Mekong Development Research Institute
Power of Knowledge

Energy transition and climate-smart agriculture in Vietnam
Pilot Activity 1 Report

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Contents

1. Introduction

Vietnam is among the world's top rice producers, with a production volume exceeding 43 million metric tons in 2023. The rice production process generates a significant amount of straw. According to the International Rice Research Institute, the straw-to-paddy ratio ranges from 0.7 to 1.4, depending on the variety and growth conditions. This implies that Vietnam produces over 40 million metric tons of rice straw annually. This biomass source contains organic matter and nutrients, offering economic benefits if exploited properly. However, most of this by-product is not used or treated appropriately, with much of it being burned or buried in the fields. This results in wasted by-products from rice production, degrades agricultural land, pollutes the environment, affects community health, and poses challenges for the agricultural sector, especially as the country is aiming to promote the development of a circular economy and reduce net emissions to zero.

Currently, there are alternative solutions for treating straw, such as making organic fertilizers, growing straw mushrooms, and producing livestock feed. These solutions provide economic benefits and are more environmentally friendly and healthier for people. However, widespread and regular adoption of these solutions faces many difficulties, mainly due to the habits and knowledge of farmers, as well as direct costs and opportunity costs that arise.

In that context, within the scope of the research Energy transition and climate-smart agriculture in Vietnam (ETCAV), the Mekong Development Research Institute (MDRI) is collabourating with the Institute of Policy and Strategy for Agriculture and Rural Development (IPSARD), the Central Institute for Economic Management (CIEM), and the Development Economics Research Group at the University of Copenhagen, Denmark (DERG) to conduct a study on reducing straw burning in rice production in the Red River Delta – the country's second-largest rice-growing region. Specifically, the research group will design and implement a large-scale randomized controlled trial (RCT) that aims to measure the efficacy of providing farmers with financial incentives and information on crop residue burning.

In preparation for the RCT, MDRI partnered with DERG to conduct a pilot study focused on implementing support measures in finance, information, and market linkages to encourage farmers to reduce or eliminate straw burning. The findings from this pilot study provide essential insights for designing the large-scale RCT intervention. As such, the pilot study consists of three activities:

- Activity 1: Focus Group Discussions with rice farming households. This activity seeks to explore the awareness, knowledge, and practices of rice-farming households regarding smart agriculture and straw management methods. The findings from this activity also inform the design and implementation of Activity 2.

- Activity 2: Pilot measures to reduce straw burning. The purpose of this activity is to evaluate the feasibility of support measures in finance, knowledge, and market linkages in encouraging the reduction of straw burning.

- Activity 3: Rice farming households survey. The purpose of this activity is to evaluate the feasibility of expanding the research on a large scale and to assess the feasibility of the survey tool.

This report presents the main findings from Activity 1.

2. Key findings

2.1 Sample characteristics

Activity 1 was carried out in 12 communes across three provinces: Bac Ninh, Ha Nam, and Ninh Binh. The initial selection of these provinces and communes was based on the average number of fires or burnings detected by satellites within their administrative boundaries over the past three years. The research team consulted with local authorities regarding this selection, who suggested adjustments to better align the research areas with current local economic priority shifts. The list of communes is as follows:

Table 1. List of the consulted communes for the FGDs

Province	District (Initial)	Commune (Initial)	District (actual)	Commune (actual)
Bac Ninh	Yen Phong	Van Mon	Yen Phong	Van Mon
Bac Ninh	Yen Phong	Dong Tho	Yen Phong	Dong Tho
Bac Ninh	Tien Du	Phu Lam	Tien Du	Phu Lam
Bac Ninh	Tien Du	Tan Chi	Tien Du	Tan Chi
Ha Nam	Thanh Liem	Thanh Nghi	Thanh Liem	Thanh Nghi
Ha Nam	Thanh Liem	Thanh Tan	Thanh Liem	Thanh Tan
Ha Nam	Kim Bang	Thanh Son	Binh Luc	Don Xa
Ha Nam	Kim Bang	Dai Cuong	Binh Luc	Dong Du
Ninh Binh	Hoa Lu	Ninh Van	Hoa Lu	Ninh Van
Ninh Binh	Hoa Lu	Ninh Hai	Hoa Lu	Ninh Hai
Ninh Binh	Gia Vien	Gia Tan	Gia Vien	Gia Tan
Ninh Binh	Gia Vien	Gia Xuan	Gia Vien	Gia Xuan

Figure 1. Field observation in Bac Ninh

In each commune, the research team conducted a Focus Group Discussion (FGD) in one village, involving six experienced farmers from rice-cultivating households. Participants were invited by local authorities, with an effort to ensure gender balance as much as possible. Almost all of the participants were over the age of 50 and the gender ratio was approximately equal. The primary source of income for most respondents was self-employment in agriculture. However, in Ninh Hai commune (Hoa Lu, Ninh Binh), the majority were primarily engaged in self-employment in non-agricultural activities.

Figure 2. A focus group discussion in Ha Nam

The characteristics of the respondents as well as their sharing during the FGDs suggest that the demographic profile of rice farmers in Vietnam has been undergoing significant shifts over the past couple of decades. Traditionally dominated by younger generations, rice cultivation is increasingly becoming the domain of older farmers as younger people migrate to urban areas for education or seek employment opportunities in non-agricultural sectors, which offer more lucrative and stable income options outside farming. This demographic ageing is driven by rapid industrialization and urbanization in the Red River Delta provinces. As a result, many rice farmers today in the region are over the age of 50, relying primarily on traditional knowledge and practices. This challenge is exacerbated by the fragmentation of rice farming in these regions, where small, scattered landholdings limit opportunities to achieve economies of scale. Additionally, with rice productivity in the region having already reached its peak, the potential for substantial economic gains is minimal. The lack of scalability and economic incentives, combined with the relatively low income from rice farming, further hinders modernization and the adoption of greener, more sustainable practices.

Additionally, and also following the decline in the agricultural labour force, recent planning in the consulted districts tends to shift land use allocation towards industry promotion. From the consultations with the commune authorities in the pilot, almost everywhere has industrial zones or at least factories or recycling industry neighbourhoods (such as one in Yen Phong District, Bac Ninh where the first FGD was conducted). Those industrial areas also have combustion and smoke-like emissions, yet usually in darker colours (e.g., dark grey or black) than the smoke from rice straw burning. Accordingly, fragmented rice field plots have been merged into larger fields for easier management and more effective production in the long term. Along with the reallocation and shrinkage of rice field areas is the expansion of industrial areas. This is the reason for the local authority in Ha Nam to advise switching the FGDs from Kim Bang District (originally suggested) to Binh Luc District (as in Table 1) as Kim Bang has been planned for industrial promotion and hence significantly reduced its rice production area.

Figure 3. Emitting industrial chimneys adjacent to rice fields in Ninh Binh

2.2 Rice cultivation practices

In Bac Ninh and Ha Nam, farmers typically grow two rice crops each year: the Winter-Spring season (Chiem) and the Summer-Autumn season (Mua). However, in Thai Binh, only about half of the farmers grow both crops due to the region's low-lying terrain, which makes fields prone

to flooding during the rainy season, from May to November. Despite these regional differences, rice cultivation practices in the three provinces are generally quite similar.

The Chiem season is the primary rice-growing season across all three provinces. Preparation begins in December, with farmers planting rice in seedling beds while simultaneously clearing residues of the previous crop from the main rice fields. In areas where vegetables like tomatoes, potatoes, or pumpkins are grown in the winter, farmers often burn the crop remains due to the short time between seasons. However, in most areas where the transition before the Chiem season lasts several months, the farmers do not need to do much as residues of the previous crop have been naturally decomposed. After land clearing, mechanized tractors are used to till the soil, and then fields are flooded to create ideal conditions for transplanting rice seedlings in January. The Chiem crop is typically harvested in May or early June, depending on factors like rice variety, soil quality, and weather conditions.

The Mua season is characterized by the hotter temperatures and the onset of the monsoon rains. Planting rice in seedling beds and preparing the main fields generally begins in June. Due to the short time between the two crops, farmers must quickly clear the main fields. Those farming in higher terrain or areas with limited water sources typically burn the residues, while farmers in lowland areas that are more prone to flooding usually use tractors to bury straw and stubble into the soil for natural decomposition. The warm, wet conditions during the Mua season promote rapid rice growth, and harvesting typically occurs between October and early November. In areas like Gia Xuan and Ninh Hai communes in Ninh Binh, flooding is common during this period. As a result, some farmers turn to aquaculture on rice fields as an alternative livelihood, while others may rent out their land or leave it fallow until the next rice season.

Figure 4. A flooded rice land plot left unburnt after harvesting in the Mua season

Farmers in the three provinces typically cultivate rice on all the plots allocated to their households. Since the implementation of the land consolidation policy in 2013, the average number of plots per household has decreased from 5-7 to 2-4 to reduce the fragmentation of landholdings, streamline land use, and improve farming efficiency. Despite this, the plots are reallocated to households by the local authorities on a basis ensuring the number of good-quality and bad-quality plots amongst the households are as equal as possible. Thus, the household plots are still scattered across different locations, with an average distance of 300 meters to 1 kilometre between them. That different households may cultivate portions of the same field has forced the farmers to adopt agricultural practices collectively. Therefore, despite having heard about recommendations on schedule and cultivation practices from local extension staff, the farmers tend to cultivate based on the mutually agreed schedule or practice of the operation unit (also called 'to san xuat') or cooperative that they belong to.

Regardless of the season, the average cost of cultivating rice per 360 square meters (referred to as a "sao") is approximately VND 1,000,000. However, in Don Xa commune, Ha Nam, the cost is significantly lower, ranging between VND 500,000 and VND 600,000. This reduction is mainly due to lower spending on soil preparation, fertilizers, and pesticides. While these savings reduce immediate costs, they also result in a decrease in rice quality, with harvested rice in Don Xa priced 15% lower than in other areas (VND 9,500 per kilogram versus VND 11,000). Beyond rice quality, crop yield is another key factor influencing the sale price. Many farmers reported that the price of harvested rice in the Mua season was typically 10-15% lower than in the Chiem season. This price difference is largely due to the relatively lower crop yields in the Mua season, as the rainy and humid conditions during the season foster the growth of pests and diseases such as rice blast, brown planthopper, and other fungal infections.

On average, farmers typically harvest between 150 and 180 kilograms of rice per 360 square meters across both seasons. However, for the same season, crop yields might vary between households depending on the characteristics of their land. Specifically, the farmers cultivating in low-lying areas tend to achieve lower yields compared to those in higher terrain. For instance, in Ninh Van commune in Ninh Binh, yields in higher land areas can reach 180-200 kilograms per 360 square meters, while those in lowland areas typically range from 120-130 kilograms for the same plot size. In addition, crop yields are also influenced by natural disasters. For example, all farmers whose Mua crops were expected to be harvested in early October reported substantial damage from the Yagi typhoon, which struck just before harvest. The extent of the damage varied widely, with yield reductions ranging from 30% to as much as 70%, depending on the strength of the typhoon, the geographical location of the fields, and the growth stage of the rice when the typhoon occurred.

2.3 Dealing with crop residue

2.3.1 Natural decomposition

The natural decomposition of crop residues has long been a viable alternative to burning straw, particularly during the Mùa season when the extended transition period allows for the

breakdown of straw before the next planting. However, farmers encounter considerable difficulties with this approach, particularly during the Chiêm season. The shorter transition period in this season does not allow sufficient time for natural decomposition, which presents challenges for the subsequent crop.

Despite this practice, the rainy season poses problems. In Đồng Du commune, a female farmer under 60 shared the difficulties:

> "To be honest, we need your research on how to manage during the rainy season when we can't burn straw. Pulling and gathering it is extremely hard. The machines can't plow."
> (Female, under 60, Đồng Du, Bình Lục, Hà Nam)

The natural decomposition is therefore popular when the transition period is sufficiently lengthy. While in the Chiem season, farmers face significant management challenges concerning undecomposed straw, which hampers the preparation of the land for subsequent crop cultivation, thereby affecting the next agricultural production cycle. This has led to the practice of straw burning.

2.3.2 Rice straw burning

The practice of rice straw burning is not uniform across communes within and across provinces. Burning, when it happens, takes place mainly after the harvest of the Chiem season and before land preparation for the Mua season. This is because the transitional period between the Chiem and the Mua season is often too short (2-3 weeks) for rice straw to decompose on fields. That transitional duration includes all preparatory steps for the Mua season. The actual acceptable pending time for rice straw treatment is only about 07 days. Burning is thus the quickest way to eliminate the leftover rice straw in the Chiem season. Although some communes may cultivate a specific rice species or have specifically different types of soil that make their harvest time slightly earlier than others, the most common harvest period is from the last two weeks of May to the first week of June. Accordingly, ***the most common rice straw burning period is between the last week of May and the first weeks of June***.

Burning is much less prevalent after the Mua season because the longer holding period and sufficient amount of water allow rice straw to decompose on fields. Other factors influencing straw burning decisions include elevation of the fields, amount of water on the fields post-harvest, demand for rice straw, knowledge and experience with alternative treatments, etc.

Bac Ninh

In Yen Phong district of Bac Ninh province, farmers in both communes burn straw after the Chiem season. Other alternatives such as straw collection by straw balers were not sustainable as the balers compressed the soil so much that made it difficult to plough afterwards. In addition, farmers in Dong Tho commune used to apply lime powder to fasten the straw decomposition process but have stopped using it because burning is a quicker and easier method. After the Mua season, the prevalence of straw burning reduces because the pending

duration to the next season is long enough for rice straws and standing stubbles to self-decompose. In addition, Yen Phong District is industrializing and the increasing demand for labours has drawn farmers to other wage jobs immediately after the Mua season, thus overlooking the post-harvest straw.

In Tien Du district of Bac Ninh province, farmers often burn straw to get ash after the Chiem season. The straw ash is then used domestically to grow other plants. On drier and higher fields where straw balers can operate, burning incidence is reduced. In Phu Lam commune, pile burning has become less common in the last 10 years due to the adoption of combine harvester to replace manual cutting of rice crops. Both the spreading rice straw and stubble are buried in the soil to decompose during soil preparation for the Mua season. When asked about their perceptions toward straw burning, most farmers were aware of the adverse effect of air pollution, which also caused traffic accidents when burning was near main roads. Some believe that burning straw is a double-edged sword, i.e., it destroys both harmful and beneficial microbes for rice crops.

Ha Nam

In Ha Nam Province, the practice of straw-burning seems to be more uniform across communes. The majority burn straws immediately after harvesting the Chiem season, only a minority of farms (less than 10%) have straw collected for livestock feed. Burning is not feasible in low-lying fields due to flooding or when it rains continuously after harvesting. Most farmers perceive that burning is necessary to eliminate rice straw so that ploughs can function afterwards. Some even face pressure from tractor drivers to burn, otherwise, they will refuse to perform ploughing service. In addition, spread burning allows the flame to spread from one plot to the others on the same field. Therefore, one or some farmers can ignite their plots but the whole fields can be burned, particularly during windy days. Farmers are aware of the negative externalities of straw burning as air pollution and reduced soil fertility but seem to have no alternatives. Overall, farmers' priority is to burn rice straw except for when it is impossible to do so.

> "Question: After each harvest, how is the straw treated?
> Respondent 1: It can't be treated.
> Respondent 2: So they (farmers) take the opportunity to burn it.
> Respondent 1: If the field is dry and the straw is dry, they take the opportunity to burn it. If they can't burn it all... (interrupted by another respondent)
> Respondent 3: The households can't handle the straw in time...
> Respondent 1: Because in this season it's wet, it's raining...
> Respondent 3: The time is too short...
> Many respondents: They can't burn it, so they just leave it there and let ploughing machines crush it."
> (FGD in Don Xa Commune, Binh Luc District, Ha Nam Province)

In a single FGD mentioned above, farmers responded differently regarding their straw burning practices. Some burned, some did not. However, collectively they reported no burning due to wet conditions in the Chiem harvest season. On the other hand, the rice straw post-harvest in the Mua season is left on the field to self-decompose for about 02 months before soil preparation for the next season. Straw collection by straw balers is not common due to lack of machinery, asynchrony in cultivation, lack of demand for straw, etc.

Alternative treatments, such as straw mushroom production, have been experimented but were not successful and scalable due to the lack of physical space and technical capacity.

Ninh Binh

In Ninh Binh province, only one out of four communes have common straw burning practices, while the other communes do not burn straw for several reasons. Ninh Hai and Gia Xuan communes are characterized by low-lying fields, which are often flooded during the Mua season, therefore, rice cultivation is not feasible. As a result, farmers have no incentive to burn rice straw post-harvest in the Chiem season. Also, Ninh Hai commune is a famous tourist destination, thus, straw burning is limited to avoid frightening tourists away. In Gia Tan commune, rice straw burning has become less prevalent because of the increasing demand for rice straw to feed livestock. The remaining standing stubble is incorporated into the soil while preparing land for the next rice season. In Ninh Van commune, straw burning happens mostly in high-lying fields after the Chiem season due to the short transitional period to the Mua season. After the Mua season, on the other hand, many farmers go to work in other non-farm wage jobs such as in stone-carving businesses, thus leaving rice straws on fields to gradually decompose. The earnings from these wage jobs are much higher than any other straw-related businesses. When asked about their perception of straw burning, farmers were aware of the air pollution and adverse health effects. One male farmer in Ninh Van commune said:

> "We are elderly farmers who have chronic respiratory diseases. The smell of smoke from burning is terrible. We often have to hide away and only come back when the smoke is gone. However, there is nothing we can do about it, because we must get rid of the straws quickly to prepare the land for Mua season"
> (FGD in Ninh Van Commune, Hoa Lu District, Ninh Binh Province)

There are two methods of burning, namely pile burning and spread burning. Pile burning is often done after hand harvesting when the rice straw is piled up in a corner and burned altogether. Spread burning, on the other hand, is common for mechanical harvesting in which combine harvesters cut and thresh the upper part of rice crops, then spread the residual rice straw in a windrow and leave the leftover standing stubble untouched.[1]

[1] Oanh, N. T. K. (2021). Rice straw open burning: emissions, effects and multiple benefits of non-burning alternatives. Vietnam Journal of Science, Technology and Engineering, 63(4), 79-85.

2.3.3 Rice straw collection

One alternative to rice straw burning is to promote the mechanization of rice straw collection to be used in various applications, such as mushroom production, composting, substrate for bio-bedding in livestock farming, etc. However, this practice is not prevalent among communities where the FGDs were conducted. The challenges associated with post-harvest rice straw collection are multifaceted and impact both the feasibility and the economic viability of the practice.

Firstly, the high effort required for the manual collection of rice straw is a primary deterrent, particularly when compared to the relative ease of burning it. Mechanization could theoretically ease this burden, but the varied and challenging topography of these areas complicates the use of large, efficient machinery. The presence of uneven land heights and fragmented land plots (of individual farmers) hinders the operation of such equipment, making it less effective and increasing the cost of implementation.

Secondly, economic incentives—or the lack thereof—also play a critical role in this context. Mechanization of straw collection requires significant investment in machinery equipment, which is not economically viable for farmers. Farmers can rely on straw collectors. However, given the relatively low value of the straw without economic of scale and the difficulty in mechanizing the process, there is little motivation for straw collectors/balers to regularly come to these places and engage in straw collection activity, even if the farmers are willing to offer the straw for free. Furthermore, the fragmented nature of land ownership means that a farmer typically possesses several small, scattered plots. This spatial distribution makes the logistics of collecting and transporting straw inefficient and costly. Additionally, where larger fields consist of multiple smaller plots owned by different individuals, any large-scale mechanization effort would require collective agreement from all stakeholders involved, which can be challenging to achieve.

2.3.4 Microbial products

The management of crop residues, particularly straw burning, presents a significant environmental and agricultural challenge in rural Vietnam. As an alternative, microbial products have been introduced to facilitate straw decomposition, with the potential to enhance soil health and reduce pollution. However, farmers' experiences with microbial products for straw decomposition have been mixed. In Đông Thọ commune, many farmers expressed unfamiliarity with these products. A male farmer under 60 from Đông Thọ, Yên Phong district, Bắc Ninh province, commented:

> "We haven't grasped this yet; we've never done it before, so we don't know how to handle it."
> (Male, under 60, Đông Thọ, Yên Phong, Bắc Ninh)

A female farmer from the same commune echoed:

> "We've never tried it before."

(Female, under 60, Đông Thọ, Yên Phong, Bắc Ninh)

In Phú Lâm commune, the sentiment was similar. A male farmer under 60 from Phú Lâm, Tiên Du district, Bắc Ninh province stated:

"We've heard about it, but no one has done it."
(Male, under 60, Phú Lâm, Tiên Du, Bắc Ninh)

Another added:

"In Bắc Ninh, Gia Bình district has a movement, but here, there's no movement, so it's very difficult."
(Male, under 60, Phú Lâm, Tiên Du, Bắc Ninh)

Moreover, there is considerable variation in the experiences of individuals who have previously used microbial products. The absence of technical guidance and knowledge has resulted in limited efficacy when microbial products are employed. In Thanh Nghị commune, a male former cooperative president under 60 from Thanh Nghị, Thanh Liên district, Hà Nam province, shared his direct experience:

"Composting takes about 15 days, but it doesn't decompose completely. It's very challenging! Some places advised not to cut the straw, but when we spread it, I myself handled a pile of straw to compost. After applying the microbial product, the water turned black, the straw became softer but didn't rot. I was the one who did it myself!"
(Male, under 60, Former cooperative president, Thanh Nghị, Thanh Liêm, Hà Nam)

Another issue is the deviation from technical guidance. In Đồng Du commune, a male farmer under 60 from Đồng Du, Bình Lục district, Hà Nam province noted:

"Some people just apply it randomly, so over time, it loses effectiveness. People don't care much; they apply it too late or when it's too dry. Then weeds grow, and they have to buy herbicides."
(Male, under 60, Đồng Du, Bình Lục, Hà Nam)

Despite the challenges, farmers who adhered to proper instructions observed noticeable soil improvements after one or two seasons. A female farmer under 60 from Đồng Du acknowledged:

"The effectiveness is indeed good, but people don't use it because the cost is high. We used it for 4-5 seasons, and after one season, we saw it was good."
(Female, under 60, Đồng Du, Bình Lục, Hà Nam)

However, the need for collective action hinders effectiveness. The same farmer pointed out:

"If Mr. A doesn't apply it, but I do next door, it's not effective; it's not uniform."
(Female, under 60, Đồng Du, Bình Lục, Hà Nam)

Furthermore, high costs remain a significant barrier to adoption. Most farmers in the FGDs estimated a range between 30,000-50,000 VND per 'sào' (360 m^2) as affordable for them. Some

farmers feel that any additional expense is too burdensome given their current cost structure. In Đông Thọ, a male farmer under 60 stated:

> "If provided to the members, then they will do it. But if asked to buy, we don't know how effective it is, so it's very difficult. If it's effective, next time it will be easy and simple."
> (Male, under 60, Đông Thọ, Yên Phong, Bắc Ninh)

Practical challenges such as the scattered nature of plots and lack of water resources further complicate adoption. A female farmer under 60 from Phú Lâm explained:

> "We farmers want to do it most neatly and quickly. Currently, our fields are dry with no irrigation water, so how can we compost in the field? Water is very far away."
> (Female, under 60, Phú Lâm, Tiên Du, Bắc Ninh)

While microbial products for straw decomposition offer potential benefits, several barriers hinder their widespread adoption among farmers. These include a lack of technical knowledge, high costs, the need for collective action, and practical challenges related to field conditions.

2.4 Local lessons

2.4.1 Lesson from rodent-control service

Rodent damage to pre-harvest rice has adversely affected rice productivity and has been a perennial problem in the agriculture sector in Vietnam. Traditionally, farmers in our surveyed communes used various methods to control rodents, with support from extension offices and cooperatives, such as digging and hunting, trapping, electrocution, rodenticide, etc. A common method was fencing entire plots with barriers made from plastic to prevent rats and using rodenticides to kill the rats inside the fenced plot. This practice was followed by individual farmers or collectively by farmers in the same cooperative. The collective rodent control scheme organized by cooperatives typically involves the cooperative partially financing and implementing rodenticide on farms, while farmers still have to spend out-of-pocket costs and efforts to fence the farms with plastic barriers. This means the total costs farmers incur include: 1) part of rodenticide costs, and 2) all plastic barrier fencing costs. This amount was quite high at around 100,000 VND/sào/season. The results of this scheme have been unsatisfactory given its low effectiveness at reducing rodent attacks and high costs to farmers. In addition, the fact that the scheme was neither conducted simultaneously nor collectively was the major issue. A farmer in Ha Nam province said:

> “Rodents controlled in our village but not in neighbouring villages allowed a fertile environment for rodents to reproduce in neighbouring villages and come to my village to eat rice crop”.

A few years ago, cooperatives stopped implementing this scheme themselves and started hiring professional rodent-control companies to do the job. Professional companies have proved to be way more effective in reducing the prevalence of rodent damage. They applied a wide range

of methods, including chemical and non-chemical methods, depending on the different stages of rice crop cultivation. In addition, they implement their solutions not only on the entire farms but also in surrounding areas where rodents can hide and reproduce. Furthermore, these companies also communicate with cooperatives regularly to know about peak periods of rodent attacks, to announce rodenticide application schedules to farmers, etc. Under this service, farmers only need to pay between 40,000-60,000 VND/sào/season., which is much cheaper than the traditional scheme and no extra effort required. They are also guaranteed to receive compensation if their rice crops are still damaged after the services. The results were positive in most of our surveyed communes, as given by reduced incidence of rodent attacks and higher rice productivity.

The adoption of the rat-control service, delivered by professional companies, has been a gradual process among farmers, starting with only a few model farms. After a while (2-3 years), more people noticed the benefits and were convinced to adopt the service. When there were only a few farmers in the village who were still reluctant, there was peer pressure from the rest of the community. One farmer in Ha Nam put it:

> "You live in the village with everyone. Now everyone uses the service, it would be inappropriate if you don't".

The peer pressure eventually made the remaining non-compliers adopt the service. The organized community adoption of a new agriculture practice/idea/solution, facilitated by cooperatives, has been key to agriculture development in Vietnam.

In summary, lessons from rodent-control service highlight the following key conditions for a new, novel service to be effective and sustainable: 1) the service is adopted collectively by farmers in the same community, and simultaneously; 2) effective communication between the service providers and the cooperatives, in which the cooperatives are medium between farmers and service providers; 3) affordability, i.e., the service should be more cost-effective than other traditional practices, and recognizable by users.

2.4.2 Other local lessons

Common sources of agriculture information/knowledge in our surveyed communes include agriculture cooperatives, farmer's unions, plant protection services, and mass communication systems (local radio, TV). Farmers in Thanh Tan commune of Ha Nam province distrust leaflets as a method of providing new information/knowledge.

New agriculture practices are often introduced by representatives from agriculture cooperatives (transfer of technical and technological advances) and plant protection services (support with pest control and fertilizer) through seminars/workshops. Training should be synchronously organized at all administrative levels. In addition, many farmers would like to have pilot projects on model farms which allows them to see actual benefits and gain confidence before adopting a new practice. When asked about preference for training mode,

most people prefer on-farm demonstration to workshop/seminar. For most people, seeing is believing. One farmer in Gia Tan commune said:

> "We prefer on-farm demonstration as our eyes can see, ears can listen to, and hands can touch the actual product".

In case an on-farm demonstration is not feasible, a training seminar/workshop is a good alternative. This is often organized at cooperative centres of village halls. Experts often deliver the training with slides shown on screen. Q&A sessions are also important for farmers to make inquiries and give feedback.

3. Conclusion and recommendations

Findings from the FGDs suggest the following points to reconsider the design of the interventions:

- Rice straw burning spots are not homogenous. Some preassumed burning areas from satellite data turned out to be industrial areas or waste burning (either open waste burning or burning in recycling neighbourhoods).
- Terrain level is an influential factor for burning practice. Burning is not possible on low and flooded fields. Satellite data to identify terrain levels could be a useful reference for site selection.
- The most common rice straw burning period is between the last week of May and the first weeks of June. Rice straw burning in November and December seems not to be as prevalent as preassumed although there are still scattered burning spots.
- Given the scattering manner of both burning locations and periods, various satelitte datasets should be combined to better identify burning practices. For instance, different satellite cycles and accuracy levels can compensate each other as rice straw burning can happen too quickly for a 14-day satellite cycle to detect, while a satellite with a shorter cycle may not have large enough resolution to detect small and scattered spots either.
- Farmers mostly follow cultivation guidance provided by district and commune authorities. The guidance includes suggested timelines for the whole district or commune. In case it is not possible to conduct a short survey of the concerned communes to identify harvest and burning periods, it may be worth collecting those guidance documents for a timing reference.
- A strong collectivist mindset is prevalent among farmers' preferences of intervention practices regarding transboundary issues (i.e., issues whose impacts or effectiveness can span over multiple land plots or villages). From rat control to straw burning (or not burning) practices, farmers prefer collective actions at least within the whole village or

the whole unified field of multiple plots. Peer pressure and peer learning are among the key factors in their behaviour change process.

- While economic cost is a relevant factor to the willingness to pay for research, using unconditional cash as a financial incentive may not work in the RRD as the economic landscape has been improved and rice production is no longer the main income source. Furthermore, there are other stronger hindering factors for farmers' behaviour change away from rice straw burning, notably the lack of proper information, trust-building, consensus-building, and market linkages for alternative solutions (including both microbial markets and rice collection markets).

Suggested twist to the research rationale:

- The focus on air pollution reduction and financial incentives alone is not sufficient and may be challenged.
- Focusing on the co-benefits of alternative measures to rice straw burning: reducing air pollution, mitigating greenhouse gas emissions from the natural decomposition of rice straw, improving soil health and hence rice quality, and ultimately shifting farmers' mindsets and behaviours towards sustainable agricultural production.
- Also suggesting to paraphrase the research question, if possible, from "Can financial incentives and market linkages reduce crop residue burning, improving air pollution, health and farmers' economic and subjective wellbeing?" to "Can financial incentives and market linkages, or other factors, reduce crop residue burning to improve air quality, greenhouse gas mitigation from rice production, and farmers' economic and subjective wellbeing?". The wording "improving air pollution…" in the original question seems not suitable as the project aims to "reduce" air pollution to improve health and other socio-economic benefits.