose capacity to provide benefits mentioned above.

POTENTIAL RISKS

- overuse of CFR water until it dries up
- can attract illegal fishers
- people not following the rules around CFR management

Agroforestry

CLIMATE SMART AGRICULTURE TECHNOLOGIES

Agroforestry

WHAT IS AGROFORESTRY?

The process of integrating tree species and shrubs with crops cultivation, livestock production and other farm activities.

Agroforestry systems range from open parkland assemblages to dense imitations of tropical rainforests, and from planted mixtures of a few tree species to trees planted on boundaries of farms.

The approach is seen as an important component in climate-smart agriculture.

CLIMATE-RELATED ISSUES TACKLED

- land degradation
- deforestation
- greenhouse gas emissions

BENEFITS PROVIDED

Trees and shrubs on farm can provide essential ecosystem services, including soil fertility and moisture, watershed protection, animal and plant biodiversity conservation, and carbon sequestration and storage.

Appropriate combinations of crops and trees can increase farm yields and diversify production.

Contribute to food and nutritional security + increasing farmers' income and reduce risk of market failures.

RESOURCES NEEDED

- human resources: labor and time spent to implement and maintain the trees
- skills and activities: cutting and collecting tree products (branches, fruit, leaves, trunk etc.)
- materials: seeds, seedlings, saw, machete, sharp hook, secateurs etc.

POTENTIAL RISKS

Lack of past experience and information specific to Cambodia
Tree area can become a habitat for rodents and weeds

Rainwater harvesting

CLIMATE SMART AGRICULTURE TECHNOLOGIES

Rainwater harvesting

WHAT IS RAINWATER HARVESTING?

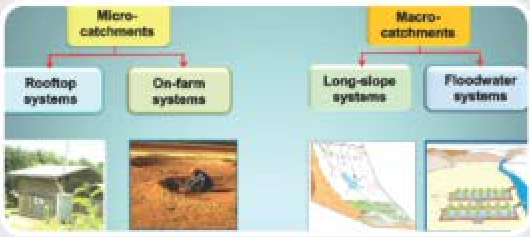
A practice of collecting rainfall runoff for different purposes

In agriculture, there are two main approaches to harvest rain water
- macro-catchments: collecting and storing water in reservoirs (ponds) or pits or earth dams
- micro-catchments: trapping and storing rainwater in the soil profile (in-field), but it can also be by redirectingwater runoff into the field from outside

In-field rainwater harvesting collects water over a short distance and stored in basins running along crop rows that will allow a deep infiltration into the soil.
Basins can be covered with mulch to maintain soil moisture for a longer time, ensuring water supply for crops, fruit and vegetable production.

CLIMATE-RELATED ISSUES TACKLED

- water shortage
- drought
- heavy rainfalls



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BENEFITS PROVIDED

In-field rainwater harvesting increases the access and availability of rainwater through the capture and retention of rainwater runoff within the fields, allowing enough time for infiltration.

Conserving limited rainfall water for longer periods enabling crop growth despite sporadic rainfalls

Reducing soil erosion and nutrient depletion due to runoff

Conserving almost 10% more carbon than traditional tillage methods

Supporting adaptation and mitigation of climate change strategies

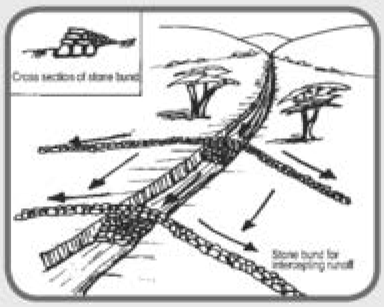
RESOURCES NEEDED

- capital investment
- materials: tank, tools to create pathways for rainwater, ponds, pump
- human resources: skills, labor and time

Rooftop rainwater harvesting tank is considered as a costly system.

POTENTIAL RISKS

- Rainwater harvesting isn't completely new to Cambodia, but very few have implemented it for agriculture activities.



Integrated pest management: Insects and disease

CLIMATE SMART AGRICULTURE TECHNOLOGIES

Integrated Pest Management (IPM)

WHAT IS IPM?

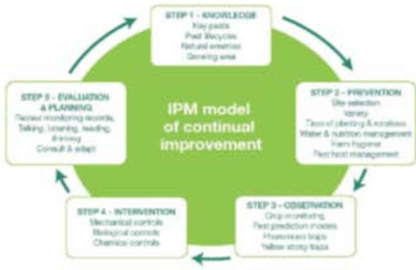
An approach in agriculture where a set of pest control techniques is used to hinder the development of pest populations in crops
IPM maintains pesticides and other interventions to the minimal level of risks for human health and the environment

Cambodian rice is specifically sensitive to hopper attack, causing the plant leaf to turn brown, and
golden apple snails have become a pest of rainfed lowland rice

Basic IPM training program is known as the Farmer Field School:
- farmers learn and implement pest control activities in the fields, including identifying rice pests from friendly insects
- farmers becoming knowledgeable in ecological principles
- basic educational model is based on farmers' own discovery-learning path and process

CLIMATE-RELATED ISSUES TACKLED

- pest and disease outbreak



BENEFITS PROVIDED

Successful IPM can increase farming production, decrease loss and damage of crops, ensure healthier soil and water resources, and reduce use and application of pesticides (money saved).

IPM helps keeping ecological balance in farming systems, while empowering farmers through informed decision-making and education.

Farmer field school empowers farmers to improve their own learning ability and knowledge of ecological principles, and implement the best pest control strategy that applies to their own field.

RESOURCES NEEDED

- capacity development: training of farmers
- farmers' time and labor
- capital investment and operational costs as IPM usually involved a series of pest control activities.

POTENTIAL RISKS

- IPM can be considered quite costly for farmers compared to usual pesticides.
- Depending on landscape, not all IPM practices can be easily applied.

Ecologically-based rodent management (EBRM)

CLIMATE SMART AGRICULTURE TECHNOLOGIES

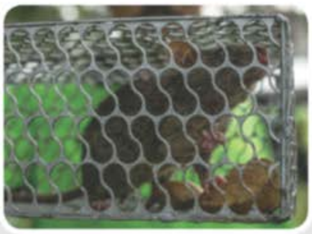
Ecologically-Based Rodent Management (EBRM)

WHAT IS EBRM?

Rodents = one of the major problems on rice farming in Asia during both pre-harvest and post-harvest stages
Common solution used by farmers to tackle a rodent infestation: chemical rodenticides such as zinc phosphide, but it's toxic and harmful to humans, animals and the environment

EBRM is a practice of Integrated Pest Management (IPM) in agriculture, used to prevent and hinder rodent infestation in crops:
- approach combining cultural and physical rodent management practices
- holistic system involving the participation of the whole community (not only farmers)

EBRM activities include:
- synchrony of rice cultivation
- implementing short two-week campaigns on rodent control at key periods (before transplanting and after),
- reducing the width of irrigation banks in rice fields to prevent rodent nests,
- improving general hygiene around the village and gardens,
- promoting synchronous fallow
- implementing community trap barrier system (CTBS)



CLIMATE-RELATED ISSUES TACKLED

- rodent infestation

Trap crop (CTBS), surrounded by a plastic barrier, with multiple-capture live-trap along each side

BENEFITS PROVIDED

EBRM helps decrease loss and damage of crops, ensure a healthy farming system, decrease costs of control and reduce use of chemical rodenticides.

Through training, farmers can gain good knowledge and skills to rodent management.

EBRM brings the community together to work in group, which enhance participation and solidarity among them.

RESOURCES NEEDED

- extended capacity development
- farmers' time and labor
- capital investment
- operational costs: mnagement and labor costs of using a CTBS seem higher than other typical baiting systems

POTENTIAL RISKS

- materials used can be costly and farmers might not be able to continue applying these activities after the project ends due to the high costs

Appendix C: Results of Participatory Prioritization of CSA Technologies

1. Climate-stress tolerant rice varieties

INPUT VARIABLE	SCORE	REMARK
Financial capital needed	3	This practice may need some budget to demonstrate the new rice varieties in the village.
Labor needed	2	This one is that different from current rice farming practices in term of labor. Currently, majority of the farmers use machineries or semi-machineries to replace human labors.
Degree of dependency on female labor	2	The heavy workload is taken care by men while the rest is taken care by women
Outside technical support needed	4	It is partly new for our farmers since we used to practice with traditional and other varieties. We therefore need technical guidance and support from project staff or experts to ensure we apply it correctly.
Amount of cooperation needed among villagers	3	This practice can be piloted in either individual household or famer groups but of course we need cooperation among the farmers. For instance, update the progress, exchange result and lessons, and find the market.
TOTAL SCORE	**14**	
OUTPUT VARIABLE		
Sustainable resource use and conservation /environment improvement	3	This practice will not destroy any natural resources or environment, and it will apply on existing rice fields.
Food security	5	The practice of climate stress-tolerant rice varieties contribute strongly to food security since rice is a main food source in the rural Cambodia.
Income generation/ economic improvement	4	It will provide incomes to local farmers if these new varieties can grow well with high yields.
Benefits for women (gender equity and women's empowerment)	5	We expect the new rice varieties will provide high yield with good market price, leading to an improved economic status of the household. The benefits must also apply to the woman, who manages the finances of the household.
Community development	3	Once economic status of household is improved, the community is also developed. These practices, however, are sometimes practiced individually.
Respond to improved CC adaptive/ resilience capacity	5	This practice responds directly to improved climate change adaptation.
TOTAL SCORE	**25**	
RISK ASSUMPTION		
Social factors	3	At this stage local people generally is practicing rice farming with rice varieties that respond to market demands. Famers here are uncertain whether new varieties work or not; they also concern the market price.
Climate, weather and environment risk	3	Rice farming is highly dependent on rainfall; in some years, rainfall comes late. Another risk of practice is flood

		since this village and rice field is highly vulnerable to floods.
TOTAL SCORE	**6**	
OVERALL ASSESSMENT	☺	Recently farmers here are facing the issues of drought and flood. In some years, rice production is too low since it has been affected by weather or/and flood. Famers therefore want to try other new rice varieties that are tolerant to climate-stress.

2. Alternate wetting and drying (AWD)

INPUT VARIABLE	SCORE	REMARK
Financial capital needed	3	This one seems very new for farmers here and perhaps we need some resources and instruments to control water and other factors.
Labor needed	1	It seems that we do not need much labor to do this work, but we need more instruments and machineries.
Degree of dependency on female labor	1	This practice does not require much labor and those work are taken care by men.
Outside technical support needed	4	This one seems very new for farmers, so our farmers need technical guidance and support from the research team and other experts.
Amount of cooperation needed among villagers	3	This practice can be piloted in either individual household or famer groups, but, of course, we need cooperation among the farmers. For instance, we need to update the progress, exchange result and lessons, and find the market.
TOTAL SCORE	**12**	
OUTPUT VARIABLE		
Sustainable resource use and conservation /environment improvement	4	This practice provides a great benefit to farmers and environment because it can save water from rice farming practices.
Food security	4	Rice is a main food source for rural Cambodia.
Income generation/ economic improvement	4	If this farming method work well and provide a high yield, the farmers' income will be improved.
Benefits for women (gender equity and women's empowerment)	2	The benefits of this practice target the women, although not in a direct way.
Community development	3	Once the economic status of the household is improved, the community will develop. These practices, however, are sometimes practiced individually.
Respond to improved CC adaptive/ resilience capacity	3	This practice responds directly to climate change adaptation. It saves water in rice farming.
TOTAL SCORE	**20**	
RISK ASSUMPTION		
Social factors	1	Local farmers are practicing rice farming that respond to market demands, but they sometimes lack water resources. They are interested in piloting this water-saving method.

Climate, weather and environment risk	1	It is not that risky since this method can control water.
TOTAL SCORE	**2**	
OVERALL ASSESSMENT	☺	Lack of water for rice cultivation is one of the main issues in Cambodia's agriculture sector; thus, rural farmers want to test the rice cultivation method that requires less water.

3. Community fish refuge (CFR)

INPUT VARIABLE	SCORE	REMARK
Financial capital needed	3	Community fish refuge, of course, needs more capital and resources to be implemented and it also takes time since it requires collective work. However, some infrastructures, both hard and soft infrastructures, already existed for this intervention; for instance, the committees of community fisheries and water user group are structured and some ponds are already in place.
Labor needed	4	This work is labour-intensive, which requires consultations with villages and key stakeholders, rehabilitation of refuge ponds, building of water infrastructures, raising awareness, and monitoring and maintenance of infrastructures, among others.
Degree of dependency on female labor	2	Most of the work required is physical labor; thus, it needs more male laborers. This project, however, requires women to participate in the process.
Outside technical support needed	4	The community fishery is already existing in the village, but a project of community fish refuge seems still new to our people. We need technical support and lessons from experienced communities, the project team, and other experts.
Amount of cooperation needed among villagers	4	This requires collective work; thus, we really need a strong commitment and cooperation among villagers and key stakeholders.
TOTAL SCORE	**17**	
OUTPUT VARIABLE		
Sustainable resource use and conservation /environment improvement	3	This project focuses on protecting the fish in the refuge ponds and improving fish habitats and migration channels. With this project, fisheries resources, both in refuge and rice fields, will improve.
Food security	3	Once fish resources are increased in the rice fields, local people can catch more fish for household consumption.
Income generation/ economic improvement	3	If their catch is beyond their consumption, households can sell the excess to generate more income.
Benefits for women (gender equity and women's empowerment)	2	If the amount of catches increases, food security and income generation will be achieved, which will directly benefit the women and children of the households.
Community development	2	This requires collective work. The success of this project entails the development of the community.

Respond to improved CC adaptive/ resilience capacity	2	Water in the refuge pond is not just for fish only, but also for household consumption and home gardening.
TOTAL SCORE	**15**	
RISK ASSUMPTION		
Social factors	1	There are no major challenges in terms of social arrangements since the community fishery has been set up there and supported by many stakeholders, including the village, commune, and fisheries authorities.
Climate, weather and environment risk	1	The environmental and ecological systems suit the community fish refuge, but some ponds and water connectives need to be restored.
TOTAL SCORE	**2**	
OVERALL ASSESSMENT	☺	Previously, fishery resources were abundant; local people even earned from their catches. However, recently, fish resources faced a sharp decline. The community refuge pond project is the most suitable approach to restore and improve fish resources.

4. Agroforestry

INPUT VARIABLE	**SCORE**	**REMARK**
Financial capital needed	5	Agroforestry is not that new to us, but we only apply it on a small scale such as around our houses or in home gardening. It may need big financial investments if we are to apply it in a large-scale level.
Labor needed	4	Labor is required regardless if the implementation is applied on a small- or large-scale level. For instance, in terms of small-scale implementation, we need labor for nursery plants, land preparation, tree planting and maintenance.
Degree of dependency on female labor	3	It requires more physical labor, but the participation of both women and men is most crucial to its success.
Outside technical support needed	4	We need technical support from the research staff and technical outsiders on topics such as tree species identifications, associated plant identifications, planting technical, and harvesting systems.
Amount of cooperation needed among villagers	4	This practice can be piloted either in an individual household or community level. If we apply it at the community level, we need the cooperation of all villagers.
TOTAL SCORE		
OUTPUT VARIABLE		
Sustainable resource use and conservation /environment improvement	4	This is a kind of activity that improves the environment, which entails replanting of flooded forests in the conservation zones and community ponds.
Food security	4	Tree and vegetable products provide can be allotted to household consumption. Trees and shrubs on farms can provide feeds to livestock.
Income generation/ economic improvement	4	If local people are practicing agroforestry in a larger scale, they can sell agroforestry products to generate income.

Benefits for women (gender equity and women's empowerment)	3	This practice does not target the women directly, but it may contribute some benefits such as food and income generation to women and children.
Community development	3	It will contribute to community development through food and income generation in the community.
Respond to improved CC adaptive/ resilience capacity	4	Trees and shrubs on farms will play essential role to maintain the soil fertility and moisture, watershed protection, biodiversity conservation, and carbon storage.
TOTAL SCORE	**22**	
RISK ASSUMPTION		
Social factors	1	Some households want to grow trees on the farm borders, while some neighbours are reluctant to do so since they believe that the shade of tree will affect crop production negatively.
Climate, weather and environment risk	1	Some trees cannot grow in paddy field since those areas are usually affected by floods.
TOTAL SCORE	**2**	
OVERALL ASSESSMENT	☺	There were plenty of flooded forests in that area before 2000 but they were destroyed due to agriculture land expansion and market demands. We believe that trees will provide benefits to our farms and our living condition such as soil fertility and moisture and watershed protection and food.

5. Rainwater Harvesting

INPUT VARIABLE	SCORE	REMARK
Financial capital needed	4	Rainwater harvesting is a good practice to introduce here, but it needs a big investment, both financial capital and commitment. The capital will be invested into a piece of land for water pond building or restoring and internal regulation.
Labor needed	3	Yes, labor is required to prepare and maintain the water ponds.
Degree of dependency on female labor	2	The works are mostly physical in nature and do not require female labor. Still, we need the participation of women on this project.
Outside technical support needed	4	We can build the pond for collecting rainwater, but we are uncertain in terms of the technical aspect. We need technical experts to support this project.
Amount of cooperation needed among villagers	4	Generally, this project requires collective work; we really need cooperation among the community members and the village and commune authorities.
TOTAL SCORE	**17**	
OUTPUT VARIABLE		
Sustainable resource use and conservation /environment improvement	4	The pond can store water for longer periods, especially during dry seasons, and it can even be used to grow vegetables by that time.

Food security	3	It will also provide water for household and animal consumption during the dry season. Also, it sometimes provides fish, which the households can consume.
Income generation/ economic improvement	3	This project does not generate income right away but it can reduce the farmers' vulnerability to drought.
Benefits for women (gender equity and women's empowerment)	3	It may benefit the women since they are taking care of the food and domestic water for their households.
Community development	4	This is a collaborative effort. It can foster community development in the long run.
Respond to improved CC adaptive/ resilience capacity	3	This project responds directly to climate change because it improves the community resilience. During dry seasons, for instance, the pond can be used for domestic and animal consumption and recuse the vegetable in the dry season.
TOTAL SCORE	**20**	
RISK ASSUMPTION		
Social factors	1	Some households face challenges due to lack of water supply. They would want to build or restore this for water storage.
Climate, weather and environment risk	1	Flood may destroy some ponds, and those that are too small and shallow may not be able to store water for long periods.
TOTAL SCORE	**2**	
OVERALL ASSESSMENT	😐	Generally local people there want to build or restore some ponds to collect rainwater for consumption during the dry season but what they concern is capital investment. The local people are reluctant on this project.

6. Integrated pest management (IPM) - insects and disease

INPUT VARIABLE	SCORE	REMARK
Financial capital needed	3	It does not need much financial recourse; some ingredients are cheap and available locally as well.
Labor needed	3	Labor is required to find certain ingredients such as neem, tobacco, and other elements.
Degree of dependency on female labor	3	This practice does not require labor from the women alone. In general, it needs both men and women although it still depends on the household.
Outside technical support needed	4	In this village, farmers usually apply chemical pesticides and lack understanding about integrated pest management techniques. We need technical support for this project.
Amount of cooperation needed among villagers	4	We sometimes cannot fight pest and disease outbreaks alone; we need to work together.
TOTAL SCORE	**17**	
OUTPUT VARIABLE		

Sustainable resource use and conservation /environment improvement	4	Integrated pest management is more based on biological treatment, so this approach will not harm the environment.
Food security	4	If the pest or diseases on crops are treated well, of course, it will contribute to food security.
Income generation/ economic improvement	3	Same with the previous case, crops are grown and treated well so they will generate more income for the farmers. Moreover, this approach helps the farmers save some money from chemical pesticides.
Benefits for women (gender equity and women's empowerment)	3	This practice can generate more income for the women, improving their living conditions and their power in the households.
Community development	3	We can work together to achieve community development, although this seems to be not finalized yet.
Respond to improved CC adaptive/ resilience capacity	3	It may contribute to climate change adaptation, but not in a direct manner.
TOTAL SCORE	**20**	
RISK ASSUMPTION		
Social factors	1	Many farmers are interested in integrated pest management since they are plagued with issues on pest and disease.
Climate, weather and environment risk	1	Many things are controllable, but the result of treatment is coming slowly.
TOTAL SCORE	**2**	
OVERALL ASSESSMENT	☺	We really need this method to treat our crops since we are facing pest and disease outbreaks almost every year. We also apply a chemical approach that costs a lot of money and provides negative impacts to our health and to the environment.

7. Ecologically-based rodent management (EBRM)

INPUT VARIABLE	SCORE	REMARK
Financial capital needed	3	It does not need a large financial recourse. Some materials are cheap and readily available as well.
Labor needed	4	Labor is required to collect the materials.
Degree of dependency on female labor	2	It relies more on physical labor; thus, men here will be more involveds.
Outside technical support needed	4	Rat outbreaks are a major concern on this village. Our farmers resort to biological methods and sometimes chemical approaches to catch rats. However, these are not effective. At this stage, perhaps we need alternative methods from outsiders or experts.
Amount of cooperation needed among villagers	4	We cannot address this issue alone. We must work together to wipe out those rats.
TOTAL SCORE	**17**	
OUTPUT VARIABLE		

Sustainable resource use and conservation /environment improvement	3	Ecologically-based rodent management is an environmental friendly approach; it will not harm the environment.
Food security	3	If we can protect our rice and other crops from rats, yields will be improved. This will contribute to our food security.
Income generation/ economic improvement	3	Once yields are improved, this will provide more income to the farmers. They can even save some money because they will reduce their use of pesticides.
Benefits for women (gender equity and women's empowerment)	2	This practice can generate more income for the women, improving their living conditions and their power in the households.
Community development	2	We can work together to achieve community development, although this seems to be not finalized yet.
Respond to improved CC adaptive/ resilience capacity	2	It may contribute to climate change adaptation, but not in a direct manner.
TOTAL SCORE	**15**	
RISK ASSUMPTION		
Social factors	1	Some farmers are interested in this approach and want to apply this method here.
Climate, weather and environment risk	1	It seems that this method is not affected by climate or weather.
TOTAL SCORE	**2**	
OVERALL ASSESSMENT	😐	It is a good practice but perhaps we should prioritize others such as pest management, which addresses our immediate issues.

Appendix D: Workshop Agenda

DAY I: PREPARATION (DEC 23, 2015)			
TIME	Main Activities	Leaded by	Remarks
08:00-12:00	Introduce the program and approaches to CSV team members: - Overview of workshop program - Review all CSA technologies/practices (posters, PPT presentations, video clips) - Task divisions	Dyna	- All CSV team members - AS office
14:00-17:00	- Continue the work and - Logistic preparations for workshop	CSV team	
DAY II: WORKSHOP DAY (DEC 24, 2015)			
TIME	Main Activities	Leaded by	Remarks
08:00-08:10	- Introduction to workshop program, objectives, and approaches - Brief remark of the CCAFS program	Dyna	- All participants
08:10–09:10	- Give an overview of first four/five CSA technologies/practices (through posters, PPT presentations, or Video clips) - Question and answer	CSV team	- All participants
09:10-09:40	- All participants are broken into small groups - Each group visit the posters of CSA technologies/practices by busing bus stop method (CSV team members stand at each poster boot to explain what is CSA technologies/practices about)	Dyna	- All participants - Bus stop method
09:40-10:00	- Tea break		
10:00-11:00	- Give an overview of second four/five CSA technologies/practices (through posters, PPT presentations, or Video clips) - Question and answer	CSV team	
11:00-13:00	- Lunch break		
13:00-14:00	- All participants are broken into small groups - Each group visit the posters of CSA technologies/practices by busing bus stop method (CSV team members stand at each poster boot to explain what is CSA technologies/practices about)	CSV team	- All participants - Bus stop method
14:00-14:30	- Introduce the CSA scoring method	Dyna	- All participants

	- Question and answer		-
14:30-15:30	- Exercise on participatory selection of CSA technologies/practices	CSV team	- All participants - Scoring method
15:30-15:45	- Tea break		-
15:45-16:30	- Present the result of exercises and discussion	Dyna	- All participants - Plenary
16:30-16:45	- Conclusion and closing	CSV team	- All participants
TIME	Main Activities	Leaded by	Remarks
08:00-12:00	Introduce the program and approaches to CSV team members: - Overview of workshop program - Review all CSA technologies/practices (posters, PPT presentations, video clips) - Task divisions	Dyna	- All CSV team members - AS office
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14:30-15:30	- Exercise on participatory selection of CSA technologies/practices	CSV team	- All participants - Scoring method
15:30-15:45	- Tea break		-
15:45-16:30	- Present the result of exercises and discussion	Dyna	- All participants - Plenary
16:30-16:45	- Conclusion and closing	CSV team	- All participants

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