

Report of an exploratory field Mission Senegal May 2024



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*This document summarises key findings and observations from this joint mission and serves as the basis for **Deliverable D1.7.2 for S9**; and **Deliverable D2.4.1 for S14**.*

1 Introduction

Sustainable intensification (SI) refers to increasing agricultural yields without adverse environmental impacts or converting additional non-agricultural land. Implementing SI in semi-arid West Africa, where cereal- and legume-based, mixed crop-livestock systems are prevalent, presents significant challenges. Despite the productivity gains demonstrated by innovative farming practices in research settings, adoption by local farmers remains limited.

To address these challenges, the CO-developing Innovations for Sustainable Land Management in West African Smallholder Farming Systems (COINS) project was launched. This collaborative project focuses on sustainable farming and land use to improve livelihoods, enhance food security, and boost natural resources. COINS aims to foster effective governance and incentivise sustainable land practices by promoting measures that reverse land degradation and increase resource-use efficiency. The German Federal Ministry of Education and Research (BMBF) funded the project under the funding code O1LL2204E, with a project timeline from 2022 to 2026.

The Project is made of several subprojects amongst which include:

- **Subproject 9** led by the University of Hohenheim (UHOH) examines targeted sustainable land management approaches and advisory services from a socio-psychological perspective.
- **Subproject 14** led by the Leibniz Centre for Agricultural Landscape Research (ZALF) evaluates environmental, economic, and climate-related risks.

To advance the objectives of the two subprojects, an exploratory field mission to Senegal was organized by UHOH and ZALF, in collaboration with COINS local partners, including Initiative Prospective Agricole et Rurale (IPAR) and Manobi Africa Group. Realised between May 27th to June 2nd, 2024, this mission enabled UHOH and ZALF to conduct research activities through the innovation labs established by the COINS project across the regions of Podor and Dagana..

2 Objective of mission

This joint UHOH/ZALF/IPAR/Manobi Africa mission to Senegal aimed at:

- Establishing a comprehensive understanding of farmers' coping strategies and social cohesion mechanisms, for better appreciation, integration, and positioning of introduced SI measures (Task 1.7.2), and
- Understanding Risk management strategies as a basis for attempting answers to the question: *of how farmers can mitigate risk related to their farming activities and climate change based on bio-economic modelling.* (Task 2.4).

3 Methodological approaches employed

3.1 Data collection

For data collection, we made use of a mix of farm visits and participant observations, key farmer interviews, and mixed stakeholder focus group discussions lasting over 2 hours each. These were taking place across three regions of Senegal starting from Podor, to Galoya and Kassack within the Dagana District.

Table 1: Data Collection methods realised across case study regions in Senegal

| Methods | Podor | Galoya | Dagana (Kassack) |
|-------------------------|--|---|---------------------------|
| Interviews | 01 Key farmer interview, 3 expert interviews | 01 expert interview | |
| Focus Group Discussions | 01 Focus Group Discussion | 01 Focus Group Discussion | 01 Focus Group Discussion |
| Farms Visited | 01 experimental farm at Tarédji Décollé, 02 individual farm visits at Ndiawar and Diatar | 01 experimental farm at Thilambol, 01 individual farm visit at Mbolo Birane | 01 individual farm visit |

3.2 Data analysis

All audio recordings from interviews, discussions during farm visits, and focus group discussions were systematically transcribed via Riverside's transcription tool to generate differentiated text. A crucial step in this process involved filtering out responses from interviewees while excluding both the translator's interventions and the interviewer's questions. Following transcription, codes were developed in preparation for qualitative text analysis using MAXQDA. The complete code system, along with detailed explanations, is provided in the appendix.

The analysis was conducted using MAXQDA version 24 (released on 2024.5.1), the latest version featuring integrated AI-assisted coding. This integration enabled the generation of summarized observations from the three case study regions, with a focused examination of key elements for quantification, specifically on the frequency and interrelationships of observed phenomena. To initiate the analysis, custom codes were developed and enriched with clarifications and examples within the code descriptions to ensure clear guidance.

Leveraging MAXQDA's AI capabilities, each code was applied three times across the transcripts, with variations reviewed to ensure consistency. Manually selected coded sections were then finalized, aligning precisely with the code descriptions, while retaining uncoded portions of the original text. In the final stage, summaries were generated for each code, supporting a thorough and precise analysis of the findings.

4 Findings and observations for Podor

The findings from Podor reveal several **critical threats** facing the agricultural landscape:

4.1 Critical threats, risks and other climate-related challenges

One significant concern is the **irrigation and water management challenges**, which stem from unequal water distribution due to limited pump station capacity covering a vast area of 1,200

hectares. This issue is exacerbated by frequent breakdowns of pumping machines, resulting in costly delays and hampering the ability to maintain the seasonal calendar for planting.

Furthermore, the **impacts of climate change** pose additional threats. Unpredictable weather patterns complicate the distinction between dry, rainy, and cold seasons, while increased temperatures and reduced rainfall necessitate more frequent irrigation. Consequently, cropping calendars are shifting, with certain crops failing during traditionally hotter months and irregular rainfall leading to either flooding or drought conditions. The agricultural ecosystem is also affected by the rising presence of pests, such as grasshoppers and birds, which further damage crops.



In addition to these **environmental threats**, there are notable resource and input challenges. Farmers face difficulties accessing and affording necessary fertilizers and agricultural inputs, while a lack of sufficient machinery and equipment leads to operational delays. Labour demands are increasing, particularly for tasks that require male labour, such as machine repairs and pipe installations.

The impact on **crops and livestock is evident**, with extreme weather events resulting in crop losses and reduced grazing lands, necessitating the importation of animals for religious festivals. In response, various adaptation strategies are being utilized.

Gender dynamics also play a significant role in these challenges. While women can independently manage many farming tasks, they often find themselves reliant on men for heavier work, such as machine repairs. Moreover, women express concerns over the reliability of pumping machines, which are crucial for their livelihoods.

Farmers are employing traditional methods to deter pests, collaborating with agricultural extension services to navigate changing conditions and utilizing practices like planting maize as windbreaks to enhance microclimate resilience. Additionally, they are shifting cropping calendars and relying on government and development programs for support and infrastructure improvements.

4.2 Hindering Factors to SRI

Finally, the analysis identifies key hindering factors for System of Rice Intensification (SRI) adoption. Labour and cost-related challenges are paramount, as SRI is labour-intensive and demands more workers than are readily available. The high costs are associated with the re-transplanting process, including nursery expenses, transportation, watering, and

supervision—further complicating adoption. Additionally, land and water management issues persist, as farmers contend with limited access to water due to shared irrigation systems serving large areas, leading to timing conflicts. The compounded effects of climate change exacerbate these challenges, making effective water management increasingly difficult.

5 Findings and Observations for Galoya

The findings from Galoya reveal several key threats and challenges faced by farmers and the agricultural sector in the region.



5.1 Critical threats, risks and other climate-related challenges

One major issue is the **difficulty with mechanization** and access to appropriate farming machinery. Farmers struggle to find affordable and accessible machines for essential tasks such as weed removal, land levelling, and other labour-intensive processes. This lack of mechanization not only makes their work more arduous but also significantly increases the time required to complete these tasks.

Another significant challenge highlighted is the **lack of access to financial services and credit**. Farmers exhibit hesitance in approaching banks for loans, largely due to the banks' reluctance to lend to this community. This disconnect creates substantial barriers, hindering farmers' ability to invest in necessary equipment and agricultural inputs. To overcome this issue, facilitating better collaboration between farmers and financial institutions has been identified as a potential solution.



The findings also emphasize the **severe impacts of climate change** on the local environment and agricultural practices. Farmers report experiencing drastic changes in weather patterns, including prolonged hot and dry conditions, erratic rainfall, and the disappearance of distinct seasons. These changes have led to significant crop losses and reduced yields, complicating traditional farming methods. Insufficient rainfall has further impacted water availability, particularly affecting the cultivation of crops like sweet potatoes.

Moreover, farmers face **threats from pests and wildlife**, including birds and insects that damage their crops. The prevalence of these issues has intensified, exacerbating the challenges faced by the agricultural community. Overall, the findings underscore the multifaceted nature of the threats and obstacles confronting farmers in the region, ranging from technological and financial barriers to the profound impacts of climate change and environmental degradation.

5.2 Hindering factors to SRI adoption

When it comes to the **hindering factors for the adoption of the System of Rice Intensification (SRI)**, the passages identify several key issues. The high labour requirements associated with SRI practices, the lack of mechanization, difficulties with land levelling, and the need for more training and understanding of the SRI system are all significant barriers. Farmers have expressed that the SRI system is labour-intensive, involving a lot of manual work such as re-transplanting with ropes, which is particularly time-consuming. The absence of appropriate machinery for tasks like land levelling further complicates the situation, as uneven plots make effective water management challenging. Additionally, some farmers feel they require more training and support to fully comprehend and implement SRI techniques effectively. This is especially true for women farmers, who face additional challenges in utilizing the necessary tools and equipment.



6 Findings and observations for Kassach-Dagana

Farmers in the Kassack-Dagana region are confronted with several **key threats** that jeopardize their livelihoods and the broader food sovereignty of the country.

6.1 Critical threats, risks and other climate-related challenges

One major issue is the **limited access to mechanized harvest devices**, which significantly hampers their efficiency. A lack of sufficient equipment, such as tractors and harvesters, delays the start of the planting season and adversely affects crop yields.

Additionally, **climate change-related challenges** are becoming increasingly pronounced, with extended cold periods, heat waves, and heightened bird pressure contributing to declining rice yields and quality. The emergence of problematic weeds, coupled with a scarcity of chemical control products, complicates production further. These challenges not only impact the initial stages of farming but also hinder processing and transformation, as lower volumes make it difficult for farmers to secure adequate inputs and repay loans for the subsequent

season. Another climate challenge highlighted is the difficulties in keeping up with the agricultural calendar due to climate change

In addition to these threats, farmers face various **organizational problems** that exacerbate their struggles. First, there is a significant challenge regarding **access to finance and inputs**. Especially, farmers believe that the financing model used by Senegalese banks does not allow farmers to advance because of the very short repayment periods, of the order of six months. Farmers often find it difficult to obtain timely and affordable financing, which leads to late planting and subsequently reduced yields. They also encounter shortages of quality seeds and agricultural inputs, such as herbicides, as Mauritanian farmers frequently outcompete them in the local market. The short loan repayment periods further complicate matters, leaving farmers without sufficient capital to restart their operations for the next season.



The **mechanization and infrastructure** landscape is another area of concern. A severe shortage of essential machinery, including tractors and harvesters, impedes farmers' ability to fully cultivate their land and adhere to planting schedules. Moreover, irrigation and drainage infrastructure suffer from inadequate maintenance and issues related to salinization, further limiting agricultural productivity.

Conflict arises from **farmer-herder interactions**, with crop farmers often clashing with pastoralist herders over land use. Herders grazing their livestock on farmers' fields, particularly during the critical grain-filling stage, leads to significant crop damage. Although attempts have been made to allocate separate grazing areas, such efforts have yielded limited success. It should be stressed that this is a fairly serious problem which has even led to deaths across the region.



Additionally, **insurance and subsidy challenges** present barriers to financial stability. Many farmers underreport their cultivated areas to lower their insurance premiums, only to claim full payouts when losses occur. Assessors may also manipulate loss reports to favour insurers, complicating the relationship between farmers and insurance providers. Furthermore, subsidies and other support programs are not always equitably distributed, leaving some farmers at a disadvantage.

Finally, **institutional and governance gaps** contribute to the difficulties faced by farmers. While policies and programs exist to address these issues, the lack of effective implementation and enforcement leaves farmers feeling that their concerns are not adequately represented or addressed by authorities and cooperatives.

6.2 Hindering factors to the adoption of SRI

As the practice of SRI in Kassack was barely absent, we did not explore this area for this region during our visit

7 Cross-cutting synthesis and conclusions

This report summarizes the findings of a field mission conducted in Senegal, focusing on the challenges faced by smallholder farmers. The mission aimed to understand the specific threats, adaptation strategies, and potential solutions for improving agricultural productivity and sustainability in the region.

Key Findings:

- **Multifaceted Threats:** Smallholder farmers in Senegal face a complex array of challenges, including climate change, limited access to financial services, inadequate infrastructure, and organizational constraints. These challenges are reflected in the wider West African context, highlighting the need for sustainable intensification (SI) and sustainable land management (SLM) practices across the region.
- **Coping and Risk Management Strategies:** Farmers employ both coping and risk management strategies to navigate these challenges. Coping strategies, often discussed collectively, focus on short-term solutions to immediate problems. Risk management strategies discussed more individually, emphasize mitigating longer-term threats like climate change and resource scarcity.
- **Regional Variations:** Each region visited during the mission presented unique challenges and adaptation mechanisms:
 - **Podor:** Limited pump station capacity and frequent machinery breakdowns hinder irrigation, leading farmers to shift cropping calendars and utilize traditional pest control methods. However, climate change impacts, such as fluctuating temperatures and rainfall patterns, continue to destabilize agricultural practices.
 - **Galoya:** Limited access to financial services restricts investment in inputs and mechanization, exacerbating the impact of climate change and resulting in crop losses. Strengthening collaboration between farmers and financial institutions could alleviate these financial constraints.
 - **Kassack-Dagana:** Shortages of mechanized harvesting equipment and complex relationships between crop farmers and pastoralists highlight the need for improved land and resource management.
- **Organizational and infrastructural challenges:** inadequate irrigation maintenance and high repair costs further hinder productivity.

- **Low adoption of innovative practices:** despite the potential benefits of the system of rice intensification (SRI), its adoption remains low due to labour-intensive requirements and high costs.

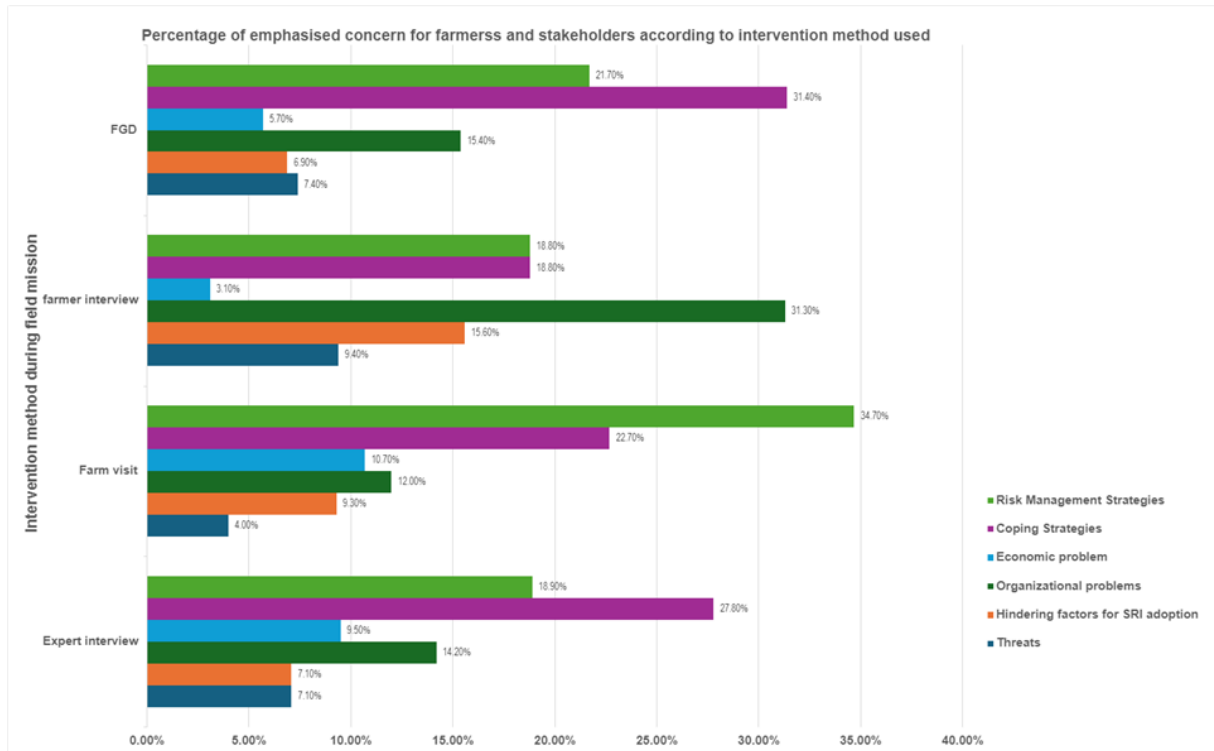
Recommendations:

- **Promote SI and SLM practices:** implement programs and initiatives that encourage the adoption of sustainable intensification and land management practices across Senegal and West Africa.
- **Strengthen financial inclusion:** facilitate access to financial services for farmers, enabling investment in inputs, mechanization, and climate-resilient technologies.
- **Improve infrastructure:** invest in irrigation infrastructure maintenance, repair, and modernization to ensure reliable water access for farmers.
- **Address organizational constraints:** develop strategies to improve coordination and collaboration among farmers, government agencies, and other stakeholders to enhance resource management and address infrastructure challenges.
- **Promote SRI adoption:** provide training, subsidies, and access to appropriate machinery to encourage the adoption of SRI, mitigating labour-intensive requirements and reducing costs.

In sum, the challenges faced by smallholder farmers in Senegal are multifaceted and require a multi-pronged approach to address. By promoting sustainable intensification, strengthening financial inclusion, improving infrastructure, and addressing organizational constraints, Senegal can create a more resilient and productive agricultural sector, ensuring food security and economic prosperity for its rural communities.

1 Appendix

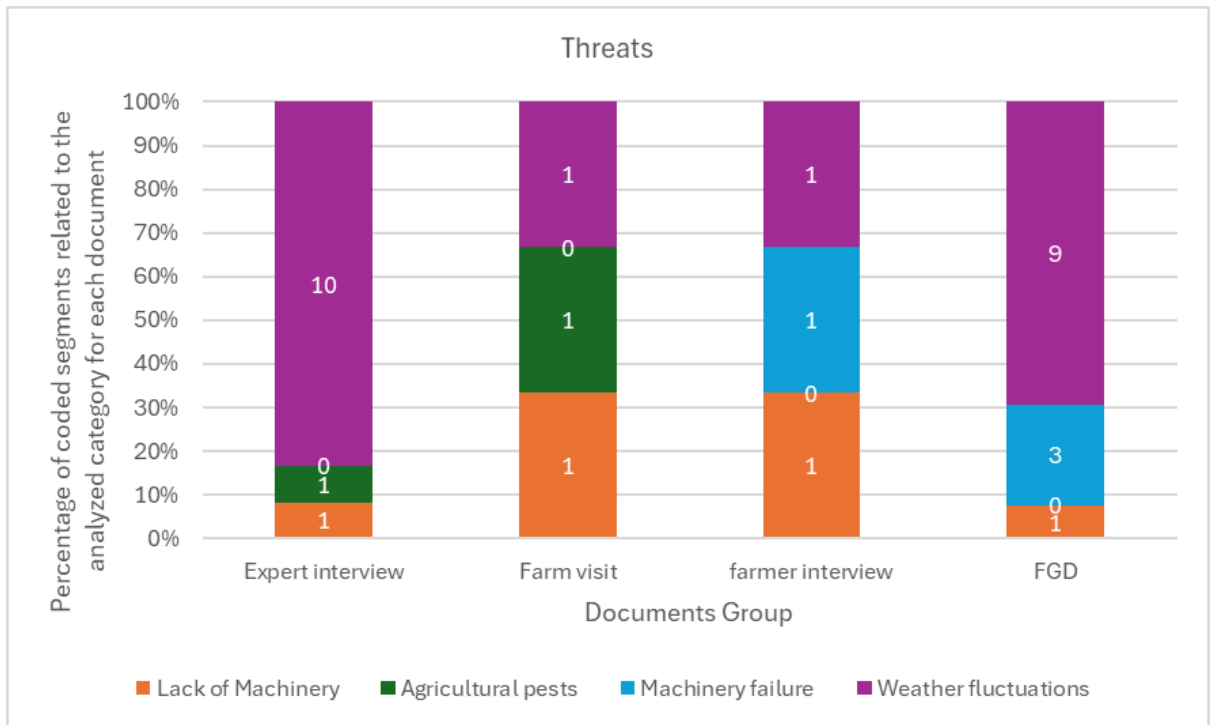
1.1 Specific concerns emphasized by farmers and stakeholders in Podor



Both risk management strategies and coping strategies were widely discussed in all the Interviews, differences can be seen when it came to talk about organisational problem which during the farmer interview were highly discussed (31% of the conversation focused on them while for the other interviews this aspect covered only 15% of the interview maximum).

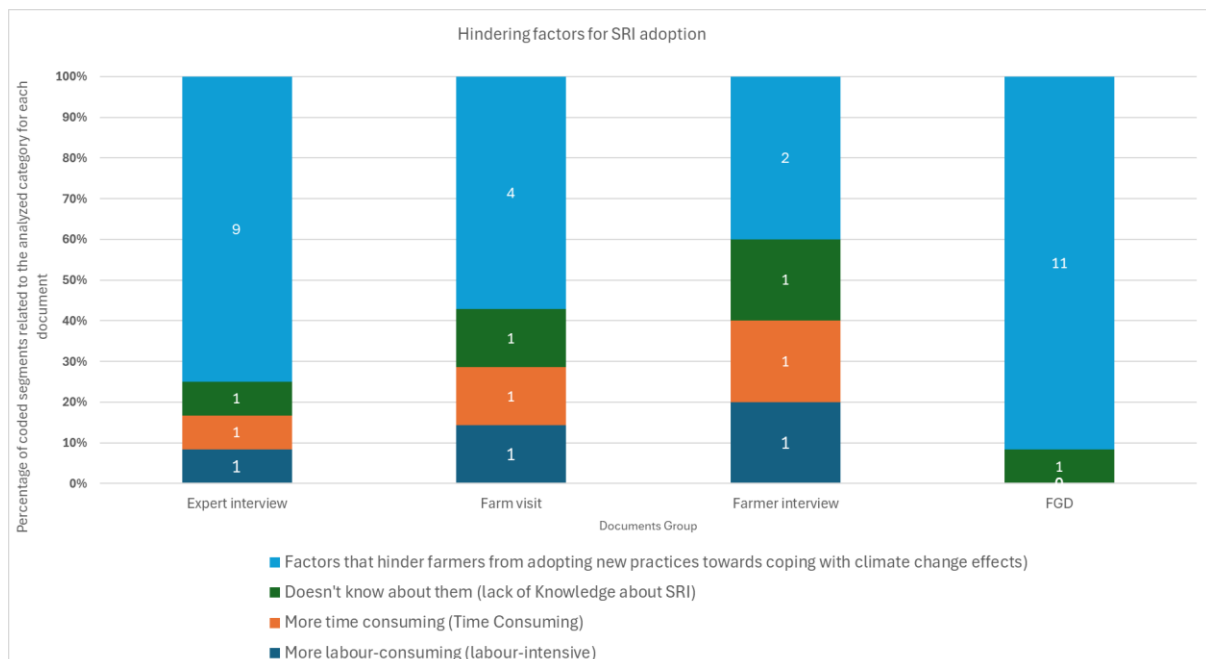
The least discussed problem in Podor focus group discussions were agricultural threads followed by the economic problems and the hindering factors for SRI adoption

1.1.1 Threats



In the conversations when talking about threats the most discussed aspect was weather fluctuations, this topic and related challenges were always present, and they represent most of the threats. Agricultural pests represent a side problem with machinery failure and lack of machinery is a minor problem present in every interview.

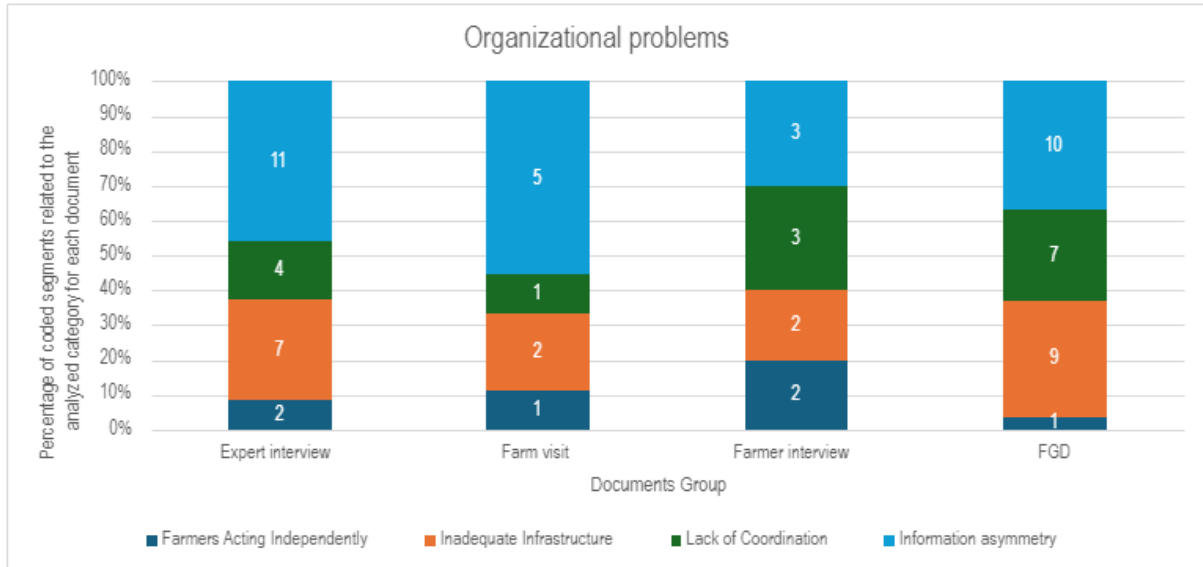
1.1.2 Hindering factors SRI adoption



During the analysis, it was searched what the interviewed respondents perceived as hindering factors for SRI adoption. In general, they express that there are some barriers to adopting

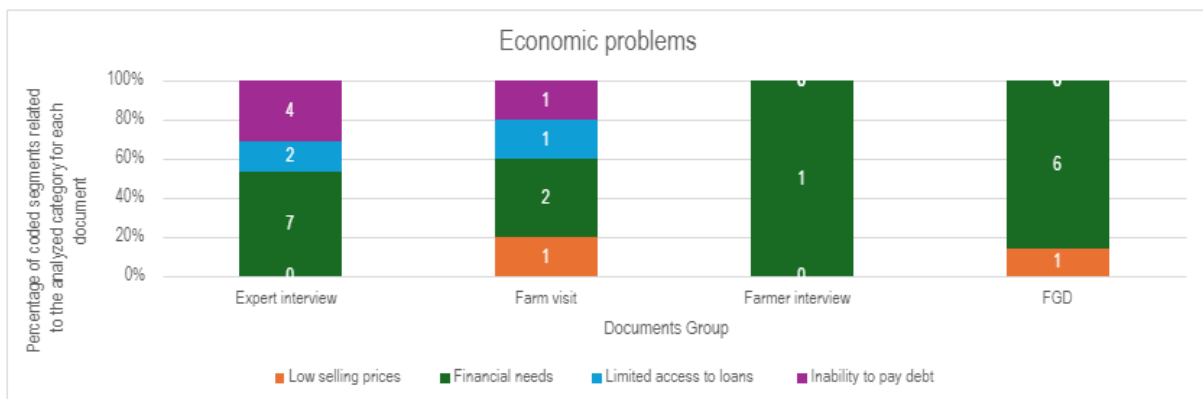
SRI. When these reasons were deepened to understand what kind of barriers there are, we could code just a few segments for each interview. During the FDG and the expert interview, these aspects were more discussed (more segments could be coded) compared to the farm visit and the farmers interview.

1.1.3 Organizational challenges



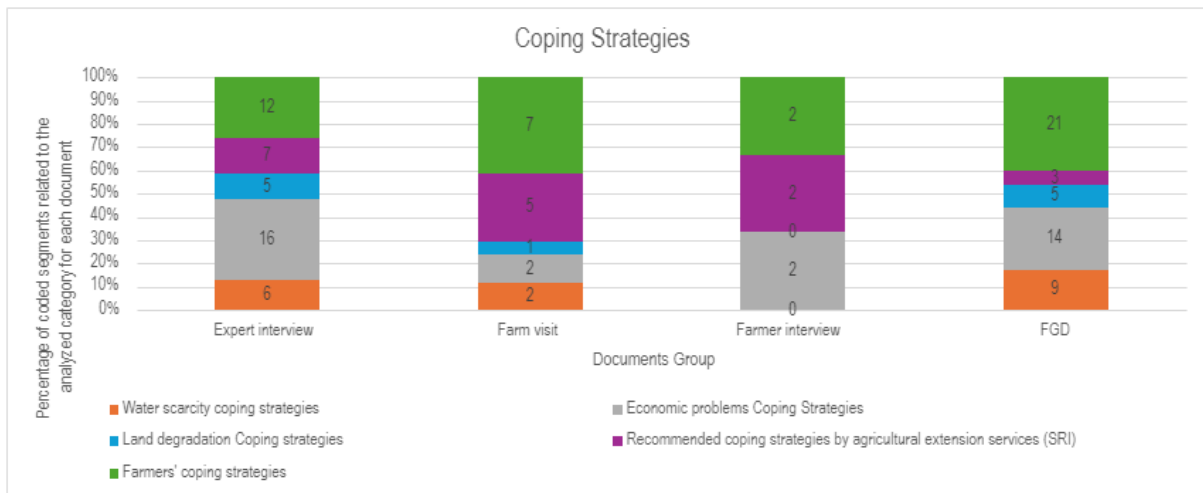
This aspect is influenced in particular by information asymmetries. In some interviews it represented more than 50% of the organizational problems, followed by inadequate infrastructures, while the least of the problems is the farmers acting individually during the FDG this aspect was mentioned only once.

1.1.4 Economic problems



During the FDG and farm visit, economic problems were a prominent topic in expert interviews. However, these issues were only briefly touched upon during the farmer interview, with a single mention lacking any deeper exploration of the various contributing factors. While both farm visits and expert interviews delved into the reasons behind these economic challenges, the most frequently discussed problem was the financial needs of farmers, closely followed by their inability to pay debts.

1.1.5 Farming coping strategies



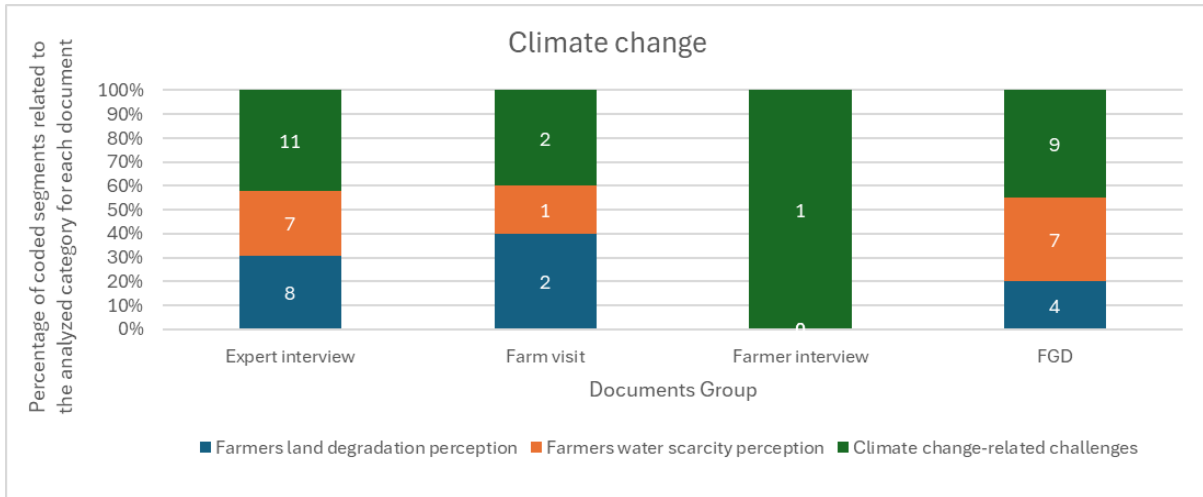
Coping strategies were widely discussed, especially during the FDG and the expert interview. The most common coping strategies involved Economic problems and in general farmers' strategies the least covered topic was the coping strategies towards land degradation and water scarcity.

1.1.6 Risk management strategies



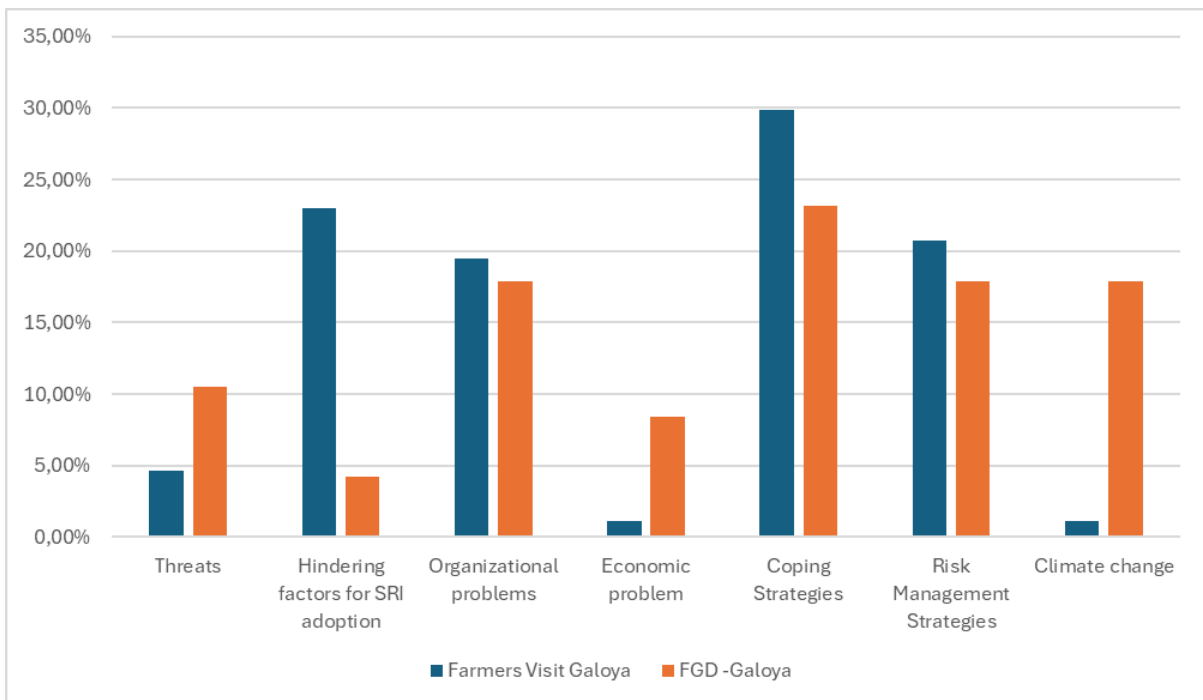
When it comes to long term strategies, these were less discussed, especially the economic strategies, and it seems that during the different interactions they were discussed in the same amount.

1.1.7 Farmers Climate change perception and challenges



Climate change was a recurring theme throughout the interviews conducted in Podor. The challenges posed by climate change were repeatedly discussed, with water scarcity and land degradation consistently mentioned as key concerns. However, during the interviews with farmers, these issues were not explored in as much depth.

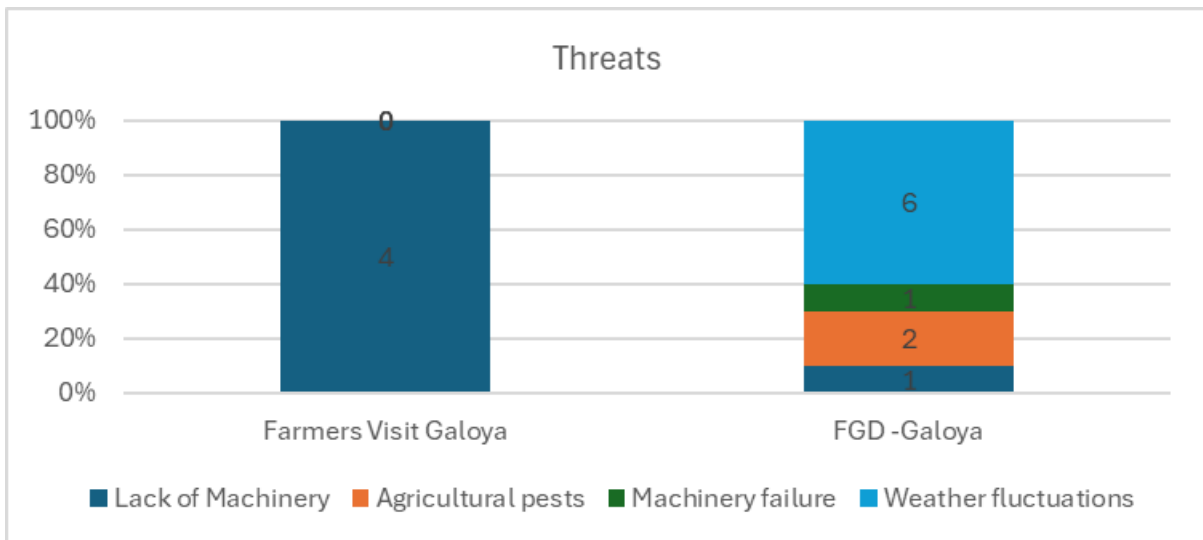
1.2 Specific concerns emphasized by farmers and stakeholders for Galoya



In Galoya, two interviews were conducted, revealing that coping strategies were the most frequently discussed topic, followed by risk management strategies and organizational problems.

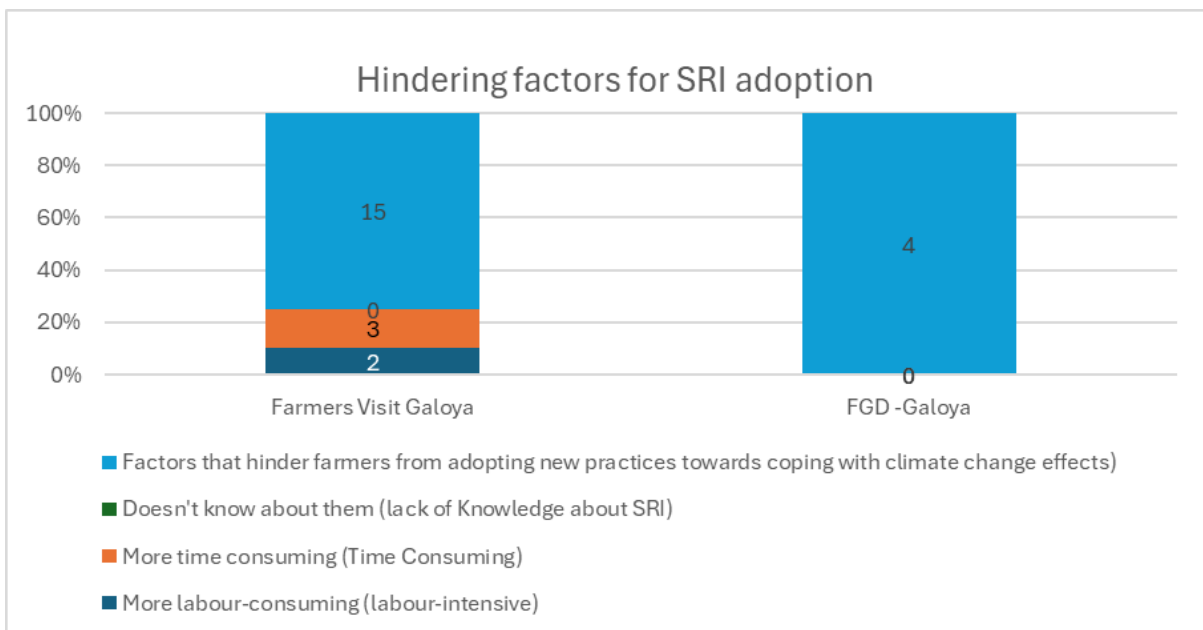
While climate change, economic problems, and threats were more prominent topics during the FDG, the farmer visit in Galoya focused more deeply on hindering factors.

1.2.1 Threats



Based on the two interviews we can notice that lack of machinery is the only problem mentioned on both occasions, during the farmers visit in Galoya it was the only aspect discussed. Weather fluctuation was the most discussed problematic during the FGD. While lack of machinery, machinery failure and pesticides were discussed the least.

1.2.2 Hindering factors SRI adoption



During the conversation it was talked about hindering factors for SRI adoption, through the analysis it was noticed that during the interviews aspects like not knowing about the SRI, or

the perception about SRI as time consuming and Labour -intensive were not discussed so much.

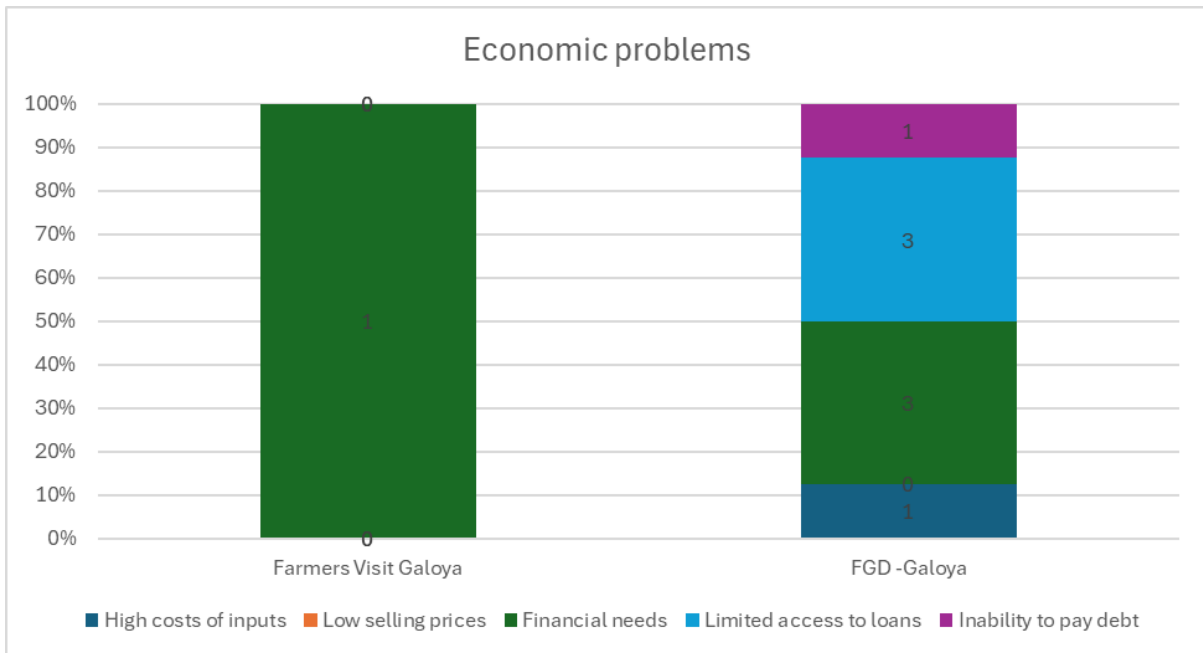
During the Fdg it was discussed in general about Hindering factors for SRI adoption and deepening other influencing factors was not possible. While during the farmers visit in Galoya other influencing factors were discussed. One factor that was not found during the analysis was Doesn't know about them.

1.2.3 Organizational challenges



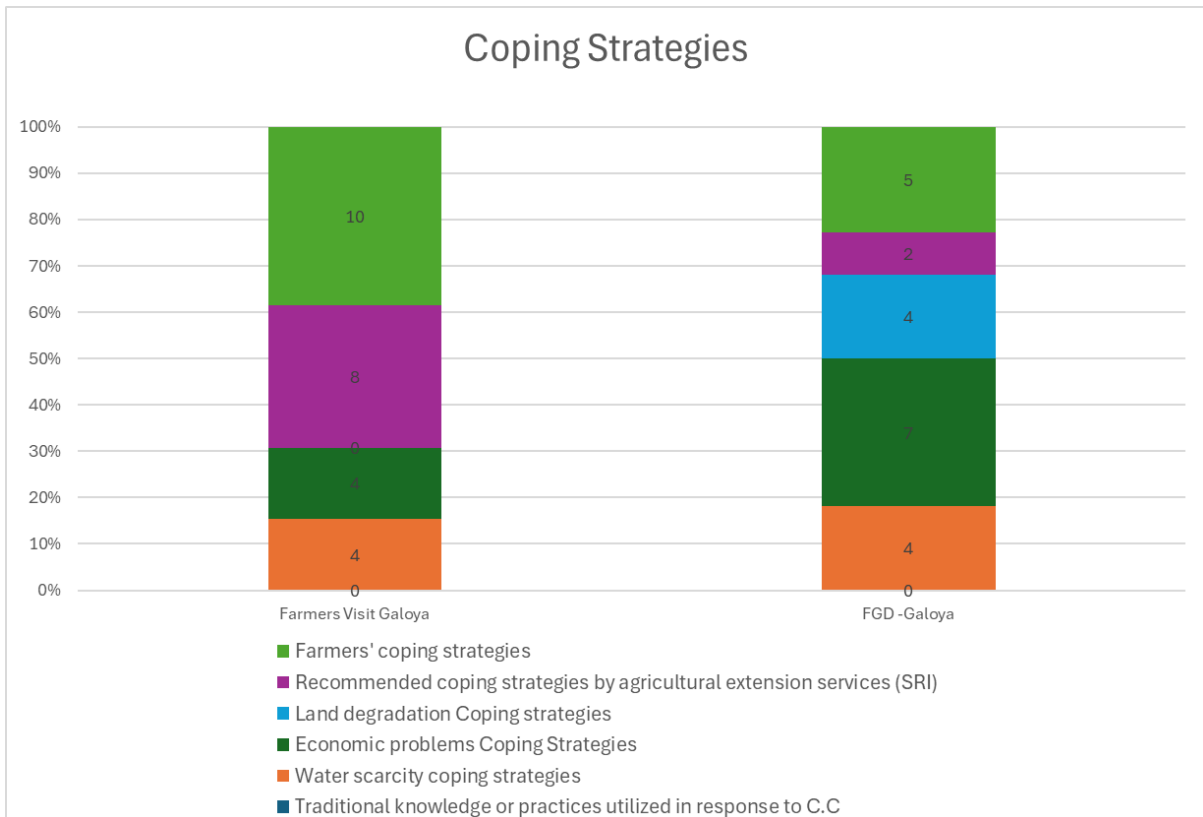
Information asymmetry is the most common problem discussed. Especially during the visit where all the rest wasn't deepened or talked about, while during the FGD the topics were more heterogeneous and every aspect was discussed. In fact we can say that also In this case like previously Podor Inadequate infrastructure influenced a lot the farmers business.

1.2.4 Economic problems



Financial needs are the shared problem during the two interviews, then limited access to loans results to be a common problem.

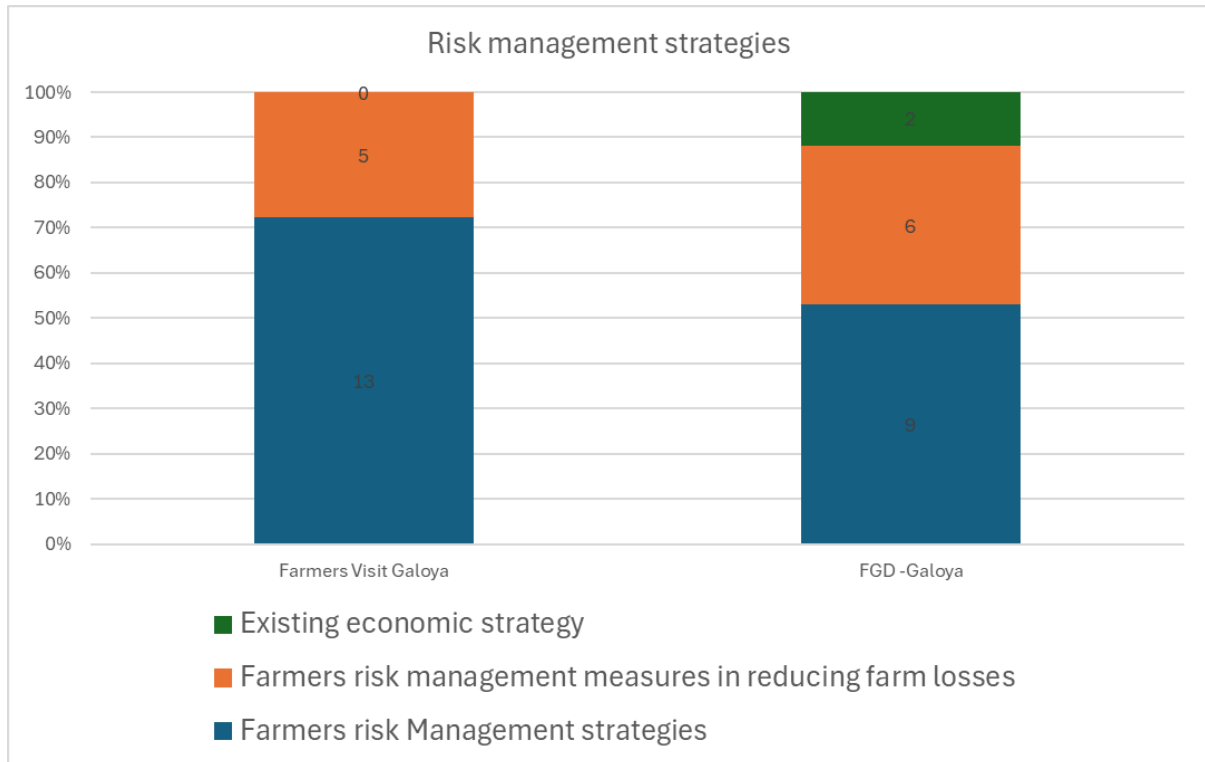
1.2.5 Farming coping strategies



During the visit the conversation focused a lot on farmers' coping strategies and the recommendation by the extension services. The latter was less discussed during the FGD where the main topic was the economic problem strategies and as the previous case the

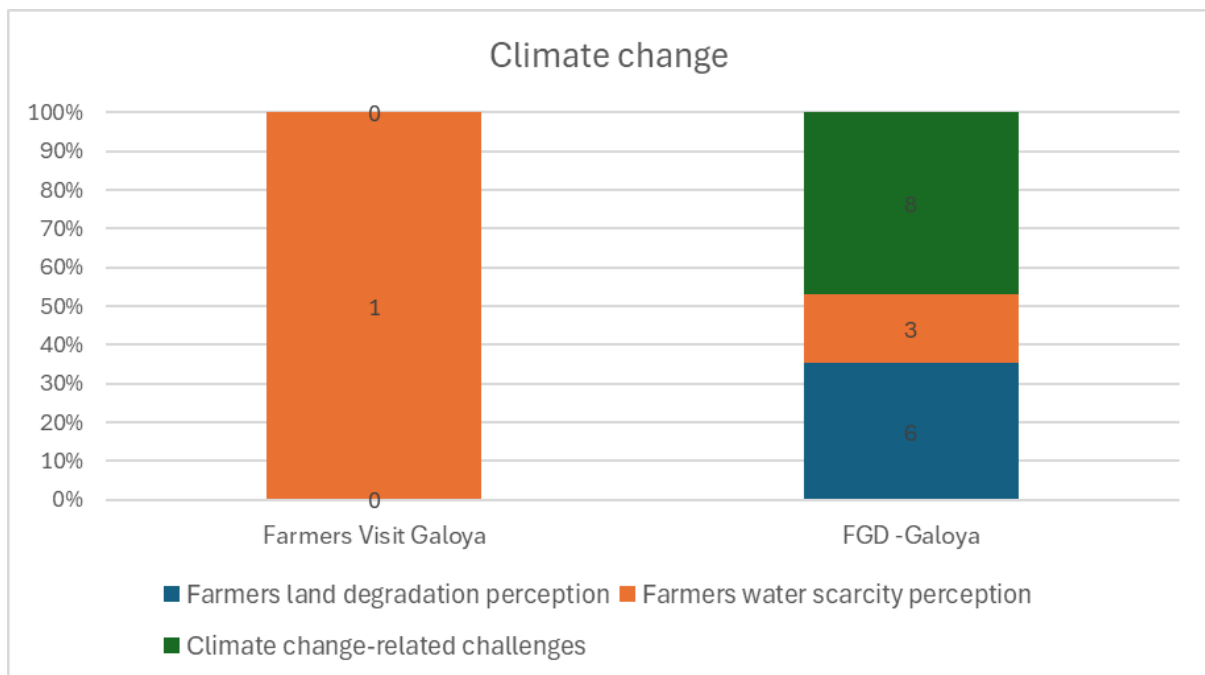
farmers' coping strategies. During the visit it wasn't discussed the land degradation coping strategies while both discussed the Water scarcity coping strategies.

1.2.6 Risk management strategies



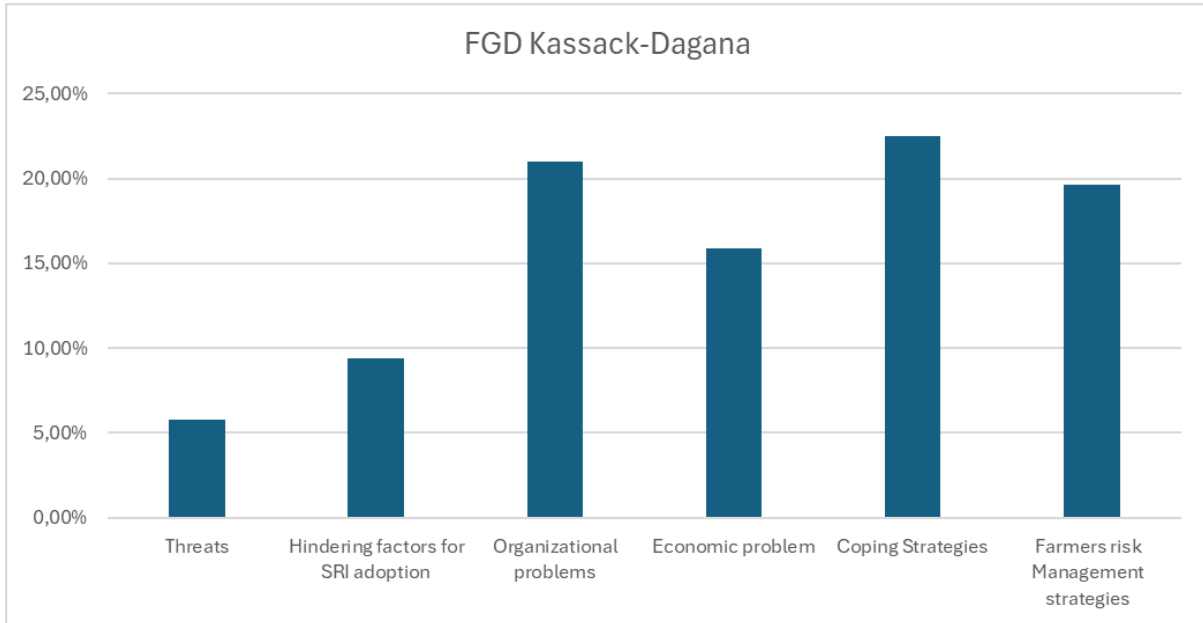
When focusing on risk management strategies there were many moments were they were discussed in a general way and focusing on reducing losses, while it result that the economic aspect wasn't deepened in both occasions.

1.2.7 Farmers Climate change perception and challenges



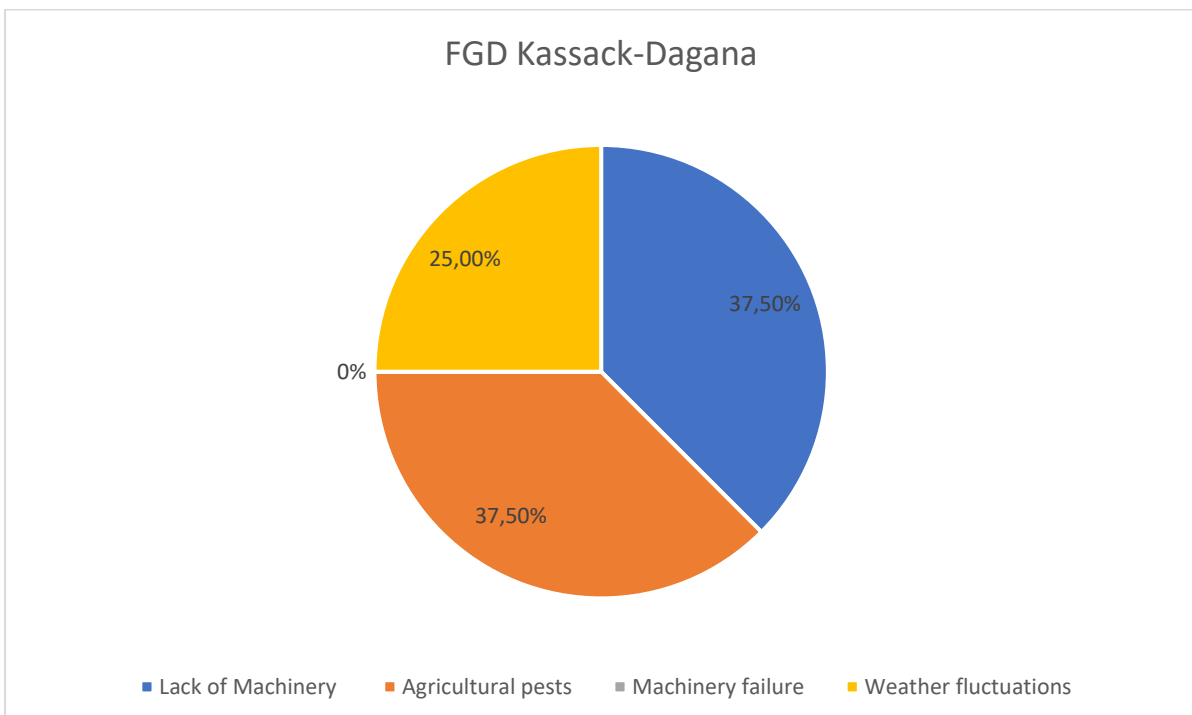
In Galoya during the visit the climate change challenges weren't discussed so much, while during the FGD they talked about it in all the analyzed aspects and land degradation turned out to be frequent during the conversation.

1.1 Specific concerns emphasized by farmers and stakeholders for Kassack



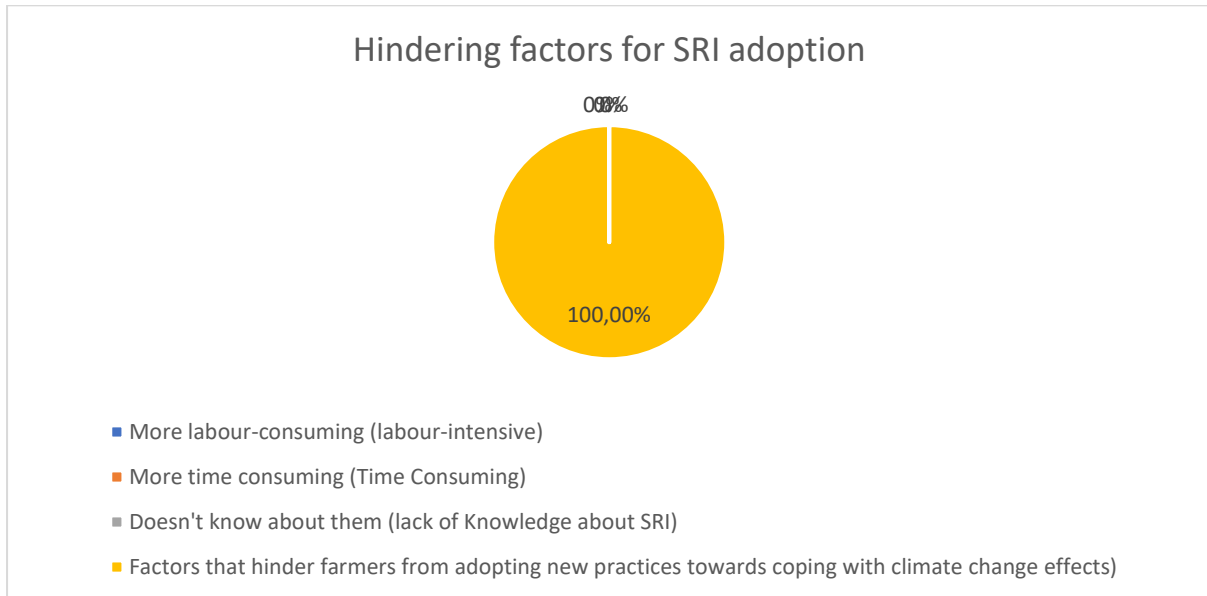
In Kassack-Dagana only one FGD was carried out, during this discussion most of the conversation focused on Coping Strategies followed by Organizational Problems and Farmers Risk Management Strategies. The least discussed aspects were Threats and Hinder factors For SRI Adoption these aspects were discussed less than half compared to the most discussed

1.1.1 Threats



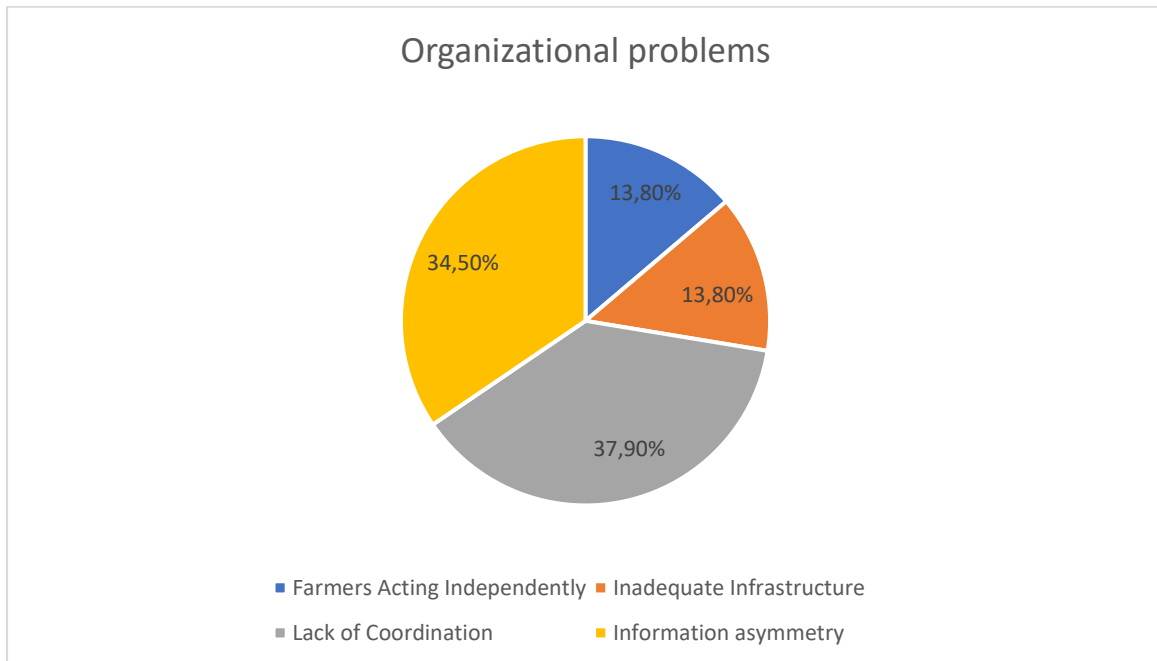
The main problems result in Agricultural pests and Lack of machinery, followed by weather fluctuation while machinery failure wasn't discussed.

1.1.2 Hinder factors SRI adoption



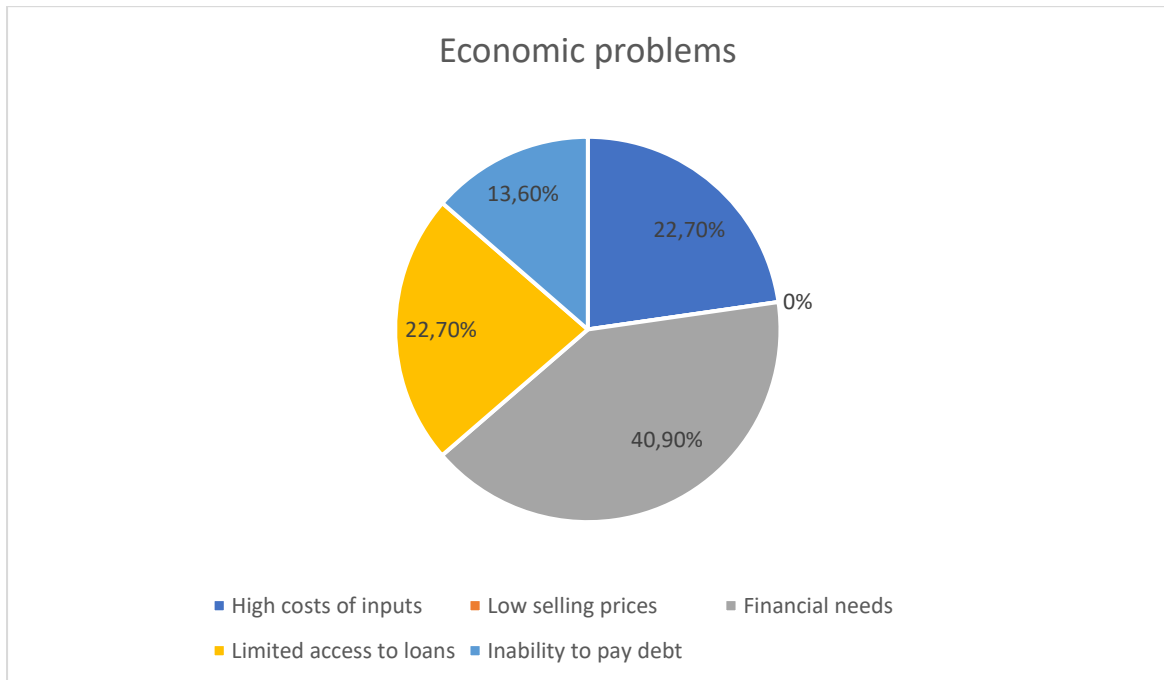
This aspect wasn't deepened during the interview.

1.1.3 Organizational challenges



Lack of coordination and Information asymmetry results to have so much influence in the conversation, while other aspects are present but way less compare to the priors.

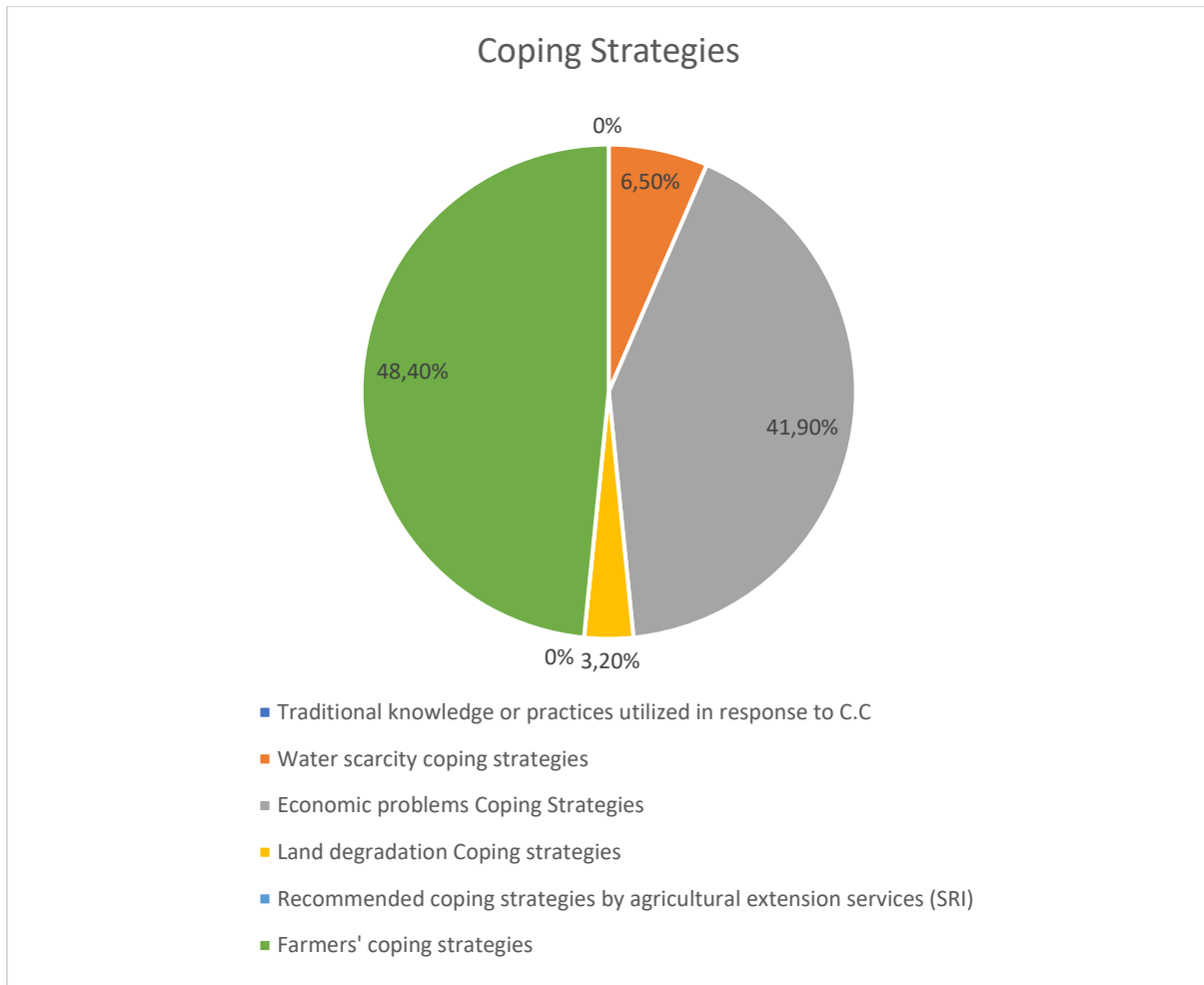
1.1.4 Economic problems



Financial needs represent almost half of the economic problems explored during the conversation.

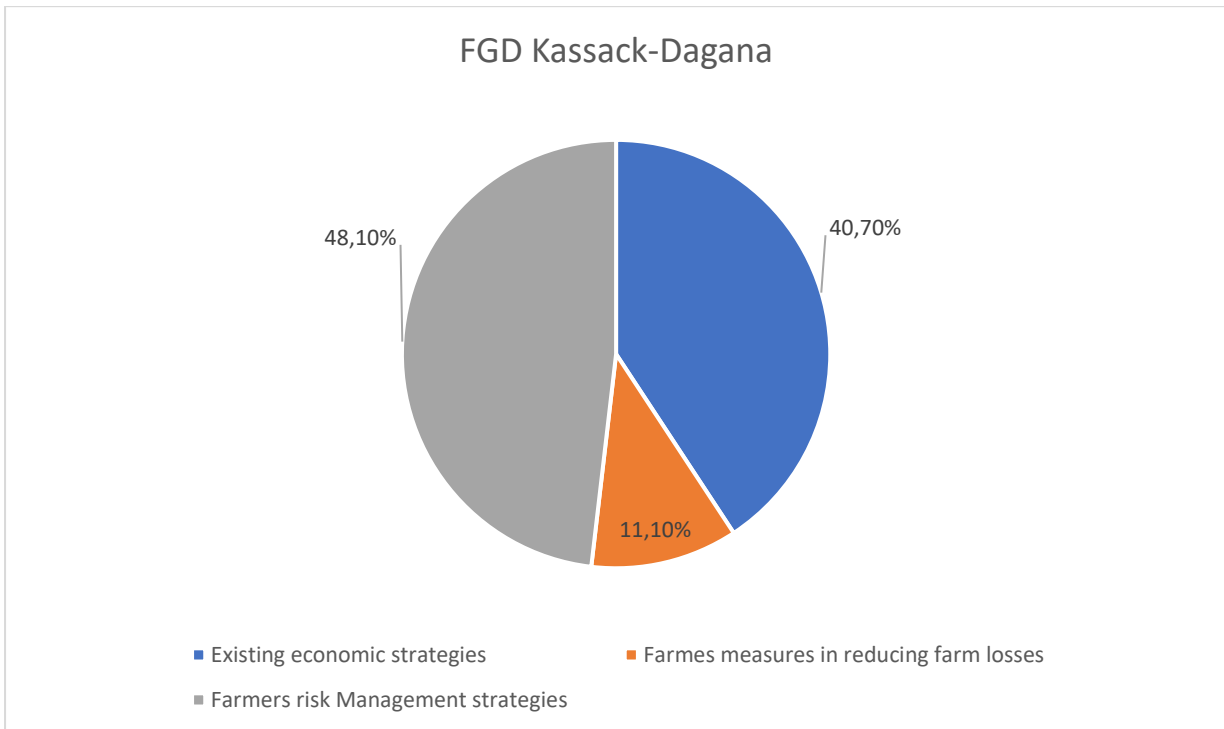
The least influencing factor is the inability to pay debts. The rest of the aspects are present during the conversation but way less compared to the main one.

1.1.5 Farming coping strategies



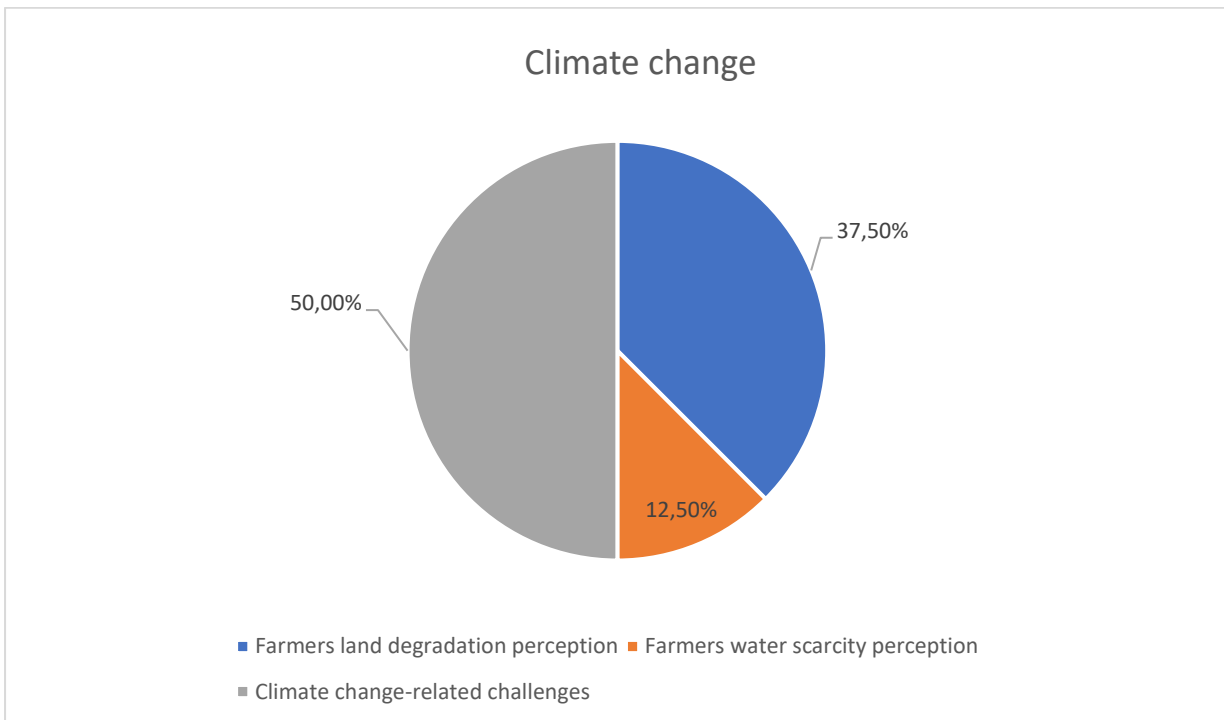
In Kassack Farmers' coping strategies and economic coping strategies represent almost the total of the discussed aspect, while the least was land degradation.

1.1.6 Risk management strategies



Farmers’ measures in reducing farm losses weren’t explored so much while for the most part the conversation on this topic focused on economic strategies and the farmers’ economic strategies.

1.1.7 Farmers Climate change perception and challenges



Durin the FGD it was discussed about climate change related challenges and the land degradation perception for most of the time, water scarcity wasn’t explored as much as the priors.

7.1 Guided Questions use for exploratory fields mission

1. Climate Change Perception:

- *Investigate the perception of climate change among farmers in the case study areas, particularly in relation to land degradation.*
- *Analyze the specific climate change-related challenges faced by farmers across the three regions visited.*

2. Coping Strategies

- *Identify and document the coping strategies employed by farmers in Podor and Dagana to mitigate the effects of climate change.*
- *Explore the utilization of traditional knowledge and practices in response to climate change challenges.*
- *Examine the recommended coping strategies provided by agricultural extension services, especially those pertaining to Sustainable Rice Intensification (SRI) practices.*
- *Assess the coping mechanisms farmers employ to address the impacts of land degradation resulting from climate change in the case study areas.*

3. Social Cohesion

- *Investigate the collective activities engaged in by farmers, such as participation in farmer groups and joint efforts to combat climate change and land degradation.*
- *Explore the role of social cohesion within communities, emphasizing the significance of common initiative groups and various forms of collective actions.*
- *Analyze how collective action and enhanced collaborative activities among farmers support their efforts to cope with the impacts of climate change in the case study areas.*

4. Risk Management

- *Identify the risk management strategies farmers are currently employing to mitigate losses in their agricultural activities.*
- *Investigate whether farmers are actively considering measures to reduce losses and improve resilience in their farming practices.*
- *Examine the existence of economic strategies, such as saving groups, that facilitate easier access to loans compared to traditional banking systems.*
- *Identify the factors that hinder farmers from adopting new practices aimed at coping with the effects of climate change in the case study regions.*

7.2 Explanations of codes used in Analysis

1. Threats

1.1 Lack of Machinery

- *Definition: This code is applied when there is an explicit mention of insufficient agricultural machinery.*
- *Examples: Missing tractors, harvesters, or irrigation systems that impede farming operations, leading to inefficiencies and reduced productivity.*

1.2 Agricultural Pests

- *Definition: This code refers to explicit mentions of pests affecting crops.*
- *Details: Includes insects and mites damaging crops, weeds competing for nutrients and water, plants obstructing irrigation systems, and animals such as rodents and birds consuming young plants and stored food.*

1.3 Machinery Failure

- *Definition: This code is used when there is explicit mention of machinery or equipment failing to perform as intended.*
- *Implications: Such failures can lead to delays in farming activities and decreased operational efficiency.*

1.4 Weather Fluctuations

- *Definition: This code applies to explicit mentions of variations in weather conditions over time.*
- *Scope: Includes daily, seasonal, and annual fluctuations that can significantly impact agriculture, environmental conditions, and human comfort.*

2. Hindering Factors for SRI Adoption

2.1 More Labor-Consuming

- *Definition: This code is applied when Sustainable Rice Intensification (SRI) practices are explicitly described as requiring more labor than traditional methods, discouraging adoption.*

2.2 More Time-Consuming

- *Definition: This code is used when there is an explicit mention of SRI practices that demand more time for implementation, leading to reluctance from farmers to adopt these methods.*

2.3 Lack of Knowledge about SRI

- *Definition: This code applies when farmers express unawareness of SRI practices, leading to their non-adoption.*
- *Implication: Lack of knowledge can hinder farmers from leveraging innovative techniques that could improve productivity.*

2.4 Barriers to Coping with Climate Change

- *Definition: This code is utilized for explicit mentions of factors that prevent farmers from adopting new practices to mitigate climate change effects.*
- *Examples: Barriers may include limited access to information, high costs of new technologies, resistance to change, and inadequate support from agricultural extension services.*

3. Definition of SRI

- *Sustainable Rice Intensification (SRI): An agroecological approach aimed at enhancing the productivity of irrigated rice through improved management of plants, soil, water, and nutrients. The goal is to increase rice yields while using fewer resources—such as water, seeds, and chemical inputs—thereby enhancing soil fertility and promoting robust plant growth*