Annex 2b

Market Study for GCF Thai Rice

GCF Funding Proposal

Thai Rice:
Strengthening Climate-Smart Rice Farming

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Version 1

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Introduction

A. Background and objective of the study

The rice sector of Thailand—the country's most important food crop—faces growing climate impacts such as extreme weather events, rising temperatures and changing rainfall patterns; these climate pressures place increased burdens on farmer livelihoods as well as the national economy. Simultaneously, the rice sector continues to stand out as the largest agricultural contributor to GHG emissions—released as methane through the flooding of rice paddies. To address these interwoven issues, Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) GmbH is developing a Funding Proposal (FP) for the Green Climate Fund entitled "Thai Rice: Strengthening climate-smart rice farming" to support climate resilience of rice farmers and lowered GHG emissions in the Thai rice sector though the implementation of low-emission sustainable rice production methods (sometimes referred in this report as Climate Smart Agriculture technologies, or CSA technologies).

To support the GIZ Green Climate Fund proposal, a qualitative market study was conducted in three rice-growing regions— the Northeast, Central Plains, and a reduced scope of work in Chiang Rai—to understand the main value chain barriers and enablers (economic, social, cultural, logistical, etc.) associated with the uptake of the Climate Smart Agriculture technologies among farmers. Through the study's analysis of the barriers and enablers, several solutions and recommendations were developed on how to improve CSA delivery models, as well as the demand and acceptance of the technologies among farmers. Additionally, the study provides insight into farmer perspectives on the key market and agronomic challenges they face in the three regions, as well as the region-specific packages of technologies that have the highest potential for success based on regional delivery models, socioeconomic and agro-ecological conditions, and farmer attitudes.

The low-emission sustainable rice production methods/Climate Smart Agriculture technologies that were explored for their market potential in this study are listed as follows:

Technology/production method	**Description**
Laser Land Leveling (LLL)	Laser land leveling is leveling the field within certain degree of desired slope using a guided laser beam throughout the field.[1]
Alternate wetting and drying (AWD)	A water-saving technology that farmers can apply to reduce their irrigation water consumption in rice fields without decreasing its yield. In AWD, irrigation water is applied a few days after the disappearance of the ponded water. Hence, the field gets alternately flooded and non-flooded.[2] (IRRI, n.d.).

[1] IRRI. (N.D.) "Laser Land Leveling- A technology for Resource Conservation." India Rice Knowledge Bank. http://www.knowledgebank.irri.org/rice-knowledge-for-india/resources/training-resources/item/laser-land-leveling-a-technology-for-resource-conservation

[2] IRRI. (N.D.) "Saving Water with Alternate Wetting Drying (AWD)." India Rice Knowledge Bank. http://www.knowledgebank.irri.org/rice-knowledge-for-india/resources/training-resources/item/laser-land-leveling-a-technology-for-resource-conservation

Site specific nutrient management (SSNM)	SSNM provides guidance relevant to the context of farmers' fields. SSNM maintains or enhances crop yields, while providing savings for farmers through more efficient fertilizer use.[3] (CGIAR, 2015)
Straw and stubble management (SSM)	The ways to manage the rice straw and stubble once it is removed with the rice grains during harvest. It might end up being piled or spread out in the field depending if it was harvested manually or using machines. Moreover, there are many means to manage rice straw beside leaving it in the field or burning it, e.g., fertilizer, packaging material (pulp and paper), livestock feeding and biomass feedstock for energy (biogas etc.). [4]
Integrated pest management (IPM)	It is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment.[5] (EPA, n.d.).
Rice variety diversification	It is to encourage farmer to switching to more climate-resilient rice varieties in certain geographies (e.g. drought- or flood-resistant rice). The focus will be on high-yielding, climate-smart (drought- and saline-tolerant) rice varieties that are compatible with a range of farming practices (e.g. changing crop rotations, switching between irrigated and rain-fed, etc.)
Intercropping and rotational (after) crops	Crop diversification means growing more than one crop in an area. Diversification can be accomplished by adding a new crop species or different variety, or by changing the cropping system currently in use. Commonly it can mean adding more crops into an existing rotation.[6] Diversification can also be implemented to replace low-value commodities with high-value commodities, such as vegetables and fruits (UNR, n.d.) - Crop diversification will provide an option for

[3] Richards, MB, Butterbach-Bahl, K., Jat ML, Lipinski B., Ortiz-Monasterio I., Sapkota T. (2015) "Site Specific Nutrient Management: Implementation guidance for policymakers and investors. Climate Smart Agriculture Practice Brief." Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security.
[4] IRRI. (N.D.) "The value of sustainable rice straw management." IRRI: Rice Straw Management. https://www.irri.org/rice-straw-management.
[5] EPA. (N.D). "What is IPM" Integrated Pest Management (IPM) Principles. https://www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles#:~:text=For%20more%20information-,What%20is%20IPM%3F,their%20interaction%20with%20the%20environment.
[6] Walia, M. (2020). "Crop Diversification." Extension: College of Agriculture, Biotechnology and Natural Resources. https://extension.unr.edu/publication.aspx?PubID=3816.

	rice farmers to switch from off-season rice (dry season) farming to cultivate other crops
Drones	Supports to other technologies, SSNM and IPM, the drones will be used for spraying the precise amount of fertilizer and any agro-input (pesticide etc.)
Post-harvest mechanization technologies (e.g., tractors, combine harvesters)	The universal/ group of technologies that could help farmers reduce their carbon footprint in rice cultivation, e.g., rice straw utilization - tillage back (link with SSM). The usage of machinery will be included here, e.g., tractors and baler.

B. Qualitative Methodology

1. Sampling and selection of study sites

To cover GIZ's regional interest in the Central Plains, Northeast (Isan), and Northern Thailand, this study chose to focus on specific sites within the three regions. The reason for choosing specific sites rather than multiple sites was to increase the breadth of insight, including contextual information on social relations that helps to clarify farmers' perspectives, within a shorter timeline. With support from the GIZ Field Teams, the qualitative market study chose the following sites:

- Derm Bang District, Suphanburi Province in Central Plains
- Warin District, Ubon Ratchathani Province in Isan (Northeast)
- Wiang Pa Pao District and Mae Chan District in Chiang Rai (North)

The market study field team was provided with direct contacts to megafarms the districts and megafarm leaders were asked to support the team in identifying farmers with specific characteristics, including megafarm members and non-megafarm members in the district who are:

- Older farmers (55+)
- Younger farmers (~40 or under)
- Farmers who have applied multiple climate smart technologies
- Farmers who have not applied any climate smart technologies
- Service providers of technologies for other farmers

The market study also identified additional farmers, service providers and stakeholders to approach using a snowball method. In total, the study engaged with over 80 farmers (including service providers) in all regions, as well as 6 extensionists.

This study was developed around participatory design and engagement with all relevant stakeholders in the market for CSA technologies in the Thai rice sector. Input for the GIZ-GCF Funding Proposal package comes from in-depth discussions and validation to ensure that all relevant stakeholders' perspectives and concerns are incorporated and provided equal weight. It draws on the Principal Investigator's expertise in qualitative methods for stakeholder engagement and cooperation through the four following approaches:

2. Stakeholder Informant Interviews

A series of semi-structured stakeholder interviews through phone call, online calls, and in-person meetings with key actors on the Thai rice value chain and climate smart agriculture services/resource (see list of potential stakeholders below). The interviews drew on stakeholder experiences of delivering CSC and CSC-related service and resources to rice farmers; in particular, they captured the following insights:

- Current CSA delivery models within the regional rice value chains and their challenges/successes, including cost-benefit calculations of farmers and service providers, as well as farmers' input regarding their values and motivations in rice production, and experiences of climate change impacts.
- Stakeholders' perspectives and goals on the effective delivery of CSA resources and services, including challenges, opportunities, and enabling environments necessary for CSA technology adoption.

The interviews were used to identify:

- Package of CSA services and resources that are promising to these stakeholders and viable to implement according to regional characteristics.
- Key barriers and enablers to the delivery of the CSA, including actors and strategies required for effective delivery and effective delivery models.

Stakeholders reached through these interviews included:

- Megafarm leaders
- Service providers of drones, tractors, combine harvesters, laser land leveling, fertilizing mixing, and milling.
- Members of the Department of Agricultural Extension in all regions
- Fertilizer Center leaders
- Bioethanol companies
- GIZ Field Officers
- Olam
- Crop Tech Asia
- IRRI

3. FGDs and Key Informant Interviews with Farmers

Key informant interviews and informal FGDs were conducted with selected growers matching the categories identified in Section 1. Both interviews and focus group discussions were semi-structured but open-ended with the purpose of receiving input on the targeted needs of different categories of farmers for adopting CSA and an overview of barriers and enablers to the adoption of CSA based on farmer perspectives. The objective of these two farmer-facing engagement methods was to gain an overview on farmers' differences in adaptive capacities to adopt CSA, including gendered, socioeconomic, and other intersectional barriers and enablers to adoptions. FGDs and interviews with the farmers were used to gather the following insight:

- Farmers' access to capital and decision-making processes of different kinds of farmers regarding farm management practices and investments

- Farmers' access to inputs and resources, training, and extension
- Farmer perspectives towards the GIZ-identified climate smart practices
- Social networks of different kinds of farmers: where information about new practices is learned and where resources are best accessed.
- Farmers' current investment commitments and attitudes towards further investments

4. Co-creation workshops/Design Sprints

Co-creation workshops or "mini-design sprint" sessions were held with the farmers in Derm Bang (Central Plains) and Warin (Isan/Northeast). These workshops/design sprints drew from Human Centered Design principles to deepen and validate the insights about barriers and selling points for each of the CSA technologies, which were drawn out from the interviews and FGDs. The purpose of these design sprints was to generate ideas of solutions and to ignite conversation among farmers and service providers on how to overcome constraints to the delivery and uptake of the nine climate smart agriculture technologies.

The workshops generated ideas and solutions on how to address bottlenecks in the value chain in delivering CSA services and resources to farmers. Additionally, further details on the barriers and selling points of the technologies helped to determine the feasibility and potential of certain technologies for two regions.

C. Key findings and recommendations

- **Region-specific packages of technologies**

The nine proposed CSA technologies are not equally applicable in all areas and each of the technologies may have potential for successful uptake among farmers based on the agro-ecological, geological and market conditions of the region. Location-specific packages of CSA technologies needs are required for increasing the climate resiliency and mitigation among farmers, as some of the technologies are complementary. For example, Straw and Stubble Management, and Post-harvest Mechanization can complement Site Specific Nutrient Management in areas with poor soil conditions while also reducing farmer's use of nitrogen chemical fertilizers and burning of straw and stubble.

This study's findings in the case study sites highlighted the key climate-related challenges that farmers face in growing rice in their specific localities. Climate-related issues of water access and pests and diseases, combined with local conditions such as soil and topology determined the location-specific package of technologies with the highest potential for successful uptake among farmers.

In the Central Plains field site, experiences of prolonged drought were the most pressing concern for farmers; however, connection to public irrigation meant that farmers had the ability and motive to practice Alternate Wetting and Drying, as well as implement Laser Land Leveling to improve their ability to do AWD. Fear of brown plant hopper infestations and rising chemical prices means that farmers are eager to learn methods for preventing future outbreaks that are effective and reliable.

In the Northeast/Isan field site, unpredictable rain combined with a rainfed irrigation system meant that farmers were resistant to practicing Alternate Wetting and Drying. Nevertheless, farmers will accept Laser Land Leveling as a method for helping them to retain better water levels in their land and to suppress weeds. Additionally, due to the site's sandy loam soils, Site Specific Nutrient Management, Straw and Stubble Management and Post-harvest Mechanization stand out as a means for farmers to improve their soil conditions while also reducing input costs on nitrogen fertilizers.

In the Chiang Rai field site, worsening soil conditions due to excessive nitrogen also meant that Site Specific Nutrient Management, Straw and Stubble Management and Post-harvest Mechanization were key technologies for increasing soil fertility while also preventing burning. At the same time Integrated Pest Management reduces chemical fertilizer use—specifically nitrogen—which is related to increase incidences of bacterial leaf blight. Additionally, due to farmers' experiences of "muddy holes"/quagmires, and connection to public canals or rivers as water sources, farmers are drawn to Alternate Wetting and Drying as a method for improving their land conditions.

- **Improving recordkeeping to build farmers' business mindsets**

In general, except for some megafarm leaders, farmers were unlikely to keep records of their expenditures, yields, and profits for making decisions about future investments. Improved record keeping can lead to increased confidence among farmers regarding the investment returns of specific technologies, such as those with high one-time costs like Laser Land Leveling. However, farmer's unwillingness to invest in technologies to improve their yields and resiliency against climate impacts is also highly related to landownership; farmers are unwilling to uptake certain CSA technologies regardless of their confidence in the technology and financial ability to invest because they feel insecure in their current land tenure status.

- **Improving extension on good agricultural practices for rice**

Farmers have many misconceptions about their rice growing practices due to reliance of experiential knowledge and advice from other farmers and lack of proper training and extension from experts. For example, farmers in Suphanburi often spray pesticides as a protective layer against brown plant hoppers, whereas the act of preventive spraying early in the seasonmay increase the appearance of the pest. In Chiang Rai, many farmers incorrectly believe that they require less fertilizers in the wet season due to increased sources of nitrogen from the water. Many farmers also claim to practice Alternate Wetting and Drying but without the proper technique to maximize effectiveness, by counting 10 days after irrigating to irrigate again, or until the soil is white in color. Misconceptions such as these highlight the importance of increased training and extension on good agricultural practices for farmers that can improve farmers' knowledge of how and why certain practices are important.

- **Development of extension and delivery models for non-megafarm members**

In all regions, farmers outside of the megafarms are the most marginalized and have the least amount of access to resources and services that can help them to effectively uptake the CSA technologies. As a group, megafarms have increased capacity to negotiate prices on inputs such as base fertilizers, and they also receive financial support from the government to provide certain agricultural technologies to members at lower prices. Farmers outside of megafarms may not even be aware of certain technologies because these are typically promoted through megafarms.

Provision of training from DOAE requires that farmers form group; therefore, individual farmers without a strong social network or time and willingness to form groups are unable to request for specific trainings on their own.

Nevertheless, farmers may be largely unwilling to join megafarms because they do not want to pay the shares or abide by the group's strict rules, including attendance of meetings. As such, there are two pathways for improving the current CSA delivery model: either megafarms can be further promoted and improved to increase membership, or a non-megafarm delivery model needs to be implemented to reach all individuals outside of the megafarm with the same services and resources.

1. Central Plains

1.1. Overview of the area

Landscape: Suphanburi is characterized by clay soils and flatter low-lying lands that are mostly connected to public irrigation systems. There are some areas in this province where farmers are not connected to public irrigation and therefore dependent on rainfall as well as groundwater. Some farmers have farms in curved or hilly areas, but the majority have relatively even land. Most farmers have larger sized lands (above 20 rai each) that are sometimes divided into smaller plots. Long dry spells and periods drought in this region over the past several years (since 2015) has led to restrictions on water use from the public irrigation system, leading some farmers to dig wells to pump in water from the ground and some farmers to reduce to only one crop per year during the wet season.

Since the severe drought in 2015, water distribution from the public canal has been managed by a community irrigation group per subdistrict whereby each gate in the canal is operated by one committee. During periods of dry spells or droughts, the group will come together with the head of the village, the DOAE, and subdistrict officers to make collective decisions on the timing and amount of water that can be released from the canal to farmers. This larger committee will set limitations on water usage as a specific number of cubic meters per hour in each connecting gate of the canal based on the size of the area tied to that gate. Under these limitations, there are some free-rider risks, for example a farmer may decide to attach multiple pipes connecting to his farm to receive more water than other farmers, or a farmer may also decide to pump continuously, for more than is required for his fields. However, for example in Derm Bang district, strong collectivity around water management—spurred by shared experiences of suffering under previous droughts—has led to peer pressure to use AWD and community accountability around excessive water use in the area.

Farmers: Many farmers in this area rent land to grow rice. These rental agreements are typically verbal and renewed on a yearly basis; farmers mentioned that rice farmers legally cannot enter land rental agreements for more than 5 years—leases that are 5 years or more are typically reserved for only sugar cane farmers. Because of the insecurity of their land rental agreements, farmers feel that landlords may be able to take back the land at any given time. Farmers in this area mostly sell to general millers, and some of them to CP, which has a processing plant nearby Derm Bang megafarm. Under CP however, farmers are required to follow guidelines regarding growing practices and are not guaranteed a market after the CP quota has been reached.

Farmers in this area mostly grow rice for two seasons as their main source of income; some farmers may also have mangos, vegetable farms, as well as livestock. Due to increased drought conditions and dry spells, farmers are less inclined to grow additional cash crops due to high investment costs for pumping water. Some farmers may rely on additional activities such as selling their labor or selling Thai desserts or handicrafts (through the megafarm's dessert and handicraft cooperatives).

Megafarms: To join megafarms, members must agree to attend a minimum number of meetings per year as well as pay a small share to the megafarm that will re-distributed at the end of the year. Most farmers mention that that they are motivated to join megafarms to receive extra knowledge; however, the DOAE notes that training attendance from megafarm members remains low (typically less than a fourth of the total membership). Non-megafarm members may also be able to join any trainings provided through the megafarms, but the subsidized machinery and input benefits are limited only to members.

Derm Bang megafarm started as an IPM Community Center prior to transforming into a megafarm under government initiatives. This megafarm has higher recognition in the area due to its success on a farmer competition television event and has a membership of 123 members encompassing a total of 5000 rai. The megafarm has invested in numerous technologies to provide services for both members and non-members, including, milling (for small batches), ploughing, laser land leveling (supported by BAAC revolving fund), drones, customized fertilizers and biological pesticides (e.g., Trichoderma). Additionally, some of the fields from the megafarm have been selected as demonstration fields for straw and stubble management and laser land leveling as well as forecasting plots for pest management.

Yang Non megafarm in Suphanburi is a smaller megafarm consisting of only 44 members totaling over 1,200 rai. While this megafarm has not yet received investment support for an LLL machine, it offers a number of other services for farmers including machine transplantation of seeds, certified seeds (both seedlings and seeds for broadcasting of the RD41 variety), ploughing, drones, customized fertilizers, and biological pesticides (e.g., Trichoderma).

1.2 Key Takeaways

Farmers in this region are facing the biggest challenges with regards to weedy rice, more regular droughts/dry spells, and infestations of brown plant hopper. Based on the evaluation of farmers perspectives and experiences, service providers experiences, and the existing models for delivering services to farmers in the region, this market study regards **Integrated Pest Management, Laser Land Leveling and Alternate Wetting and Drying** to have the highest importance for climate resiliency and highest potential for adoption based on farmers' acceptance and needs.

1.2.1. Laser Land Leveling

Market potential score: High
Overall review: • While LLL has high potential, a large proportion of farmers (especially non-megfarmers and those who do not own land) will be not be motivated to move away from traditional techniques for flattening their land. • LLL is an important tool for AWD and IPM in this region and needs to be better demonstrated to provide improvements against traditional methods.

Selling points:

- Helps farmers to practice AWD more effectively to:
  - Save water and reduce irrigation costs (fuel for pumping water)
  - Reduce input costs (chemicals) by reducing pest and disease outbreaks
- Strengthens roots of crop for better quality rice

Barriers:

- **Rented land:** farmers are not likely to apply LLL on land that they have rented.
  - Currently, land is being rented out on a yearly basis through verbal contracts. Farmers fear that investments are a risk on land that is not secured for at least 5 years. This is also limited by the fact that current land laws limit rice farmers from renting land for more than 5 years.
- **Traditional methods are price-competitive**: because land evenness is not perceived as a severe issue in the Central Plains, farmers will continue to use traditional methods to flatten their land.
- **Non-megafarmers have less access to affordable services:** Non-megafarmers do not have access to the same price subsidies as megafarmers

Other considerations:

- Traditional technique is 600-800 THB/hour and can take up to 20 hours depending on skill of labor; however, since land is relatively smooth in this area, the farmers do ont need to invest a lot for the smoothing of the land.
- Length of investment in Central Plains could last up to 5 years or more given the weather patterns and land type here (already relatively flat).
- Farmers may not be convinced to use it on entire plot in a single year time.
- LLL machines are centralized in a few megafarms at the moment. The cost for members currently charged to use LLL services quoted by an interviewee is 1,000 THB/rai (not including land preparation costs) and the cost for non-megafarmers is 4,000 THB/rai.
- Service providers find that the ideal land size for doing LLL is small: 5-8 rai due to labor time of measurements and the way the sensors work.

Recommendations:

- Do demo farms, experiments and cost calculations that show farmers the major differences in these techniques, including lowered costs.
- Promote and demonstrate the benefits of LLL to landlords in addition to farmers.
- Incentivize early uptake of the LLL technology through targeted subsidies or price incentives

1.2.2. Alternate Wetting and Drying

Market potential score: High

Overall review:

- High potential of AWD and high acceptance among farmers as a perceived way to minimize pest and diseases, save water, and strengthen crops. Proper technique of AWD is limited as farmers mostly learn about AWD through word-of-mouth.

Selling points:

- Reducing chemical use (management of P&D)
- Strengthening rice crops for better quality rice.
- Saving water and reducing irrigation costs (fuel for pumping water)

Barriers:

- **Knowledge delivery models**: majority of farmers learn AWD through word-of-mouth; lack knowledge of AWD techniques means that many farmers are not practicing it correctly.
- **Lack of water storage systems**: farmers unwilling to use land for water storage purposes**.**

Other considerations:

- Currently used with public irrigation systems (free). During droughts and in areas without connection to public irrigation, farmers pump water and use AWD as a way to reduce pumping costs.
- Farmers (especially non-megafarmers) have had few trainings on AWD from extensionists. Farmers learn from their own experiences and from word-of-mouth; therefore, most farmers do not have correct knowledge of how to apply AWD-- some farmers believe that they need to wait 10 days to drain and 10 days to irrigate, some farmers believe that they only need to irrigate when the soil is "white" in color....
- In this area, AWD use appears to be the result of heavy social pressure, including strong leadership from megafarms and village heads in managing water use (in light of the drought situations). There is no rule on how much farmers can flood during the time when they have access to public irrigation. However, not many farmers in this area flooded irrigation because of drought experiences in the past and increasing pressure and influence from others to do AWD in community.
- Public irrigation is managed by community irrigation group (1 committee per sub-district around a canal gate). During droughts, the committee plans on how much water farmers can receive and for how long. There is no direct incentive other than social pressure for farmers to change practices or follow water sharing rules despite having an irrigation group [No penalties on farmers for not following water sharing patterns or flooding fields]

Recommendations:

- AWD needs to be combined with a water sharing and [underground] storage system in order to adapt to increasing dry spell/droughts.

1.2.3. Site Specific Nutrient Management

Market potential score: Medium-low

Overall review:

- Current lack of demand and potential for SSNM appears to result from exclusivity of the benefits: megafarm members are more likely to access the resources and support services that enable them to use both the soil doctor and mixed fertilizers.

Selling points: • Helps farmers to reduce their fertilizer costs
Barriers: • **Lack of guidance and training:** site specific mixes are believed to be too complex to make**.** • **Lack of machinery for non-megafarmers** to mix fertilizers effectively and efficiently. • **Difficulties finding base fertilizers commercially**
Other considerations: • Soil type here is mostly clay which is more likely to absorb water and retain nutrients. • Non-megafarmers have less access to soil doctor services and trainings on SSNM. • SSNM is easier for megafarmers because they have access to a mixer—megafarmers can mix formulas and sell back to their members at lower costs. Megafarms that have access to a computerized mixer can mix fertilizers even more efficiently. • It is becoming more and more difficult for farmers to find base fertilizers in the store; it is also more expensive and less cost-efficient for individual farmers to buy each base rather than a mixed bag. Megafarmers can buy inputs at negotiated prices
Recommendations: • The megafarm is a channel through which SSNM mixes can be provided the most efficiently and effectively; however, for megafarms to be better service providers, they need support in accessing base fertilizers and in digitalized mixing equipment.

1.2.4. Straw and Stubble Management

Market potential score: Medium-high
Overall review: • Higher potential for straw collection during the dry season but first requires better management of P&D and weedy rice.
Selling points: • Additional income from selling straw. • Decomposition of stubble fertilizes soil and reduces cost of fertilizers.
Barriers: • **Farmers burn fields to prevent P&D and weedy rice:** farmers do not currently know how to manage weedy rice and pests and diseases except through burning their fields. • **Farmers are risk averse towards land preparation:** farmers need to prepare land after harvesting rice for the next crop; they may abandon plans to decompose stubble or sell straw because of impending rain--farmers need to prepare the land before the rain starts or before water from public irrigation becomes available. • **Straw cannot be collected during wet season:** straw collectors will not collect wet straw due to the labor demands and costs of collection during the wet periods.

• **Collectors prioritize certain farmers:** balers prefer to bale on land that has easy road access and shorter furrows (only 30% have short furrows); they will prioritize these farmers, leading to long delays for other farmers. Farmers waiting in a queue are prone to burn at the last minute to prepare their land for the next crop.
Other considerations: • Straw bales are sold at 100 THB/rai and collected by balers. • Straw cannot be collected if it is wet. During wet season, balers are not able to collect bale and farmers must resort to either decomposition or burning. • -Some farmers will not allow balers to come to their fields because they believe that the machine will make their soil more compact and difficult to deal with. • Biological substances that can quicken the pace of stubble decomposition are not easily available, especially for non-megafarmers. • Balers noted that they would be able to collect more straw because there is a large demand for straw by livestock producers; however, supply does not reach demand due to farmers' tendencies to burn to prepare for the next crop. • Biofuel companies may be interested to use rice straw in their plants; however, the rice straws would need to be made into smaller pieces before being sold to the biofuel companies-- the additional machine for cutting the straw into smaller pieces is a high investment cost for balers. Additionally, price company would offer for straw is much less than livestock producers.
Recommendations: • Focus on improving seed collection practices, promote only 2 crops a year, and improve IPM training for farmers to better manage with weedy rice and P&D. When farmers have reduced P&D and weedy rice, they are more likely to do straw and stubble management. • Coordination with the irrigation department on the water schedule and improved weather forecasting may also mitigate the risk averse behaviors of farmers towards land preparation.

1.2.5. Integrated Pest Management

Market potential score: High
Overall review: • This technology has high importance in this area due to the recurrent issues of brown planthoppers. However, at the moment IPM is mostly perceived by both extensionists and farmers as increased use of biological chemicals rather than increased pest scouting and selective spraying. Farmers will continue to do protective spraying at the beginning of the season regardless of seeing any pests in order to prevent outbreaks.
Selling points: • Enables reduction of costs for chemicals: chemical prices are rising globally
Barriers: • **Biological pesticides are complex to make and time-intensive:** farmers believe that substances like Trichoderma are too complex and time intensive to make.

Biological substances require clean and cool conditions to produce; however, outside of the megafarm, farmers may not have the right equipment to effectively make these substances.
- **IPM training focuses too heavily on biological substances:** farmers and extensionists mostly understand IPM to be about using more biological substances to manage P&D. However, fuller management techniques such as scouting and selective spraying are not seen as important.
- **Forecasting plots are not reflective of farm conditions:** current forecasting plots used by the megafarm do not accurately represent the P&D situation of farms and are therefore not helpful tools for determining spraying schedules used by farmers.

Other considerations:

- Non-megafarmers are allowed to join IPM trainings that take place at the megafarm; however, these are currently taking place at times that are not convenient to all farmers. Best time for trainings should be before 9am.
- For megafarm members: megafarm members are connected directly to the Agricultural Extension Officer via a Line Group for the megafarm. Forecasting plot results will be posted on this Line Group and farmers can also seek advice through the Line group. However, non-megafarm members mostly receive news through a less-active Village Line Group as well as through word-of-mouth.
- Some megafarm areas will have forecasting plots; however, these forecasting plots never match with the conditions and experiences of the farmers. They believe that the forecast plot is rather a “toy for pests” and does not reflect the kind of pest and disease experiences they have on their own plots.
- Most farmers will continue to do protective spraying and believe that biological substances cannot be fully protective against all insects.

Recommendations:

- Given that AWD and LLL are both correlated with reduced P&D; these two technologies require less continuous labor than pest-scouting for farmers and are therefore more likely to be accepted as methods for reducing P&D.
- IPM training in this area needs to have stronger focus on management of brown planthopper.
- Farmers are also interested in technologies for reducing labor-time associated with pest-scouting as an IPM tool.

1.2.6. Rice Variety Diversification

Market potential score: Medium-low

Overall review:

- This technology has low potential to succeed unless shorter-duration varieties have good markets/prices in comparison to other varieties.

Selling points:

- Farmers will grow shorter duration varieties if they have : good yields, guaranteed buyers who do not have conditions on farmer practices; and ability to consume the rice varieties in the household (due to taste).

Barriers:

- **Farmers keep seeds from previous crops:** farmers are likely to grow seeds they collected from previous crop. This causes weedy rice but also prevents farmers from switching varieties in order to save costs.
- **Farmers lack knowledge and experience on effectively growing shorter-duration varieties:** farmers may tend to grow shorter duration varieties for longer than they are required, or they may get poor yields from these varieties due to lack of knowledge of how to gain the best yield from the variety. Because farmers are most likely to follow variety choices based on the miller's suggestion and/or suggestions from other farmer, they do not get the extension support that comes along with new varieties.

Other considerations:

- Shorter duration varieties do not have good prices from millers; these varieties tend to be poorer quality varieties that are made into rice powder to produce other rice products. Seed choice is highly influenced by millers; if there is no market for a variety, farmers will not grow that variety.
- Farmers mostly broadcast seeds to reduce labor, especially non-megafarmers who have less access to seed transplanting machines.
- Farmers believe that shorter duration varieties are more labor-intensive because they require labor to be limited with a shorter time period.
- Seed collection trainings are reserved for seed producers that want to get certified; regular farmers do not get trainings on how to properly collect seeds from previous crops to avoid weedy rice.

Recommendations:

- Increase trainings on seed collection to reduce incidences of weedy rice for farmers.

1.2.7. Crop Diversification

Market potential score: Medium-low

Overall review:

- This technology has low potential to succeed unless there is first a market/agronomic study on crop suitability specific to the area. Farmers are also unlikely to grow additional crops without approval from their landlords.

Selling points:

- Provides additional income to support farmers, especially during drought periods.

Barriers: • **Farmers who rent land are unlikely to grow additional crops**: farmers are required to report to landlords about the crops that they grow on the land rented. Most landlords will only allow short-term crops in addition to rice. • **Lack of knowledge on appropriate rotation crops:** farmers do know have knowledge on which crops can be best grow in drought-prone areas that also have a good market. • **Farmers fear that there is not enough water:** farmers are reluctant to grow additional crops due to lack of water and resistance to pumping water for low-priced crops.
Other considerations: • Farmers believe that many crops that they could grow after carry a lot of P&D (including sugar cane and cassava); the chemicals used on these crops may also affect rice. • There are few trainings offered to both megafarmers and non-megafarmers on crops suitable to grow in this region; therefore, farmers are mostly growing crops based on their experiences and from word-of-mouth. • Some megafarms currently offer support for women on alternative income generating activities, such as handicrafts and Thai desserts.
Recommendations: • Conduct a market/agronomic study on crop suitability specific to the area.

1.2.8. Drones

Market potential score: Low
Overall review: • This technology does not add to climate mitigation or adaptation for farmers and is unlikely to reduce labor time/cost sufficiently so that farmers will invest in other CSA technologies.
Selling points: • Reduction of labor time • Prevents damage to crop due to human labor.
Barriers: • **Service providers do not service all areas:** not all land types are compatible with drone, especially those areas that are further away from a road. Drones batteries do not last long and require constant recharging; service providers may opt to work in areas close to the road where the car can be used as a method for recharging batteries. Drone batteries are also costly to re-charge. • **Farmers prefer labor during many crop stages:** drones are not compatible with rice crop at all stages, especially when the crop is too high. Farmers may also prefer to

retain their relationships with labor for security reasons--to prevent laborers from moving on to other clients.
Other considerations: • Drones do not promote more efficient use of chemicals or biological pesticides: most service providers will choose not to service for biological products. Regular chemicals must also be highly diluted; this dilution leads to reduced effectiveness against pests and diseases.
Recommendations: • Do not promote this technology.

1.2.9. Post-harvest mechanization

Market potential score: Low
Overall review: • Due to high competition of combine harvesters, this technology is not efficiently reducing post-harvest yield loss and should therefore not be further promoted.
Selling points: • Reduces labor costs and time for harvesting.
Barriers: • **Service providers do "rush jobs" to compete for clients** and make up for high fuel and maintenance costs of the machines. Because of the inefficiency of the service provision, yield collection is less precise than through manual labor.
Other considerations: • All farmers use the combine harvester.
Recommendations: • Do not promote this technology.

2. Isan/Northeast

2.1. Overview of the area

Landscape: Warin district in Ubon Ratchathani has a mixture of hilly, sloped, and uneven land that is mostly sandy loam with poor organic content due to overuse of chemical fertilizers. Land in the area also contains several obstacles such as large rocks as well as trees—many of which are considered to be “holy trees” and taboo to remove from the rice fields. In this region, less than 20% have access to public canals for irrigation, while the majority are dependent on rainfed irrigation. Due unpredictable rainfall patterns, lack of access to public irrigation, and habitual use of traditional farming practices, almost all rice farmers in the Northeast use flooded irrigation techniques. Over the past five years, farmers have noticed even more erratic rainfall patterns, including periods of heavy rainfall, flooding and prolonged drought during the wet season. In this region, the government has supported farmers with subsidies to dig ponds on their fields for storing 12,500 cubic meters of water; however, most farmers have agreed that these ponds are too small to use for water storage for irrigation purposes—80% are currently using the ponds to raise fish for selling and home consumption.

Farmers: The majority of farmers in the area are landowners with land sizes that range between 10-15 rai; some farmers have over 30 rai of land. Less than 10% of farmers do not own land at all and those who rent land are landowners who want additional land to grow more crops. In this region, farmers grow rice only once per year during the wet season and maintain alternative jobs, as well as other crops and livestock, to support their household for the rest of the year. Many farmers in Ubon Ratchathani grow corn after rice due to its high price and guaranteed market from buyers such as CP and Kao Na Kai Sod. Cassava for bioethanol fuel is also a burgeoning crop in the region that grows during the same time as rice; due to its quicker cash returns, some farmers have switched to cassava from rice (despite higher investment costs).

Megafarms: government budgets for Ubon Ratchathani are mostly focused on the promotion of organic homali rice; therefore, funding support and extension from the DOAE is prioritized for groups of organic rice farmers. Megafarms in the area are mostly developed out of former community rice centers; membership in these groups has declined over the years as many farmers are unwilling to attend all required meetings, and others have switched to growing only corn. Megafarms in the area provide services such as ploughing, baling, harvesting, milling, and laser land leveling (limited). Fertilizer Centers and some megafarms also have mixers or methods for making customized fertilizers for members at reduced prices.

2.2. Key takeaways

Farmers in this region are facing the biggest challenges with regards to unpredictable rainfall and poor soil conditions. Based on the evaluation of farmers perspectives and experiences, service providers experiences, and the existing models for delivering services to farmers in the region, this market study regards **Laser Land Leveling, Straw and Stubble Management, Site Specific Nutrient Management, and Rotational (after) Crops** to have the highest importance for climate resiliency and highest potential for adoption based on farmers’ acceptance and needs.

2.2.1. Laser Land Leveling

Market potential score: High

Overall review:

- High potential of LLL for Isan region given the characteristics of the land in this area; however, requires more attention and support to bolster funding support and extension to encourage investment.

Selling points:

- Farmers mostly practice rainfed irrigation in this area; they flood their fields after rain with dikes to keep water in the field and drain when it is between 15-30 cm (depending on stage of rice and farmer's individual preference. There is no water inflow from an irrigation canal or river in this area. Therefore, LLL enables them to better:
  - retain water in the field
  - improve fertilizer application (broadcast)
  - improve herbicide application (some farmers claim to use broadcasting method for applying chemicals, some claim to apply this through sprayers)
  - suppress weed growth through flooding
- Improves the roots of the crop for better yields.

Barriers:

- High investment costs without ability to take out loans: price is not competitive with traditional leveling methods; farmers currently are taking out the maximum amount of loans from BAAC and unable to make high investment costs. Since farmers are only growing 1 crop of rice per year, high investment costs are not justified for LLL.
- Extension on LLL is exclusive: Lack of knowledge and understanding of LLL among farmers who are not in certain megafarms. Currently, LLL is centralized in one megafarm; farmers who are in other megafarms and non-megafarmers are not convinced by LLL benefits because they have not received adequate information and demonstration.
- Those who rent land are unwilling to invest in LLL: this is less of a barrier in Isan where many farmers own land. For those who rent land, landholdings as well as land rental prices are not guaranteed each year.

Other considerations:

- There are currently few providers in the area. Service provision in Warin district is centered around 1 megafarm that has 2 LLL machines; services are 1,000 THB/hour (covers 1 rai) for members and 1,200 THB/hour for non megafarmers. There is currently no BAAC revolving fund for the farmers in Isan.
- There is confusion about requirement that farmers still need to do traditional level before doing LLL; this confusion exists among both extensionists as well as farmers (both megafarm and non-megafarm). Farmers are unwilling to invest in LLL if they also need to pay for traditional leveling to do LLL.
- Farmers, service providers and extensionists claim that traditional land leveling can help to reduce the costs of LLL by reducing the time required to do LLL (LLL price is calculated per hour; however, farmers claim that it typically equates to price/rai). Additionally, farmers and service providers believe that they are required to do basic

land preparation prior to LLL. Price of traditional land leveling is currently 600-700 THB/rai. Farmers find that the current price of LLL is too high compared to traditional leveling given that the 1,000/hour (rai) does not traditional leveling costs (optional, but preferred) and basic land preparation costs required for LLL; they would therefore not opt for LLL, especially those who have smaller plots. • Farmers are already taking out maximum amount of loans from BAAC and only able to pay off interest rate each year with earnings from rice. Farmers are unwilling to take out additional loans and believe that they would not be qualified for any programs on LLL given current debts. • LLL supports improvements in yield and water level in all crops, not just rice. However, seems to only be promoted for rice; farmers only grow 1 crop a year, in farmers' perspectives, it does not make sense to invest in technologies that only have benefits for rice.
Recommendations: • Demonstration farms that include documentation about cost benefits should be implemented in more areas. • Negotiate loan terms for LLL that do not depend on farmer's existing debts.

2.2.2. Alternate Wetting and Drying

Market potential score: Low
Overall review: • AWD is not appropriate for this region and has low potential for success and low acceptance among farmers.
Selling points: • Reduces pests and diseases • Enables rice crops to be stronger
Barriers: • **Lack of public irrigation:** rainfed area means that non-flooded irrigation techniques are risky. • **Unpredictability of rainfall:** farmers will flood fields to reduce risk due to unpredictability of next rainfall. • **Lack of water storage systems:** government-built ponds in the area are too small to be used for draining and storing water to be used for rice. • **Sandy soil:** lack of organic content in the soil means that soil in this region does not retain water as well.
Other considerations: • For many farmers, fertilizer and chemical application is done through applying directly through the water during flooding of the fields; farmers do this to reduce labor costs for spraying and fertilizer application. • Groundwater is currently being used for corn only; farmers are willing to invest in pumping costs for corn due to higher price of corn.

- Funds to support building larger-sized ponds have only been concentrated on megafarms.
- After flooding, farmers may drain some of the water into other areas; however, the "appropriate" flood level is not agreed upon by all farmers.
- Farmers are currently using a combination of regional media (such as TV, radio.) and traditional methods (watching the timing of the mango blossoms and watching ant patterns) to make predictions about rain which are not accurate. Farmers believe that the weather forecasting they currently use is not localized enough to be useful to them. to change practices or follow water sharing rules despite having an irrigation group [No penalties on farmers for not following water sharing patterns or flooding fields]

Recommendations:

- Focus on developing more accurate weather forecasting tools for farmers to promote more accurate planting time and reduce need for flooding.
- Invest in better water storage system for farmers to reduce dependence on unpredictable rainfall.
- Invest in experimental AWD demonstration farms for areas with sandy soil to determine required techniques for success.

2.2.3. Site Specific Nutrient Management

Market potential score: High

Overall review:

- High potential for SSNM in this region and high interest among farmers due to poor soil quality.

Selling points:

- Helps farmers to reduce their fertilizer costs
- Increases yield

Barriers:

- **Lack of guidance and training:** site-specific mixes are believed to be too complex to make; farmers have limited knowledge about their soil quality or guidance on how to use and make customized fertilizer, especially outside of the megafarm.
- **High cost of base fertilizers:** base fertilizers are less commercially available at affordable prices.
- **Lack of soil doctor support services:** lack of soil doctors in the area means farmers have less individual access to their services; soil doctors do not have enough test kits and are required to send samples to the district labs, leading to delays in results.

Other considerations:

- Soil quality in Isan has less organic matter and farmers in the area do not have adequate knowledge and extension support about soil quality, especially those outside of megafarms. Use of pre-mixed fertilizers that do not fit with the soil has led farmers to overuse fertilizers (especially nitrogen). Even though many farmers in this area use organic fertilizers, most will do this in combination with 46-0-0.

- There is a lack of budget from the Rice Dept and DOAE to reach all farmers with support on SSNM, especially those outside of the megafarm. Current policies in Ubon Ratchathani focus on organic farming which means that organic farmers also receive special privileges (however, there are few registered organic farmers in the area).
- Farmers are unlikely to request for soil testing due to the feeling that they do not need it and because results are often delayed or do not come at all.
- There is a Fertilizer Community Center in the area (1 per district) that is open to farmers who grow rice and other crops. This center provides customized fertilizer services; however, membership is not high, and many farmers do not buy the fertilizers due to distance and belief that the fertilizers are poorer quality than those in the shop.

Recommendations:

- Build sub-district soil testing laboratories to reduce delay on soil testing and improve professionalization of soil doctors on fertilizer recommendations following soil tests.
- Increase extension support on SSNM to farmers outside of megafarm and organic farm groups.

2.2.4. Straw and Stubble Management

Market potential score: High

Overall review:

- High potential for SSM in this region given the demand for straw bales. High potential for stubble decomposition in order in order to reduce fertilizer cost and improve soil quality.

Selling points:

- Additional income from selling straw.
- Bales used to feed livestock.
- Decomposition of stubble fertilizes soil and reduces cost of fertilizers.
- Livestock producers have high demand for straw in this area.

Barriers:

- **Farmers burn fields to get rid of weeds and to prepare for next crop:** farmers who grow corn are likely to burn the stubble in order to prepare the land easily. Some tractor services will even refuse to provide ploughing services if farmers do not burn stubble.
- **Additional investment cost if use technique for "flipping" and "mowing" stubble into soil:** tractor service providers do not invest in the additional tools for making stubble smaller; farmers do not want to invest in additional services to make stubble smaller for ploughing.

Other considerations:

- Balers service for 10 THB/bale and the farmers can sell the bales at 25 THB/bale, mostly to livestock producers, or farmers can keep the bales for their own livestock.
- In some farm groups/megafarms, they will collect straw and mix it with manure in order to make fertilizer. This was taught to them by the DOAE.

• Some tractor service providers will refuse to provide ploughing service if farmers don't burn the stubble (the field not "clean"). If stubble gets stuck in the machine, it is difficult to get them out. The "flipping/mowing" attachment for a tractor cost around 75,000 THB for the service provider. The service itself costs around 230-250 THB/rai. Some service providers believe that If tractor service providers invest in this service, it is less likely that the stubble will get "stuck" in the machine. This belief may depend on the skill level of the service provider; some providers may have the skill and technique to plough stubble directly into the soil and some providers may believe that they require additional equipment in order to do so. • In one megafarm, the group has agreed to make a cash incentive for those who plough stubble. Those who plough after harvesting receive 500 TBH (total) from the Megafarm's savings/profits (they've done this for the past 2 years). There are already 30 farmers (50%) who do this.
Recommendations: • Investment support for tractor service providers and farmers to invest in "flipping/mowing" method of stubble. • Consider applying monetary incentives for those who do not burn.

2.2.5. Integrated Pest Management

Market potential score: Low
Overall review: • Low potential for IPM in this region because farmers do not face substantial P&D issues.
Selling points: • Enables reduction of costs for chemicals: chemical prices are rising globally
Barriers: • **Lack of P&D issues:** few people in this area face P&D issues due to 1 crop of rice per year**.** • **High labor costs:** farmers are more likely to use herbicides to control weeds. • **Lack of training on IPM:** IPM programs mostly concentrate on reaching megafarms due to the budgetary constraints of DOAE.
Other considerations: • Farmers have received trainings on both IPM as well as a chemical-heavy regime from Bayer; however, most trainings are only given to megafarm members. Trainings on IPM are currently prioritized for farmers who grow organic homali 105 rice due to budgetary restrictions of DOAE in Ubon Ratchathani. The policy of Ubon is to promote this province as organic, so all budgets go to organic farmers. • Outside of the megafarm, farmers mostly receive information on P&D management through the internet, village broadcasting radio, and from other people in the village. • Farmer receive news about outbreaks through Line, village announcements and extensionists; however, most do not appear to do any active scouting of pests. Farmers may sometimes face rice blast and brown plant hopper but not regularly.

When faced with brown plant hopper or rice blast, farmers will spray chemicals but do not have any training on how much to apply/when to apply. • Many people use chemical herbicides as base weed protection at beginning stages of growing rice.
Recommendations: • Improve reach of existing IPM programs to farmers outside of organic rice groups and megafarms.

2.2.6. Rice Variety Diversification

Market potential score: Medium-low
Overall review: • Lower potential due to farmers' risk aversion when it comes to rain. Farmers are unlikely to grow shorter duration varieties in this region unless they have better water management.
Selling points: • Farmers will grow shorter duration varieties if they have : good yields, guaranteed buyers who do not have conditions on farmer practices; and ability to consume the rice varieties in the household (due to taste).
Barriers: • **Unpredictability of rain:** regardless of the rice variety, farmers will grow rice for longer duration due to unpredictability of rain and requirement of broadcasting early.
Other considerations: • Shorter duration varieties have lower price than longer duration (105). Farmers will grow RD 15 (shorter duration) if they grow corn after rice; however, difference in growing period is not too different (~20 days). • Farmers grow homaly because it is promoted by the rice department; farmers will mostly choose varieties based on what the millers accept and what other farmers are growing. • RD 81 is not popular for growing because it has a lower price and is lower quality (used mostly to make rice crackers). • Farmers are able to get bonuses if they sell to Olam (up to 150 THB) but they may not prefer this because payments from Olam take too long to receive in comparison to millers (2-3 months after selling is too long to wait). • There is not a big market for organic rice; farmers need to find a market, but it is difficult outside of the megafarm. • Farmers feel that they do not have much negotiation power in this region; there are only 4-5 big millers that farmers work with.
Recommendations: • Improve weather forecasting tools for farmers. • Support to improve negotiation power with millers on the rice price.

2.2.7. Intercropping and Rotational (After) Crops

Market potential score: Medium-high
Overall review: • High potential for rotational/after crops such as sun hemp and green beans to fix nitrogen in soil.
Selling points: • Provides additional income to support farmers, especially during drought periods.
Barriers: • **Farmers do not have enough water:** farmers may be unwilling to grow crops after-rice that do not have high price due to lack of water and high investment costs in pumping water. • **Lack of sufficient water storage:** ponds are too small for providing enough water for irrigation of after-crops. • **Lack of knowledge on after-crops:** farmers do not have sufficient knowledge on which crops are suitable to this region's market/environment.
Other considerations: • Farmers in this region mostly grow corn after rice because it has a higher price, despite higher investment costs. Kao Na Kai Sod and CP are the biggest buyers of corn, which is used for producing chicken meat. Some farmers are also switching from rice to cassava because cassava pays quicker than rice. • Most farmers have alternative income generating activities, including after crops and other jobs in service industry or being service providers because they only grow 1 crop of rice per year. • Very few farmers are growing after crops for fixing nitrogen. • Farmers mention that extensionists have promoted crops such as cannabis that do not have a market in this region.
Recommendations: • Additional extension support on after-crops that can improve soil and match regional market needs. • Support in investment in improved water storage systems.

2.2.8. Drones

Market potential score: Low
Overall review: • This technology does not add to climate mitigation or adaptation for farmers and is unlikely to reduce labor time/cost sufficiently so that farmers will invest in other CSA technologies.

Selling points: • Reduction of labor time • Prevents damage to crop due to human labor.
Barriers: • **Lack of service providers**: there are few service providers in this area. • **Farmers use flooding to broadcast fertilizers:** farmers spread fertilizers and herbicides through flooding as well as spraying services. They do not have high incidences of P&D to require drone services.
Other considerations: • Drones are too expensive and not priority to buy for megafarm (40,000 THB) because not needed. • Many farmers do not have knowledge about drones • Currently Bayer is a drone service provider in the region but offers it only when purchasing chemicals from them.
Recommendations: • Do not promote this technology.

2.2.9. Post-harvest mechanization

Market potential score: Medium-high
Overall review: • High potential for improving ploughing services through extension of current service providers on technique for incorporation of stubble into soil. • Large number of harvesting service providers in this region, including those coming from other areas such as the Central Plains means that service providers are competing for customers. Due to high competition of combine harvesters, combine harvesters do “rush jobs” to gain more customers. As a result, these services are not efficiently reducing post-harvest yield loss and should therefore not be further promoted.
Selling points: • Reduces labor costs and time for harvesting. • Ploughing of stubble will improve soil fertility
Barriers: • **Service providers do "rush jobs" to compete for clients** and make up for high fuel and maintenance costs of the machines. Because of the inefficiency of the service provision, yield collection is less precise than through manual labor. • **Additional investment cost if use technique for "flipping" and "mowing" stubble into soil:** tractor service providers do not invest in the additional tools for making stubble smaller; farmers do not want to invest in additional services to make stubble smaller for ploughing.

Other considerations:

- Central Plains harvesters do come to this area—the customers don't want to wait in a queue for their regular harvesters so they will catch the next available one. Because of this, harvesters will speed up in order not to lose customers. This leads to reduction in yields.
- The "flipping/mowing" attachment for a tractor cost around 75,000 THB for the service provider. The service itself costs around 230-250 THB/rai. If tractor service providers invest in this service, it is less likely that the stubble will get "stuck" in the machine

Recommendations:

- Investment support for tractor service providers and farmers to invest in "flipping/mowing" method of stubble.

3. Chiang Rai

3.1. Overview of area

Landscape: The two chosen sites for Chiang Rai—Wiang Pa Pao and Mae Chan district—represent two important regional landscapes, whose characteristics are key to determining the locally-specific viability of the technologies for farmers in Chiang Rai. Wiang Pa Pao is a more remote area that connects Chiang Rai to Chiang Mai, with a mixture of mountainous, sloping, and flat lands. The whole district is connected to public irrigation system is managed by the Irrigation Department and locally, through the sub-district representative. In the mountainous regions (20% of Wiang Pa Pao), farmers rely on rainfed irrigation; according to the District Agricultural Extension Officer, rainwater comes regularly, and farmers do not currently face any challenges in water access to date. In both instances of public irrigation canals and rainfed water sources, farmers mostly use the flooding technique for irrigating their rice fields. Mae Chan district, land is mostly uneven and sloped—many farmers will grow rice in terrace-like patterns, dividing their land into small plots that can sometimes be less than half a hectare in size. Mae Chan farmers use both public irrigation as well as rivers or streams—depending on where their farms are located. Both districts experience occasional flash floods in the months of May and June but no droughts.

The general soil type in both Wiang Pa Pao and Mae Chan is clay. Due to flooded irrigation practices and erratic rainfall patterns, a large number of farmers in both areas also face problems of “muddy holes” or “quagmires,” which are large holes scattered throughout the rice fields. Farmers claim that this problem results from flood irrigation practices, sometimes combined with the use of heavy machinery, which puts pressure on wet areas, causing large holes to form.

The total rice growing area in Wiang Pa Pao is 47,600 rai and the average landholding of farmers is approximately 7 rai per farmer. In Mae Chan, total rice growing area is about 94,067 rai during the wet season and 55,132 rai during the dry season, with farmers holding an average land holding aof about 5-10 rai.

Farmers: Landownership in both Wiang Pa Pao is about 50% and in Mae Chan, ownership encompasses about 40% of farmers. In both regions, farmers are renting land from landowners who may be either local-based or absentee owners based urban areas such as Bangkok. As in other regions, contracts for rice growing land do not exceed 5 years and are mostly based on verbal agreements between owner and tenant.

Farmers in Wiang Pa Pao grow a mixture of rice, corn, soybean, and sometimes potato (in limited areas), in addition to some instances of longan and rubber. In Mae Chan, farmers grow rice, corn and sometimes sun hemp. However, most of the farmers in the region grow 2 crops of rice per year in the wet season and dry season. According to the District Agricultural Extension Office, farmers’ main source of income in flat-land areas is mostly rice whereas in mountainous regions, it is mostly corn.

The are 2 ethnic villages in the Wiang subdistrict of Wiang Pa Pao (mostly “Hmong”), where registered rice farmers mostly grow a unique type of “upland rice,” which sometimes precludes them from attending rice extension trainings. Farm sizes in ethnic minority regions tend to be small (3-4 rai), but some ethnic minorities have moved down from the mountainous regions to buy land in flat-land regions for growing sticky rice or through government projects to improve ethnic minority access to infrastructure or reduce forest burning. In both districts, some farmers have

noted that they hire ethnic minorities to work on their farms as laborers as they are perceived to be better-skilled and more diligent than non-ethnic minority laborers, as well as cheaper to hire. In Chiang Rai, media and public information often use ethnic minority groups as a scapegoat for the air pollution issues that result from burning of leftover agriculture products on the field. Most of the burning in the region comes from corn rather than rice and many ethnic minorities in the mountainous regions grow corn. Nevertheless, ethnic minorities are not more likely to burn leftover products on their field than other ethnic groups.

Megafarms:

Membership in megafarms and fertilizer centers remains low, with memberships declining due to unwillingness of farmers to pay shares to the group and attend all meetings. In the sub-districts of Mae Chan, megafarms face funding challenges due to the limited budget of the DOAE to provide seed funds and extension support. In general, the DOAE is undergoing budget cuts of 20-30% over the past few years; as a result, DOAE support to megafarms is selective—they choose only those megafarms that have strong group cohesion and high attendance rate. Megafarms provide members with key services such as baling of straws, ploughing, harvesting and milling. Fertilizer Centers and some megafarms have mixers or methods for making customized fertilizers for members at reduced prices. Megafarms are also channels through which the DOAE and Rice Department is currently promoting new seed varieties, such as RD6.

3.2. Key takeaways

Farmers in this region are facing the biggest challenges with regards to “muddy holes”/quagmires, high incidences of on-field burning of straw and stubble, and declining soil health. Based on the evaluation of farmers perspectives and experiences, service providers experiences, and the existing models for delivering services to farmers in the region, this market study regards **Alternate Wetting and Drying, Straw and Stubble Management, Integrated Pest Management, Intercropping, and Rice Variety Diversification** to have the highest importance for climate resiliency and highest potential for adoption based on farmers’ acceptance and needs.

3.2.1. Laser Land Leveling

Market potential score: Low
Overall review: • Low potential in this region. In some areas that are flatter, LLL could have more potential but there are currently few service providers, little knowledge amongst extensionists and farmers on its benefits, and high percentage of rented land. In areas where land is more mountainous and sloped, farmers have smaller plots and machines are even less accessible due to remoteness of some areas. Smaller plots may not be conducive to LLL, as validated by Crop Tech Asia and service providers in other regions who agree that the ideal size for LLL should be at least 5 rai for maximum effectiveness.

Selling points:

- Farmers practice flooded irrigation; therefore, LLL enables them to better retain water in the field

Barriers:

- **Those who rent land are unwilling to invest in LLL:** about 50-60% of farmers rent land in this area are unwilling to make investments given insecurity of rental agreements.
- **Lack of access in certain regions:** difficulties applying LLL in mountainous and remote regions due to lack of accessibility. Some areas face big muddy holes ("quagmires") which make it difficult for machines to access if the land is not dried out; machines are actually believed to further exacerbate the problem of quagmires due to pressure and weight if the land is not completely dried during application.
- **Land size:** farmers who have small sized plots (typically those in sloped areas with terraced fields) under 1 rai believe that it is difficult to apply LLL on their land and that costs will be higher than if their lands are conglomerated in 1 plot.
- **Lack of knowledge on LLL:** in this area, there are currently no service providers. Farmers and extensionists alike are not aware of the full benefits of LLL.

Other considerations:

- 'There are no service providers in this area. There has been one pilot with one farmer in Chiang Rai, but the results are unknown, and the practice has not been expanded otherwise.
- Some areas may have wetter soils during the time periods when LLL can be applied (end of Wet Season, January/February). Mountainous areas may have erratic rain and lowland areas may have soils that are continuously wet. LLL services will be unable to service areas that have wet soils. Alternatively, farmers who grow 2 crops per year may believe that there is little available time for them to do LLL before the next season.
- Farmers are continuing to practice "traditional leveling" services given the smaller sizes of their plots. Traditional leveling prices range from 300-600 THB/rai or up to 1,300 THB/"spot"; however, farmers may not apply this every year (only every 3 years) and they may opt to only level a particular area of land rather than the whole plot. As such, traditional leveling does not stand out as a large one-time investment and is therefore more appealing than LLL.

Recommendations:

- Demonstration farms that include documentation about cost benefits should be implemented in more areas.
- Sharing costs between farmer and land owner for rented land.

3.2.2. Alternate Wetting and Drying

Market potential score: High
Overall review: • High potential in this region as the farmers are currently sourcing their water from public irrigation, rivers, or streams, and therefore better able to control water levels manually. Additionally, farmers believe that by drying the land, AWD can help them to reduce quagmires (large muddy holes) from forming in their fields; reduction of quagmires is seen to reduce pest and diseases as well as enable other machine-oriented practices to be more effective (e.g., tractors, balers...).
Selling points: • Reduction of "muddy holes"/"quagmires • Enables rice crops to be stronger • Reduces possible damage to crop due to flooding during wet season • Can contribute to management of golden apple snail as well as bacterial leaf blight
Barriers: • **Preference for traditional practices:** farmers hold on to traditional practices by which they use public irrigation or river to flood their fields and retain the water 2-3 times during the season, until the water is higher than the first tiller (10-15cm) and then they will drain. • **Lack of knowledge and experience:** while farmers in some areas such as Mae Chan may already be practicing a form of AWD, there is very little training, demonstration and training on AWD techniques in this region. Farmers mostly learn about AWD through others or through their own experience. • **Cost of pumping water:** farmers in this region do not pay for pumping water into or out of their fields and are unwilling to pay those costs if required by AWD. • **Increased weeds:** dry land is conducive to weeds and will increase farmers' costs on herbicides.
Other considerations: • A large number of farmers in this region face problems of "muddy holes" or "quagmires" in their fields. These are large holes that arise during flooding; the holes can be up to 2 meters deep and the largest can be around 400 m2. Farmers believe that quagmires are exacerbated by the use of heavy machinery on wet land, which they believe puts pressure on the land and causes it to sink into muddy holes. AWD has been used by farmers to resolve the issue of quagmires by drying out the land; they find that when the soil is dry, it is unlikely to sink and cause the problem of muddy holes. • Farmers in this region may have access to three different types of water sources: 1) stream- means they usually only 1 rice crop per year (water availability varies depending on where the farmer is located relative to the stream), this source is not as reliable during the dry season; 2) public irrigation managed by the Royal Irrigation Department- means that farmers can grow 2 crops per year because water is more available through this source (water availability varies depending on where you are relative to the stream); and 3) river irrigation- means that farmers can grow 2 crops per

year as water is more easily available. Farmers mostly drain water in and out through a pipe system without a pump.
- In Wiang Pa Pao, 80% of land is flat and connected to a water source and therefore more suitable for AWD whereas 20% is rainfed (mostly in mountainous areas).
- During the wet season, farmers are experiencing flash floods. Now, farmers do not feel that this has caused major problems to their crops. However, they have noted that they may not be able to do AWD if there are flash floods because there is not possibility to drain water into other places during these events.
- Farmers are currently using a combination of regional media (such as TV, radio, etc.) to make predictions about rain which are not accurate. Farmers believe that the weather forecasting they currently use is not localized enough to be useful to them.
- Some farmers may believe that snails are also more common if they do AWD, but in fact, snails are reduced by drying out the fields.

Recommendations:

- Focus on developing more accurate weather forecasting tools for farmers to promote more accurate planting time and reduce need for flooding.
- Improve and expand extension on AWD techniques for farmers, especially for those outside of megafarms.

3.2.3. Site Specific Nutrient Management

Market potential score: Medium-high

Overall review:

- Potential for SSNM in this area to reduce overuse of chemical fertilizers. However, this requires an improved SSNM delivery model for farmers to receive efficient soil sampling and customized fertilizers. Current model means that resources for enabling farmers to uptake SSNM practices is limited to megafarms and fertilizer centers.

Selling points:

- Helps farmers to reduce their fertilizer costs
- Increases yield

Barriers:

- **Lack of urgency:** farmers in this region perceive that their soil is good quality and that they do not require testing.
- **Complexity of soil testing:** soil tests are perceived by farmers to be too difficult and too complex to collect. In order to collect soil samples, the farmers need to dig in 5 spots (at center and corners of field) 15cm, take a sample, dry it out then grind it, mix it together and bring it to the soil doctor. Farmers feel that this is too complex and too much effort and are therefore not willing to take the effort to collect their own soil samples.
- **Lack of soil doctor support services:** lack of soil doctors in the area means farmers have less individual access to their services; soil doctors do not have enough test kits, leading to delays in results.
- **Complexity of customized fertilizers:** farmers perceive that customized fertilizers are too complex and time consuming to make individually and would prefer to buy ready-made fertilizers. If farmers have large plots, they need to do this on all plots. If

the plots are connected, they need to collect in a zig zag pattern. Megafarms and fertilizer centers who offer customized fertilizers have mixers but require a minimum of 300-350kgs per batch of customized fertilizer. In some areas, soil is not dry enough for good samples. • **Lack of knowledge:** farmers (especially non-megafarmers) lack access to training on proper soil management, leading to overuse of chemical fertilizers such as nitrogen. • **High cost of base fertilizers:** base fertilizers are less commercially available at affordable prices, especially for individual farmers.
Other considerations: • There is a lack of budget from the Rice Dept and DOAE to reach all farmers with support on SSNM, especially those who are not already organized into strong groups. DOAE mentions that they have received 70% of their former budget. • Farmers who use river sources to irrigate their fields claim that they use less fertilizer during the Wet Season because they can get nitrogen naturally from the river during the wet season. • There is a Fertilizer Community Center in the area (1 per district) that is open to farmers who grow rice and other crops. This center provides customized fertilizer services; however, membership is not high and many farmers do not buy the fertilizers due to distance--one fertilizer center is located in a remote area. • Farmers claim that sticky rice straw and stubble are shorter and thinner than regular rice; therefore, it is easier to plough into the soil and decompose as fertilizer. Before wet season, some farmers may plough corn stubble into the soil as fertilizer. • Farmers in this area mostly have clay soils.
Recommendations: • Build sub-district soil testing laboratories to reduce delay on soil testing and improve professionalization of soil doctors on fertilizer recommendations following soil tests. • Increase extension support on SSNM to farmers outside of megafarm.

3.2.4. Straw and Stubble Management

Market potential score: High
Overall review: • High potential for straw and stubble decomposition in order in order to reduce fertilizer cost and improve soil quality. The straw and stubble of sticky rice appears to be easier to decompose, even without EM.
Selling points: • Additional income from selling straw. • Bales used to feed livestock. • Decomposition of stubble fertilizes soil and reduces cost of fertilizers. • Livestock producers can use the straw.

Barriers:

- **Aftercrop burning:** farmers who grow other crops after rice such as corn, soybean, potato, may have a shorter period to get rid of straws after rice harvest and decide to burn.
- **Baler access:** limited access to baler services with most balers concentrated in megafarms. Baler services in megafarms will prioritize servicing megafarm members before non-megafarmers. Those who live in the mountainous regions are unable to access baler services because service providers do not go to these regions. Service providers are unable to service farmers who have "muddy holes"/quagmires in their fields. Those who live in lowland areas with wet land may not be able to use baler services on their land.
- **Rain:** at the end of dry season, some areas may experience erratic rain events which make it difficult to bale straw due to wet land.
- **Refusal of services:** some tractor service providers will refuse service of land preparation for farmers who do not burn the straw out of fear that the straw will get stuck in the machines.

Other considerations:

- Farmers pay 17 THB/bale for baler services from the megafarm if they decide to keep the straw. If they give the straw to the megafarm, then the cost of baling services is 5 THB/bale.
- Farmers claim that some service providers will refuse to provide service if farmers don't burn the stubble (the field not "clean"). However, few service providers mentioned that they have a problem with stubble requiring burning before ploughing services. Service providers did mentione that if stubble gets stuck in the machine, it is difficult to get them out. In this region, there is a mowing attachment for a tractor that can help to "cut" the stubble and straw into smaller pieces for easier incorporation into the soil. The attachment is an extra cost for service providers (50,000 THB).
- Farmers claim that sticky rice straw and stubble are shorter and thinner than regular rice; therefore, it is easier to plough into the soil and decompose as fertilizer.
- There is a stigmatization of ethnic groups when it comes to burning rice: blame is typically placed on ethnic minorities for incidences of rice burning in Chiang Rai or in northern Thailand in general. Ethnic minorities do not specifically burn more than other farmers. Largest source of burning appears to come from industrial corn (purchased by CP), however it is important to note that many ethnic minorities grow corn for CP, but corn is also grown by other farmers as well. DOAE provided training on SSM mostly for farmers in mountainous regions who are believed to burn more stubble than in other regions. For this training, DOAE promotes knowledge on how to make manure out of straw.
- For 5 years, there has been a strict regulation on burning that is mostly enforced during the "in-season" between January and March. These are the driest months and months when pollutants are the highest; farmers are also motivated to burn during this season in order to avoid erratic rain events. Farmers may be fined 10,000 THB for burning. In the "off-season" months between November and December, farmers are able to burn their stubble without repercussions.

Recommendations: • Investment support for tractor service providers and farmers to invest in "cutting" method of cutting stubble.

3.2.5. Integrated Pest Management

Market potential score: High
Overall review: • Higher potential for IPM as a preventative and to prepare farmers for future outbreaks; farmers here already face P&D in their fields even though it has not reached outbreak level.
Selling points: • Enables reduction of costs for chemicals: chemical prices are rising globally
Barriers: • **Less incidences of outbreaks:** due to weather and climate in Chiang Rai, farmers face fewer outbreaks of pests and diseases in this area for rice and therefore mostly manage through spraying and/or drying their land without much knowledge on pest & disease scouting and management techniques. Farmers continue to spray chemicals (herbicides, especially) in the early stages of planting as a base protection. • **Lack of knowledge:** management of P&D is mostly learned through neighbors and own experiences rather than training**.** • **Limited training opportunities:** due to limited budget of the DOAE, training on IPM is limited to certain megafarms. These trainings most focus on teaching farmers how to use and make biological substances such as Trichoderma.
Other considerations: • Potato, corn, and soybean have higher incidences of pests and diseases than rice and require higher use of chemical control; there is not much evidence of P&D transfer between crop rotations. • There are 2 forecasting plots for rice in WPP. The forecasting plot is chosen among the farmers in the area and the farmer is required to monitor the plot weekly and report problems to the DOAE office. If there is an outbreak, the DOAE will report to the village head and report on Line to the farmers. • Farmers may face: bacterial leaf blight, rice blast disease from funghi, plant hopper, snails (golden apple) • Farmers will manage plant hopper by spraying chemicals or drying out the land.
Recommendations: • Improve reach of existing IPM programs to farmers outside of megafarms.

3.2.6. Rice Variety Diversification

Market potential score: High
Overall review: • High potential for shorter duration varieties if these varieties are varieties that produce good yields and have shorter stems to withstand the wind.
Selling points: • Farmers will grow shorter duration varieties if they have : good yields, guaranteed buyers, if the variety can withstand wind, and if the variety can be consumed domestically
Barriers: • **Sticky rice:** farmers mostly grow sticky rice in this region because sticky rice seem to be suitable for the weather in the area; the weather is seen to be too cold and too much water for white rice, based on experiences of growing homali rice with low yields. Sticky rice consumed domestically, it is promoted by the Rice Department, it can be sold easily to millers, and because it can withstand strong winds. Sticky rice typically grows for at least 100 days in order to get "good grains."
Other considerations: • Price of sticky rice is very low and can be as low as 5 THB/kg because it is lower in demand. Over the past 4 years, the rice price has reduced from 12 THB/kg to around 5.5-8 THB/kg. • The Rice Department has promoted Sanpotang and other sticky rice varieties such as RD6. Regular RD6 has a longer stem which means that harvesting services for RD6 cost more than for varieties with shorter stems. RD6 has one version called Nan 59, which is adapted to have shorter stem to better withstand the wind, rather than be shorter in duration. RD6 has good yield. This variety is preferred because it can withstand wind. Farmers can also grow CP888 in this region (CP produced variety, which can be sold anywhere not just CP), but this variety does not have a price guarantee. • Farmers in this area are more likely to transplant seedlings (with a transplanting machine, as labor is expensive) as they want to develop strong rice crops and avoid losing seeds during flood events. • Japanese rice as well as some homali 105 is sold through contract farming (limited areas) with a price guarantee; however, those who grow Japanese rice only do so through contract farming, which means that they are required to receive seeds, fertilizers, chemicals and advice on growing from the company. • Farmers collect rice seeds and some may broadcast; those who broadcast collect seeds may experience weedy rice (Mae Chan). Rice Department has promoted Sanpotang rice variety and provides good quality seeds so that farmers can collect seeds for up to 3 generations.
Recommendations: • Consider promoting shorter duration varieties that have good yield and shorter stems.

3.2.7. Crop Diversification

Market potential score: Medium-high
Overall review: • For those who only grow 1 crop per year, there is a high potential for after crops such as sun hemp and green beans to fix nitrogen in soil.
Selling points: • Provides additional income to support farmers, especially during drought periods. • Stubble from previous crops can fertilize the soil, reducing fertilizer costs.
Barriers: • **Pumping water costs:** Farmers currently flood their fields through public irrigation channels, natural streams, or rivers by opening a flood gate that can drain water in and/or out of the fields. During dry season, when there is less water availability in the water sources, farmers do not want to pay for costs of pumping in water. • **Farmers do not have enough water:** In some areas, farmers may face lack of water during the dry season. In such cases, farmers may be unwilling to grow crops after-rice that do not have high price due to lack of water and high investment costs in pumping water.
Other considerations: • Rice is the biggest source of income for households in the Chiang Rai region, particularly in flat-land regions. In mountainous remote areas, farmers are more likely to grow corn as a main source of income. • Some people in this area grow edamame, potato, and corn as rotation crops with rice. In some areas of WPP, farmers also grow longan as well as rubber. Farmers used to grow soybeans in this area but many of them have stopped because the price has decreased, and the harvesting process is too onerous. • Some farmers have livestock (10% in WPP); this allows them to have cash for urgent needs when necessary. • Some farmers grow sun hemp to reduce fertilizer costs—mostly those who don't grow anything in the dry season
Recommendations: • Additional extension support on after-crops that can improve soil.

3.2.8. Drones

Market potential score: Low
Overall review: • This technology does not add to climate mitigation or adaptation for farmers and is unlikely to reduce labor time/cost sufficiently so that farmers will invest in other CSA technologies.
Selling points: • Reduction of labor time • Prevents damage to crop due to human labor.
Barriers: • **Lack of service providers**: there are few service providers in this area.
Other considerations: • Drones are too expensive and not priority to buy for megafarm (40,000 THB) because not needed. • Many farmers do not have knowledge about drones
Recommendations: • Do not promote this technology.

3.2.9 Post-harvest mechanization

Market potential score: Medium-high
Overall review: • High potential for improving ploughing services to support incorporation of stubble into soil.
Selling points: • Reduces labor costs and time for harvesting. • Ploughing of stubble will improve soil fertility
Barriers: • **Lack of precision of harvesting machine:** farmers will use combine harvesters instead of labor because labor is expensive; however, many farmers noted that harvesters are not as precise as labor. While service providers and farmers did not mention high number of harvesters in this region--and therefore competition among service providers. Given that there are less harvesters in this region, imprecise yield collection is likely to be caused by lack of skill to collect rice efficiently through the machinery. • **Additional investment cost if use technique for "cutting" stubble into soil:** tractor service providers do not invest in the additional tools for making stubble smaller.

- Machine harvester is not "clean": machine harvesting is seen by farmers to be risky because it may bring in sand, stones, and weedy rice into the field.
- **Muddy hole obstacles:** service providers may not be able to service farmers that have muddy holes/quagmires as it is difficult for the machine to maneuver in that area, especially if the plot is already small. In small areas, farmers believe that muddy hole problems may actually be caused by the use of heavy machinery which has limited area to maneuver, causing the machines to put pressure into the land and destroy the soil particles**.**

Other considerations:

- In areas where harvesters can only be accessed through the megafarm, harvesting service providers will prioritize megafarm members first before servicing non-megafarmers.
- The "cutting" attachment for a tractor cost around 75,000 THB for the service provider. If tractor service providers invest in this service, it is less likely that the stubble or straw will get "stuck" in the machine.
- Harvesting costs are depending on size of rice stem higher size of rice stem tends to mean that the rice stem will fall over, making it harder to harvest by machinery. Harvesting services will charge 500 THB/rai for short stem rice and 700 THB/rai for longer stem rice.

Recommendations:

- Investment support for tractor service providers and farmers to invest in additional tools to cut stubble before incorporating it into the soil.