Master's Thesis

Sustainable Business and Innovation

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Cultivating Diversity: An insight into millet seed systems in Odisha, India

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Abstract

Image 1- Finger millet in Odisha (source - villagesquare.in)

This study explores the intricacies of seed systems in Koraput, Southern Odisha, within the context of the Odisha Millet Mission (OMM). The analysis uses the process-based value chain framework to examine the diverse seed systems and their impact on agricultural sustainability, food security, and farmer empowerment. The OMM's decentralized approach involves various stakeholders, including NGOs, research foundations, and Community Resource Persons (CRPs), to improve millet cultivation and support financial stability.

Seed System A relies heavily on generational knowledge, informal exchanges, and religious practices, lacking official registration and regulatory oversight. Seed System B combines traditional practices with support from research foundations and NGOs (appointed by the government), involving quality testing and extension services. Seed System C, driven by government entities, focuses on high-yielding varieties (HYVs) with formal registration, quality enhancement, and centralized distribution.

The OMM's efforts in preserving plant genetic resources through a centralized seed bank and supporting decentralized seed multiplication by mobilizing local organizations are highlighted. However, challenges remain, such as the dependency of farmers on the mission for free of cost seeds and quality testing, which limits autonomy.

The analysis reveals well-supported elements like product sale and home consumption, facilitated by the Minimum Support Price (MSP) and direct market access, which guarantee farmer incomes and incentivize millet cultivation. However, the processing and transformation of millet remain labor-intensive, requiring technological interventions to motivate increased production.

The study emphasizes the importance of balancing traditional and modern processes to preserve biodiversity and enhance food security. By supporting diverse seed systems, the OMM contributes to improving, food security dietary diversity, and nutritional outcomes. The mission's regulatory framework, involving multiple partner agencies, ensures collaborative millet cultivation, yet greater farmer self-sufficiency is needed for sustainable agricultural practices.

The process-based value chain (PBVC) framework proves effective in analyzing seed systems by encompassing the entire value chain, from production to market influences and regulatory regimes. Its holistic approach and adaptability make it applicable across various agricultural contexts, providing a valuable tool for enhancing seed systems globally.

The study highlights the need for continued support, ensuring local knowledge, genetic diversity, and farmer autonomy are preserved. Balancing commercial objectives with ecological and cultural significance is important to achieve resilient agricultural development in Odisha.

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Abbreviations

OMM - Odisha Millets Mission

FPO - Farmer Producer Organisation

ICAR - Indian Council of Agricultural Research

MSSRF - M.S. Swaminathan Research Foundation

WASSAN - Watershed Support Services and Activities Network

CRP - Community Resource Persons

NGO's - Non-Governmental Organisations

ICRISAT - International Crops Research Institute for Semi-Arid Tropics

PVTG - Particularly Vulnerable Tribal Groups

PVT - Participatory Varietal Trial

FGD - Focussed Group Discussion

WHSG - Women Self-Help Groups

MSP - Minimum Support Price

HVY- High-Yielding Variety

CMSS - Community Management Seed System

PBVC - Process-Based Value Chain Framework

Introduction

Millets are a critical part of India's ecological and economic security, providing millions of resource-poor farmers and cattle with food and fodder (Ministry of Commerce and Industry, n.d.). With over 20 varieties and 6000 sub-varieties of millets found across the globe, this variety of grain is said to have several advantages for both producers and consumers. Millets provide health benefits because they are gluten-free, making them suitable for people suffering from coeliac disease as well as aiding the terrors of diabetic patients (Reuters, 2023). Millets are also hardy grains that are known to survive harsh weather conditions in semi-arid regions, making them highly attractive for regions facing extreme water scarcity in India (Food Safety and Standards Authority of India, 2019). As an added advantage, the millet crop requires little to no chemical inputs, as well as minimal water during cultivation.

Millets are small-seeded members of the Poaceae or grass family of plants. In India, millets have the potential to contribute to addressing the persistent challenges of food security, environmental sustainability, and nutritional security (Ministry of Commerce and Industry, n.d.). The Green Revolution, with its emphasis on irrigated agriculture, fertilizers, and pesticides, led to high-yielding varieties of corn, wheat, and rice (Times Now, 2023). As a result, millet was given a lower status, being considered the "poor man's foodgrain" (Sanjay, 2023). This decline posed a threat to the utilization of millets in effectively addressing food security challenges, supporting farmer livelihoods, and improving climate resilience for both rural and urban communities. While the richer farmers took over the cultivation of rice and wheat, the arid and semi-arid regions with poorer populations carried on the practice of cultivating millets.

As of 2023, India is self-sufficient in terms of food production, yet 233.9 million people in India still face ‘undernourishment’ (The Wire, 2023). Today, millets have been rebranded from “poor man’s food” to “food of the future” (Lovett, 2023). In 2008, the Indian government rebranded the millet crop as ‘Nutri-cereals’ to promote and spread awareness around this all-rounder crop (Oswal, 2023). However, a number of challenges such as the state-level promotion of other commercial crops in the past years, declining demand for millet in the diet, and lower yield from subpar seed, as well as a lack of training for farmers in modern technology and good agricultural practices, are some of them (Kheya et al., 2023). Millet cultivation was no longer profitable for farmers. Even with all the efforts to promote millet across the country, India saw only a 3.19% increase in millet cultivation between the years 2013-14 and 2021-22 (Ministry of Consumer Affairs, 2023).

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is focusing on leveraging the benefits of the millet crop to combat the larger challenges of food security and farmer

security in India (ICRISAT, n.d.). It is harnessing the growing trend of populations moving towards health-conscious foods and focusing on states in India that have launched their millet missions (Odisha, Andhra Pradesh, Maharashtra, Assam, Chhattisgarh, Tamil Nadu, and others) and are attempting to promote the production, distribution, and consumption of millets.

For the purpose of agriculture, seeds serve as vital components in the process of cultivation (Kloppenburg & Kleinman, 1987; Almekinders & Louwaars, 2002). Access to high-quality seeds is crucial for cultivating millets. Seed systems are the vehicles through which farmers get good quality seeds for the new crop varieties they want and need (PABRA, n.d.). The literature on seed systems generally distinguishes two main types of seed systems, namely formal and informal. Informal seed systems refer to the methods of management used by farmers to select, produce, exchange, and use traditional practices to store seeds without government intervention. Informal methods to procure, save, and preserve seeds have been in existence for a long time and are important factors for sustainable food production methods (Sannegowda et al.; Garkoti, 2022). These methods differ from region to region, yet there has been very little study on these traditions. The formal seed systems are managed by a combination of the government and its appointed entities as well as private entities and the market. They aim to ensure quality assurance on the seed and have been promoting the cultivation of millets through certified pathogen-free seeds and selling superior varieties (Seednet.gov.in., n.d.).

The total amount of agricultural biodiversity that has been lost in India is unknown. There are a few localized studies on the decline of agricultural biodiversity over the years. For example, it is predicted that 95% of the rice varieties in the Godavari district of the state of Andhra Pradesh in eastern India have disappeared (Kothari, 1994). Seed saving is vital in the process of maintaining this diversity (Pumps, 2022). Numerous rice, cotton, small millets, pulses, and other crop varieties, numbering in the thousands, are no longer grown.

In this thesis, I will investigate to what extent interventions to promote millet in India align or misalign with existing millet seed systems - both formal and informal - focusing on the state of Odisha in India. This will be carried out by focusing on one particular intervention by the government of India called the Odisha Millet Mission. The objective of this research is to examine the processes and practices employed by the Odisha Millet Mission (OMM) to preserve seed systems in Odisha. It aims to gain a deeper understanding of the government's efforts to maintain seed diversity and support informal cultural practices. Additionally, the research seeks to explore the variations in the currently active seed systems by addressing the question: **To what extent is the Odisha Millet Mission (OMM) supporting the millet seed systems in southern Odisha, India?**

Most importantly, strengthening millet seed systems has the potential to not only economically support but also empower farming communities by promoting self-reliance, autonomy, and a sense of ownership over agricultural practices (Vernooy, et al., 2022). Insights from this research can contribute to fair and holistic multi-stakeholder policy interventions (Pti, 2023). To produce and expand millet production, strengthening and improving the efficiency of the millet seed systems is crucial (Vaidyanathan, 2023; M. S. Swaminathan, 1925–2023). In the case of India, reviving millets as a staple crop requires a change in the entire ecosystem built around wheat and rice crops after the Green Revolution in the 1960s.

While seed systems are a concept that has been frequently discussed over the last few years, there has been almost no research conducted on the different types of millet seed systems in the Koraput region of southern Odisha. For instance, a case study on groundnut seed systems in Southern India (Reddy et al., 2010) examined the use of village seed banks to provide high-quality seeds and enhance seed production. Similarly, on a global level, numerous studies on millet seed systems have been conducted; for instance, Medson discusses the importance of establishing local seed producers to supply quality seeds to community members in Zambia, Zimbabwe, and Tanzania in Southern Africa (Medson, 2015). The Adivasi belt, with its abundant millet varieties, has not been a focus area for studying seed systems.

Contextual Background

In India, small-scale farmers predominantly rely on informal seed systems sourced from on-farm reserves, local vendors, exchanges, and borrowings (Reddy, 2005). However, recurrent natural disasters such as droughts, crop failures, storage issues, and poverty strain these networks. During droughts, government-subsidized seed supplies cover only 30–40% of smallholder farmers' needs. Strengthening community seed systems is crucial to enhancing resilience.

Key actors in India's agricultural landscape include Farmer Producer Organizations (FPOs), which empower farmers economically and enhance productivity (Sangappa et al., 2023). The Minimum Support Price (MSP) system provides price guarantees for crops, shielding farmers from market fluctuations and disasters (Vishnava, 2024). However, intermediaries often exploit millet farmers by manipulating market prices (Uplaonkar et al., 2020). Local mandis serve as vital economic hubs connecting rural and urban areas (Sobti et al., 2014). NGOs and government banks also play pivotal roles in implementing policies and financing farmer initiatives.

Millet holds significant historical and cultural importance in India, as evidenced by ancient texts and rituals (Vijayalakshmi and Raju, 2023). The Odisha Millet Mission promotes millets as resilient crops, crucial for food security, especially among vulnerable Adivasi communities (UN India, 2022). In Odisha's Koraput region, rich in Adivasi culture, millets are adapted to local climates and farming practices (Patro et al., 2024). Despite their nutritional benefits and climate resilience, millet consumption has declined due to the dominance of paddy in the Public Distribution System (PDS).

The state of Odisha has the greatest diversity of Scheduled Tribe Communities or Adivasi's (Ota et. al., 2020). It has a population of about three crores out of which more than 22 percent are Adivasis. (Das et. al., 2023). The term "Adivasi population" refers to the group of native Indians who have adapted their cultural practices to fit in with their physical and social surroundings and have lived their entire lives based on the natural world (Naresh, 2014). The Adivasi population in Odisha is known for their millet seed saving practices for instance, Exceptional cases, such as the tale of Raimati in Odisha, showcase individual contributions to seed preservation (TimesofIndia, 2023). Raimati, who saved over 30 different types of millet seeds out of a personal passion for the art, collaborated with M.S. Swaminathan Research Foundation and was invited to the most recent G20 meeting to talk about her methods and learnings.

Challenges in scaling up millet production in Odisha include organized seed distribution (milletsodisha, 2021). The Odisha Millet Mission aims to preserve diverse landraces adapted to local environments, ensuring genetic diversity and resilience (Choudhury, 2023). Government departments, FPOs, and NGOs collaborate to implement and sustain this initiative at district and block levels.

Therefore, sustaining India's agricultural diversity and promoting resilient crops like millets require strengthening informal seed systems, enhancing farmer empowerment through FPOs, and addressing market inefficiencies.

Theoretical Framework

A seed system is a network encompassing all stakeholders engaged in the production, utilization, management, and exchange of seeds for a specific crop within a particular geographical context, with variations in scale from local to global (Bentley et al., 2018). Efficient seed systems can boost yields in a cost-effective and timely manner. Farmers' harvests can increase significantly if they have access to high-quality seed and are aware of better techniques of seed preservation and exchange.

The literature on seed systems generally distinguishes two main types of seed systems, namely formal and informal seed systems. As seen in Figure 1, the formal seed system is distinguished by an

institutionally structured production and distribution system, for improved varieties, which go through official quality assurance mechanisms. Formal seed systems entail government agencies, traders in the district market yards, seed exchanges through private dealers and distributors, and seeds marketed by private companies. (Sooganna & Kulkarni et al., 2023). It generally consists of large-scale, automated agricultural production systems that operate under market forces (Louwaars, 2012). This system primarily focuses on cash crops and high-yielding varieties of staple foods. Therefore, the formal seed system exhibits limited agrobiodiversity and lacks climate resilience.

Informal seed systems also called 'farmer seed systems' or 'traditional seed systems' use a method of farmer-to-farmer seed exchange, through barter systems, gift exchange, or local grain markets based on indigenous knowledge and local diffusion mechanisms (Mamo, 2023). As seen in Figure 1, this includes the practice of farmers and communities managing, producing, exchanging, and storing seeds to meet their needs for planting in the future. Many small-scale and subsistence farmers operate in areas where complex environmental pressures pose a barrier to agricultural productivity, and they mostly rely on informal seed systems (Gauchan et al., 2020). Farmers who have little to no access to formal institutions typically partake in informal systems that operate outside of legal and policy frameworks.

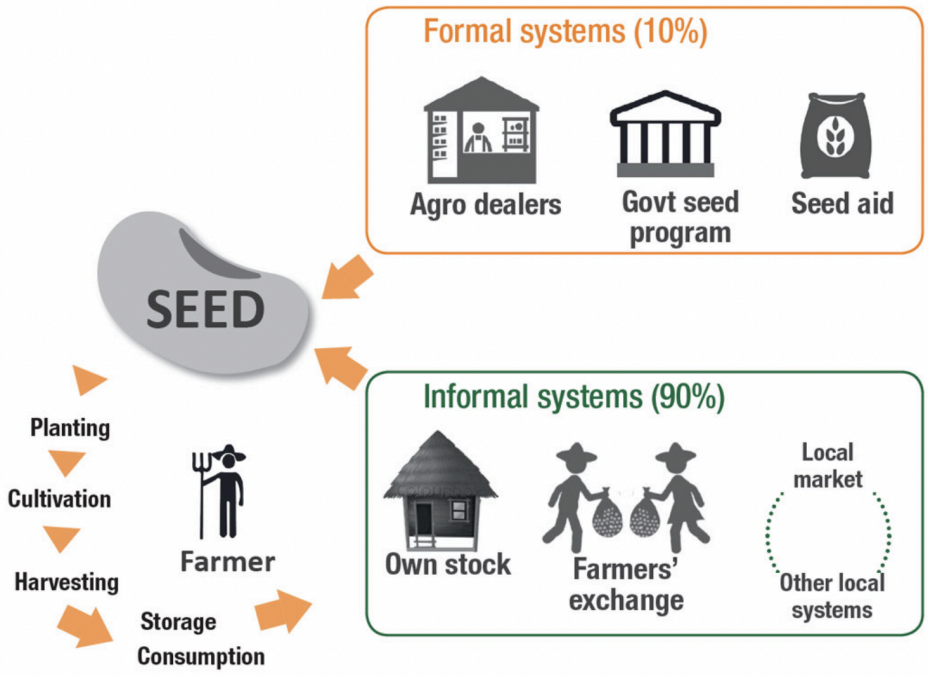

Figure 1 - Formal and Informal Seed System Chains, Source - International Crops Research Institute for the Semi - Arid Tropics (ICRISAT).

The legislative and regulatory frameworks of national seed laws often deter the growth of informal seed systems in many countries (Lossau, 2000). These laws, primarily based on international standards, often do not align with or support the practical seed systems utilized by farmers, thus creating barriers to their development.

To improve the production and expansion of millets, enhancing the efficiency and strength of millet seed systems is vital (Vaidyanathan, 2023; M. S. Swaminathan, 1925–2023). In India, revitalizing millets as staple crops requires a significant shift from the predominant focus on wheat and rice since the Green Revolution in the 1960s. A holistic millet seed system can enable farmers to generate marketable surplus, thereby increasing income and reducing reliance on commercial seeds, fertilizers, and other inputs. This economic stability enhances farmers' resilience by improving access to food and essential needs (M S Swaminathan Research Foundation, 2023).

However, the understanding of informal millet seed networks in Odisha, as elsewhere, often remains limited to generalizations, isolated case studies, or anecdotal opinions rather than comprehensive system analyses (Dyer et al., 2011). In response, seed system interventions are gaining traction to support the rapid pace of millet mission initiatives across India.

Applying a systems thinking approach to the study of seeds can have many advantages, particularly in understanding the complex web of interactions and dependencies that characterize seed systems. Systems thinking recognizes that an organization or system is greater than the sum of its individual components, emphasizing interconnectedness and mutual influence among these components (Davies, 2022). This perspective is crucial when analyzing seeds, which function as complex systems involving breeding, production, distribution, and utilization, each influenced by biophysical, socioeconomic, cultural, environmental, and economic factors (McEwan et al., 2021).

Seeds are not only agricultural inputs but integral components of broader farming systems (Almekinders et al., 2019). Farmers' decision-making regarding seeds is deeply contextualized within their local environments, considering factors such as crop diversity, animal husbandry, and household needs. For instance, the preference for immediate income from dairy products over seasonal income from crops illustrates how economic and livelihood considerations shape seed choices (Tadesse et al., 2015). A woman farmer may truly favor a high-input treatment from a demonstration trial, but if it doesn’t support her needs at home or for other consumption practices then it becomes futile.

Moreover, understanding farmers' seed demands requires a holistic approach that integrates diverse perspectives and methodologies. Almekinders et al. (2019) advocate for dialogue-based interactions

with farmers and stakeholders along the value chain to better align agricultural technologies, including seeds, with local contexts and priorities. This inclusive approach ensures that research and interventions effectively address farmers' needs and preferences, promoting sustainable agricultural practices.

Buemer et al. (2022) emphasize the limitations of market-centric approaches in seed systems, emphasizing the importance of traditional knowledge and community practices in sustainability transitions. In the context of millet seed systems in Odisha, recognizing and integrating these local practices is essential for promoting resilience and diversity in agricultural production.

Furthermore, existing literature often uses unilateral approaches focused on specific factors like farmers' willingness to pay for improved seeds (Gonfa, 2015; Horna et al., 2007). While these studies provide valuable insights into market dynamics and economic incentives, a systems thinking perspective expands the scope to include broader systemic interactions and feedback loops. This broader view is crucial for developing comprehensive strategies that address the complexities of seed systems comprehensively.

To operationalize this approach, a process-based value chain framework for seed systems can be employed. This framework not only maps out the sequential stages from breeding to consumption but also identifies key actors, and dynamics within each stage (Davies, 2022). By adopting such a framework, researchers can uncover hidden linkages and leverage points within seed systems, facilitating informed decision-making and policy development.

Therefore, adopting a systems thinking approach provides a holistic view of seed systems by capturing their complexity, interdependencies, and resilience factors. This perspective goes beyond traditional uni-dimensional analyses, integrating diverse stakeholder perspectives and local contexts to promote sustainable agricultural practices and enhance food security in evolving environments.

Process-Based Value Chain Framework

The use of a process-based value chain framework designed by Erik Lucien Delaquis fits best in the aforementioned area of study. It acknowledges the importance of the formal-informal divide but maintains a purposefully agnostic approach toward it, allowing processes and stakeholders to interact in either or both categories (Delaquis, 2023). The paradigm explicitly recognizes the effects of non-seed product transformation and sale on seed demand development, and it places networks of seed exchanges within a value chain. The framework suggests that first, seed systems consist of several steps

that influence the production and exchange of seeds, from accessing genetic resources that are needed for developing new seeds, all the way to multiplying those seeds, exchanging them, and processing them into food products; and that second, these processes of production and exchange are embedded in a system of actors that shape this production and exchange, such as regulatory regimes and market structures and overall power distributions.

It highlights that the activities surrounding the transformation and sale of crop products influence farmers' need for seeds. The value chain is itself stacked inside hierarchical levels that stand for environmental impacts, such as high-level social discussions about problems with seed systems.

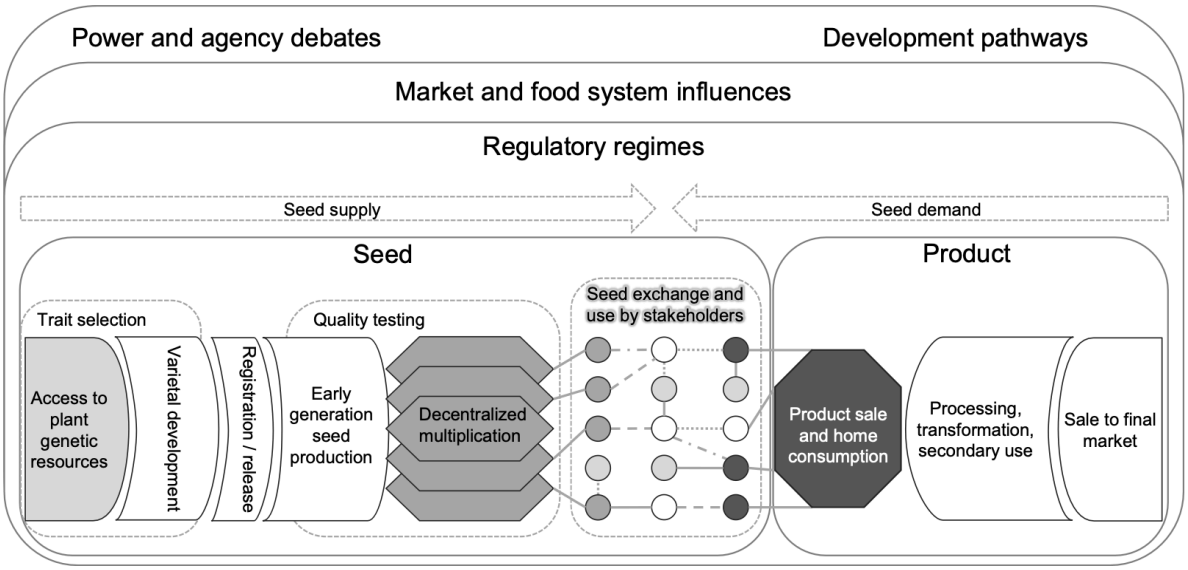

Figure 2: process-based value chain framework (E.L. Delaquis, 2023)

Figure 4 illustrates a basic model of how seeds are used and exchanged within an agricultural network. Different processes in the seed exchange system are shown as shaded shapes, with each shape representing a different activity that stakeholders repeat. Various patterns of how seeds are exchanged show the differences in these systems. The larger context of seed system development includes multiple, interconnected value chains that help form the supply and demand for seeds (Delaquis, 2023). Not every seed value chain involves every process shown.

The framework provides a holistic approach taking into account the entire seed system which aligns with the goals of the OMM, which aim to enhance millet production for the purpose of food security and nutritional improvement in the country. By acknowledging the importance of both formal and

informal seed systems and allowing for interactions between them, the framework captures the reality of seed exchanges and the coexistence of modern practices and traditional exchanges in Odisha.
The framework recognizes how the transformation and sale of crops (beyond their use as seeds) affects seed demand. This is particularly relevant for millet, a crop with significant food and economic value in Odisha. Understanding these dynamics helps in assessing how the Mission's activities influence overall seed demand. The framework also takes importance on the actors who are part of the seed system as well as the network of exchanges which implies casual farmer exchange and building of community seed banks. The framework's flexibility allows it to be adapted to the specific traits and dynamics of Odisha's millet systems. It can incorporate cultural significance, generational knowledge, and local practices, ensuring a nuanced analysis that reflects the unique characteristics of the region. The approach facilitates an analysis of the dynamics shaping millet seed supply and demand by situating seed exchanges within a larger value chain. This is essential for assessing how well the Odisha Millet Mission is doing in building a resilient and sustainable seed system.
All things considered, the PBVC framework offers an organized, yet adaptable, method for examining the Odisha Millet Mission. It makes it possible to do a thorough analysis of the different actors, processes, and socioeconomic aspects of millet seed systems, which makes it easier to evaluate the influence and support provided by the Mission.

Methodological Framework

In order to study the nuts and bolts of seed systems and how they are being supported under the OMM, a qualitative form of study was employed. The reason for employing a qualitative approach was to capture the grey areas and nuances that are everpresent in communities across India. This qualitative study was done by understanding prior case studies as well as primary data collection through collaboration with local experts, seed companies, and NGOs carrying information regarding seed systems.

Research Design

Qualitative research with an inductive approach is proposed in the research as qualitative approaches aim to answer open-ended inquiries like "how" and "why," the responses to which are difficult to quantify. One of the important aspects of qualitative research is its capacity to clarify human behavior patterns and processes, which can be challenging to measure (Tenny, 2022). This methodology is particularly useful to examine the nature of millet seeds in agriculture which often lies outside of government records and data. In a case where I analyze the existing systems, community dynamics,

traditional knowledge, and impacts of an external intervention, the need to capture the "how's" and "why's" becomes very important. Therefore a dialogue-driven, qualitative method of research is best suited to understand how well the OMM is supporting various seed system structures for millet seeds in Odisha, India.

Sampling Strategy

The strategy used for sampling was Purposive, which is sometimes referred to as judgment, selective, or subjective sampling. The reason behind selecting the state of Odisha was because it has a startlingly high rate of malnutrition, with 45% of stunted children and 41% of women having a body mass index that is below normal, according to the National Family Health Survey, 2015–16 (Shalya, 2020). The Koraput district in Odisha was selected to study seed systems because of its high Adivasi population, its history with millet cultivation, and the challenge of undulating geographical terrain, unpredictable weather patterns, and tribal millet cultivator populations (GoO, n.d.).

The method of Purposive sampling is a sampling approach where the researcher uses personal judgment to pick study participants from the community (Dudovskiy, 2012). Purposive sampling is generally used to collect qualitative data to provide relevant information for the research question, In this case, to find and purposefully choose non-governmental organizations (NGOs) that are actively engaged in projects about traditional millet seed systems, sustainable agriculture, or community structures and seed saving practices; millet farmers and members of Farmer Producer Organization's, as well as organic seed companies supporting the millet mission. Within purposive sampling, the snowball sampling method for collecting data from millet farmer communities was employed. In this case, farmer households who have knowledge of or practice the art of seed cultivation, preservation, and exchange will be targeted. Aside from the aforementioned, it is essential to capture farmers who have been a part of or involved in the OMM program. NGOs, governmental entities, and seed companies will also be interviewed regarding seed system interventions and understanding.

Through the process of open-ended interviews, a diverse range of factors based on the process-based value chain framework that had an impact on seed systems was taken into consideration.

In the case of this research, the intent was to stop sampling when the research had reached a point of theoretical saturation. This implies that the data collection ended when I interviewed enough farmers, NGO employees, and seed companies to be able to gather information on the relevant variables of the framework, learned of the different types of seed systems present in the Koraput region of Odisha as well as the workings of the OMM.

Data Collection Method

Desk research along with dialogue-based interactions (Almekinders et al., 2019) were used in the form of semi-structured interviews in order to collect relevant data. This technique for gathering data was based on the different variables in the PBVC framework. The questions were not predetermined in terms of sequence or wording and were generally open-ended (Clark et al., 2021) yet entailed a certain amount of structure in order to base it on variables of the PBVC framework. Two primary approaches were employed to gather information on the aforementioned: first, In-depth interviews with two prominent NGOs in the Korput region of Odisha were carried out to inquire about the specifics and progress of its millet mission. Information about processes, policies, and existent seed systems was derived through interviews conducted with a number of persons at NGOs such as WASSAN and Koraput Farmers Asociation (KFA), ranging from project managers to field-level employees. Research foundations like the M.S. Swaminathan Research Foundation, and the director of an organic seed Not-for-Profit company, namely Sahaja Samrudha.

Secondly, separate focus group discussions with millet farmers along with private interviews were conducted in order to understand the differences between varying traditional practices for seed saving, management, and exchange that are practiced across different millet farming communities. A total of four Focus Group Discussions (FGDs) were conducted across different villages in the Koraput district, each comprising 10-15 farmers. Additionally, personal interviews with the farmers and the village priest were conducted to ensure that findings from the FGDs were not limited, as conversations are often easier when interacting with a single person to overcome the hesitation that sometimes arises in group scenarios. The open-ended interviews were mostly oral history interviews which helped gather in-depth qualitative results on farming practices. This supported in providing different perspectives as well as more focus and direction towards the topic of study. Regrettably, efforts to obtain information on millet seed systems from government entities or private seed companies have not yielded responses.

Operationalization

The thesis was operationalized based on 11 out of 12 distinct elements of the process-based value chain framework by Delaquis, that captured the answers to the research question. It should be noted that, according to the framework, not all variables need to be used to conduct a study on seed systems. These variables have been extracted from Erik Lucien Delaquis' 'Cassava Seed Systems in Southeast Asia', The operationalization of these variables is as follows:

1. Access to Plant Genetic Resources: This variable examines the source from which farmers obtain the genetic variety of millet seeds. It assesses the availability and accessibility of different seed types within the seed systems.
2. Varietal Development: This variable explores the methods used by different seed systems and the actors within these systems to maintain and preserve various millet grain varieties in the region. It looks at how seed diversity is sustained over a certain period of time.
3. Registration and Release: This variable focuses on the entities responsible for legally approving and finalizing the release of specific millet varieties into the formal market or farmer community ecosystem. It examines the processes of certification and introduction of new varieties.
4. Early Generation Seed Production: This variable assesses the quality of seeds produced in the initial stages within different seed systems. It highlights the critical connection between breeding activities and the eventual production and distribution of seed varieties to farmers (Louwaars, 1994).
5. Decentralized Multiplication: This variable refers to the methods of multiplying and distributing seeds among farmers within a particular seed system. It looks at how seed dissemination is managed and implemented on a local scale.
6. Product Sale and Home Consumption: This variable examines the division between quantities of millet cultivated for commercial purposes and those for home consumption. It considers the purpose and ultimate usage of the millet seed, focusing on the final destination of the crop.
7. Processing Transformation and Secondary Use: This variable focuses on the processes that millet seeds undergo before reaching the final consumer. It examines methods of transforming the crop into various products and adding value for secondary use.
8. Sale to Final Market: This variable looks at the process and market where the final product ends up. It takes into consideration the different markets that might exist for various seed systems and assesses the pathways through which millet products are sold.
9. Regulatory Regimes: This variable focuses on the formal and informal governance mechanisms within various seed systems. It examines regulations that may be recognized by official government bodies as well as those that are not formally recognized but still play a significant role.
10. Market and Food System Influences: This variable considers the external factors that impact the preservation and system around a specific seed variety. It examines the influence of market demand and food systems at local, regional, and national levels.
11. Power and agency debates - refers to a person's or a group's capacity to decide, manage resources, and affect results inside the seed system and agency refers to a person's or a group's ability to act independently and choose within the seed system (Delaquis, 2023).

By operationalizing these variables, the research aims to provide a comprehensive understanding of the different seed systems in Odisha, their functioning, and their impact on millet farming in the region

Data Analysis

The process of data analysis was carried out in two major steps, First, the data was collected by conducting interviews with millet farmers and NGOs in the Korput region of Odisha. Another important task here was Data reduction: “It involves reducing the large body of information that the researcher has gathered so that they can make sense of it” (Clark et al., 2021). In this case, open-ended interviews led to large quantities of interesting yet, irrelevant information that needed to be excluded from the collection in order to make sense of the framework.

Conventional coding methods on Microsoft Excel, specifically the structural and thematic coding methods have been used. Structural coding entails content-based or conceptual phrases representing a topic of inquiry. (Clark et al., 2021) and thematic coding is used for finding, examining, and summarizing patterns in data is thematic analysis. The coding procedure is an essential component of thematic analysis, acting as a link between unprocessed data and the development of meaningful themes (Atlas.ti., n.d.). It is specifically for investigations to gather topic lists or indexes of major categories or themes. Along with that, this form of coding categorizes data to examine commonalities, differences, and relationships. To understand differences in traditions and practices of millet seed systems, the structural coding would highlight distinct preservation and exchange methods clearly.

The data was categorized into the different elements of the theoretical framework, and for each element, different codes were then developed. For example, varietal development for seed system A took place in situ, where farmers cultivated and preserved millet seeds on their individual pieces of land and passed the seeds over to the next generation. Another code, which looked at the entire value chain was product sale and home consumption in which system B had a 50%-50% division between the percentage of the crop sold and the percentage used for home consumption.

Research Quality Indicators

The quality of social research is primarily assessed through validity and reliability. Validity, in this study, is reinforced by the principle that "true knowledge" is achieved through interaction (Clark et al., 2021). Reliability is maintained by structuring data to minimize potential biases during interviews (Clark et al., 2021). To ensure the data's reliability, a peer review was conducted among experts in the field.

As a qualitative researcher, interviewer bias is a potential concern. To address this and capture the complexities of seed systems systematically, credible sources such as the Odisha Millet Mission page, interviews with WASSAN (an NGO actively working on OMM implementation), and Indian government websites were utilized for secondary data collection. To effectively answer the research question, construct validity is employed, ensuring that the study accurately measures what it intends to assess (Fink, 2010). The evaluation of how well the OMM supports seed systems is based on Delaquis' PBVC framework, providing a holistic perspective. This framework was used to measure the "how well" aspect of the research question regarding the support provided by the OMM to seed systems in Koraput, Odisha. This approach ensures that the research comprehensively addresses the nuances and intricacies of millet seed systems, allowing for a thorough understanding of the OMM's impact.

Time Schedule

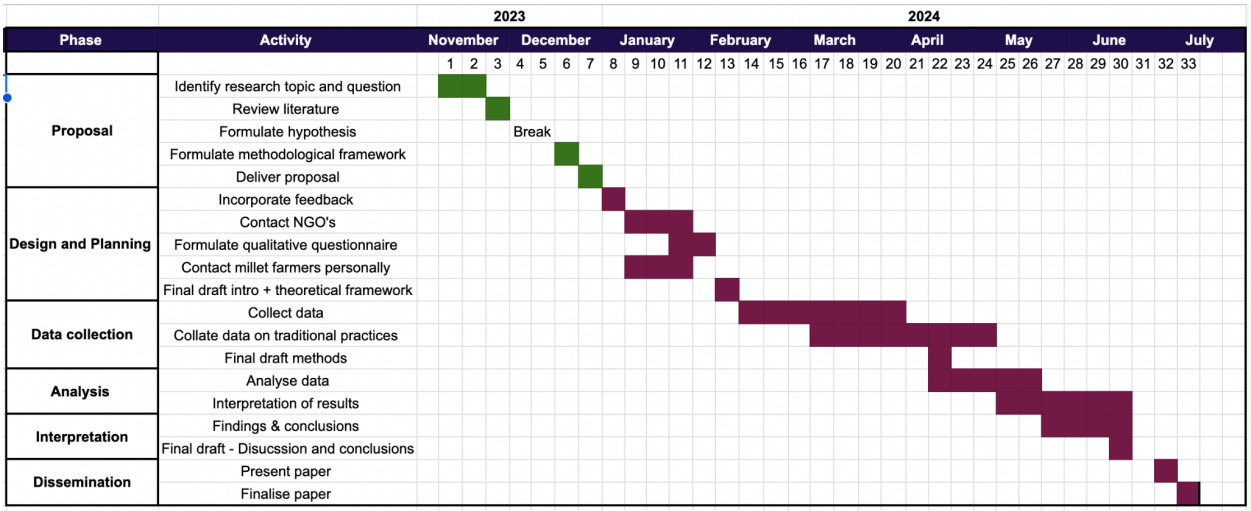

Table 1- Timeline

Results

[**Optional read** within brackets - Before I start, I would like to share this tiny snippet with you to give you a sense of what millet cultivation means to the local Advasi community in Koraput. It is more than a source of income, it is deeply integrated into their lives and the community's respect for this crop is immense.

Located 217 kilometers away from the first city lies the tiny village of Kundra (Koraput, district of Odisha). The hilly terrain and green pastures give way to a simple life and life without modern distractions. Hardly any signs of what textbooks describe as “developed”. Children screaming with the excitement of chasing wild chickens, young women peeling pees by their thatched houses, indulging in household gossip, and old men basking in the sun. There is an energy of calm and peace with a tinge of what happiness looks like, in the air.

Sonamundi ji, a 60-year-old woman belonging to the Kondh tribe, sits on the cow-dung-laden pavement with distant eyes, narrating stories from her childhood. Her fading memory gives me a glimpse into the significance of Finger Millet (ragi) in her life. For her and her forefathers, finger millet is not just another crop that is sowed and harvested for making a livelihood. It’s a story. She talks about how years ago, the gods of fortune blessed the hilly regions of Odisha with millet seeds while walking the Earth.

Her friend and neighbor, Vishali ji, a youthful-looking woman, eagerly shares her story of how finger millet saved her son when he was young and frail due to illness. At that time, the village doctor couldn't diagnose the issue, and the nearest hospital was over 30 kilometers away—an impossible journey for her weak son. She fed him millet slurry daily, prepared millet rotis, and gradually nursed him back to health.

This sense of appreciation and gratitude towards the millet crop consistently came across in all my interviews with millet cultivators and I believe, it deserved a mention in my thesis.]

Image 2 - Varieties of finger and little millet (most popularly grown in the Koraput district) (Choudhury, 2023 - WASSAN employee)

Seed System A

The first seed system found is characterized by being the oldest and most widely practiced method of seed preservation as per NGO interview 1. The research for this was conducted over the Jeypore, Lakshmipur, and Kundra blocks within the Koraput district in southern Odisha where I interacted with members of WASSAN, Community Resource Person's appointed by the state government, and millet farmers. The interviews and FGD interactions highlighted the significance of seed system A, which I also call the traditional seed system. Rooted in cultural heritage and passed down through generations, this system involves methods of cultivating, harvesting, managing, and preserving seeds using traditional processes to ensure their availability and diversity range for future cropping seasons.

The findings presented below are noted based on the process-based value chain framework, these different variables have been operationalized and highlighted in **bold** text below.

Image 3 - Focussed Group Discussion 1 with women farmers (author in black t-shirt)

Despite a significant decline in millet seed varieties (as noted by farmers interview 1 and FGD 2), traditional practices have helped maintain a relatively diverse seed pool for food crops. Research indicates that the millet production area fell by 41.65% between 1950–1951 and 2018–2019. By 2021, millet production had decreased to just 15 million hectares from 35 million hectares in 1960 (Mohanty, 2022). In spite of this, it is a well-known fact, as stated by the village priest in Kundra block was that *"the Adivasi population in Odisha is pivotal in harvesting and processing millet crops, contributing to the preservation of traditional seed varieties"- (NGO interview 1 - translated from Odiya to Hindi and then to English).*

Access to plant genetic resources, the first element of our seed system framework, is carried out through customs and oral traditions in this informal seed system. Seeds are stored and cultivated, with millet farming techniques handed down through generations, ensuring the preservation of genetic material distribution over time. Knowledge about seed regeneration, storage, and preservation is transmitted orally and through hands-on learning.*"Our forefathers have been cultivating millets for generations. This crop is a prevalent part of our diets, and therefore, the seeds are harvested and preserved every year as part of village tradition." - FGD 3 (translated from Odiya to Hindi and then to English).*

Farmers use techniques like sun drying seeds on individual rooftops, sealing them within clay pots, and using neem leaves and other organic materials to manage pest attacks are used. Also, materials like soapnut leaves and cow dung are used as a bacterial preventative for seeds that are stored in clay pots are some examples of the ancient knowledge ingrained in this method. Access to plant genetic resources, in this informal seed system, comprises two main pathways; knowledge about genetic resources (which is transmitted orally and through hands-on learning) and preservation of the physical resources (using sun drying and clay pots, etc.).

As per traditional knowledge shared by the farmers, millet seeds cannot be preserved using the same techniques as vegetables such as okra, tomatoes, etc. Vegetables and other wet seeds require longer days in the sun and are sometimes stored in the open air by hanging crop stalks from ceilings. Legumes and grain varieties need lower levels of care and moisture before they are stored. The ideal level of moisture to avoid mold and fungus on the seed is a maximum of 10%. In the traditional system, mixing neem or salt in clay pots helps prevent moisture and pests. The neem leaf has been known to prevent more than 300 species of pests (Lohar, n.d.) such as grasshoppers, mites, centipedes, and many more. These methods promote the maintenance of seed quality in the early generation seed production phase.

Celebration of millet seeds is an integral part of the traditional seed system and supports the varietal development of the seed as well. Thirteen festivals centered around agriculture are observed throughout the year in the Koraput district, highlighting the importance of agricultural land and agricultural practices in the community. Religious practices and superstitions play a significant role in the traditional seed systems. For instance, rituals such as worshiping millet saplings and pouring milk symbolize an appreciation for nature and the agricultural cycle. These practices are deeply integrated into the traditional seed systems. One example is that after harvesting and processing the crops, farmers prepare sweets made from millet and offer them to various deities, thanking them for a good harvest. *“Seeds are a gift given to us by god, we must show our respect towards them.” - Village Priest (FGD 2 -translated from Odiya to Hindi and then to English).*

Image 4 - The priest' of the village in charge of distributing millets - religious influences managing seed systems (author in green t-shirt).

Furthermore, networks of exchange within communities and neighborhoods are essential for enabling access to genetic resources. Neighbors trade millet seeds for other goods or return double the amount of seeds they receive after the following harvest season in a custom widely practiced across the region. In addition to this, there is almost no monetary exchange between farmers, mostly reciprocal barter trade, it involves a different form of reciprocity (for instance 1 kilogram of millet seeds is exchanged for 1.5 kilograms of tomato seed, as per market value or in another case 1 kilogram of millet seed is exchanged for 2 kilograms of millet crop harvest the following year) as explained by Farmer 3.

Varietal development, the second element of the PBVC Framework, is mostly in situ in traditional seed systems, involving the preservation of seeds in their natural environments or on the farms of long-time cultivators. Furthermore, the distribution of millet seeds by village priests or other religious authorities facilitates a variation in the kind of seeds that are cultivated by the same households. Priests are integral to religious rites and rituals among the Koraput region of Odisha's largely Hindu population. Priests disperse millet stalks as part of these rituals, increasing seed diversity and guaranteeing the availability of a variety of genetic resources. Some additional customs enable the distribution of different varieties of millet seeds and strengthen community relationships. For example,

a woman's parents might give millets or cultivated land as part of a wedding ritual, promoting the spread of different millet varieties across the area.

The traditional seed system does not include any governmentally recognized process for seed **registration and release**. The decision-making power regarding which seeds to cultivate lies with individual farmers, local governing systems, religious institutions, and other community-based authorities. According to Farmer 4, women typically select the seeds and decide their suitability for cultivation.

Traditionally, millet cultivation was primarily for **home-consumption**. However, following the Odisha Millets Mission, farmers who are registered and have the appropriate documentation have started dividing their harvest by selling a small percentage and keeping a larger percentage of the harvest for themselves. Millet is consumed by most Adivasi households on a daily basis where the orally transmitted knowledge that millet contains an energy drink and is beneficial before going into a hard day's work on the field, has been passed down over generations. This consumption practice is integrated into the traditional seed system, with the surplus produce being channeled toward sale to local mandis, middlemen, and neighboring households. Recently, excess grain has also been given to vans sent by the Odisha Millets Mission.

Consumption of millet seeds also requires seed **processing and transformation**. Millet seed processing and transformation for secondary use are labor-intensive, involving harvesting, sun-drying, beating the dry crop with bamboo sticks, and milling it using small-scale stone mills (Image 5). *"De-husking these millet seeds is a back-breaking process for us, but it is what makes us live longer" - (Farmer 5 - translated from Odiya to Hindi and then to English)*. Despite the effort, farmers integrate millet with other food crops for self-sustenance. Women typically handle the processing, transforming millet into various foods that enhance nutritional diversity.

Image 5- Hand-held stone mill for grain dehusking and processing

The Odisha Millets Mission provides a smooth-running platform to support the **sale of the produce to market** as well as a significant source of income through a minimum support price per kilogram. The Minimum Support Price (MSP) is a form of cushioning offered by the Indian government to incentivize the cultivation of certain food crops by providing a guaranteed price to farmers unaffected by the market or any other natural disasters. (Vishnava, 2024).

Surplus income is used for household luxuries and necessities. Millet grain processing and surplus sales decision-making are typically managed by women, granting them autonomy in their homes and giving them the power to control the entire process. The Odisha Millets Mission is seen as a great source of income, especially after the government's promise of a minimum support price per kilogram. *"We are using our income for important purchases such as buying gold jewelry, clothing, television, and fans for households"-(FGD 4 - translated from Odiya to Hindi and then to English)*. Another use of the income is the purchase of oil and salt for cooking. In the case of the Odisha Millet Mission the government of India had to ensure a higher MSP for millet than other commercial crops in order to incentivise the cultivation as stated by NGO 2.

Community exchanges and barter systems dominate the **market dynamics**. While small amounts of excess produce may be sold to nearby mandis, local exchange practices prevail. Millet production and sales are primarily controlled by households, especially those headed by women, which helps to preserve millet-based food systems.

The smooth running and decentralized structure for millet production and sales empowers individual households and strengthens networks thereby keeping the **power and agency** of the community informal in nature. This form of seed system is not only important for producing and circulating seeds but also plays a major role in bringing communities together. Women, in particular, play a crucial role in seed selection, processing, and market decisions, enhancing their agency and influence within the home economy and broader community.

The traditional seed system does not have a legally structured regulatory mechanism and relies instead on self-**regulatory regimes** and traditional methods, including religious practices, festivities, and other cultural norms. These self-regulatory practices play a crucial role in managing the millet market in Odisha, with minimal influence from external economic markets.

The larger **market or other food system influences** do not play a vital role in the production of this crop, it is mainly controlled by historical food systems and consumption patterns in the area as well as the availability of seeds that have been passed down over generations. Market demand is not too significant in the incentive to cultivate millet crops.

Seed System B

The second seed system observed in Koraput, Odisha combines the access of released seed varieties from research foundations facilitated by local NGOs (extension agencies for the government) along with traditional methods of seed acquisition, such as obtaining seeds from neighbors or using seeds preserved by their ancestors. I call this seed system, the combined seed system. The facilitating agencies for the OMM in the different blocks were Koraput Farmers Association (KFA), Centre for Youth and Social Development (CYSD) in Lakshmipur block, and M.S. Swaminathan Research Foundation in Kundra block in the Koraput region (Odisha Millets Mission, 2024).

The OMM Developed Seed System

The OMM employs the 'Alternate Seed System' which fits in the category of seed system B, it was formulated for the purpose of having a multi-stakeholder approach to the preservation of different landrace varieties. Farmers along with researchers select the best millet crops based on criteria such as taste and religious needs (Chaudhury, 2023). Selected varieties are then multiplied by Farmer Producer Organizations and distributed through the Community Management Seed Systems (CMSS).

Alternatively, as shown in Figure 3 below, selected varieties are purified and analyzed by researchers, ensuring suitability for local conditions. These are then tested in multi-locational trials, and successful varieties are proposed for release and distribution via the Odisha Millet Mission (Chaudhury, 2023). This comprehensive approach ensures the preservation and enhancement of valuable landrace varieties

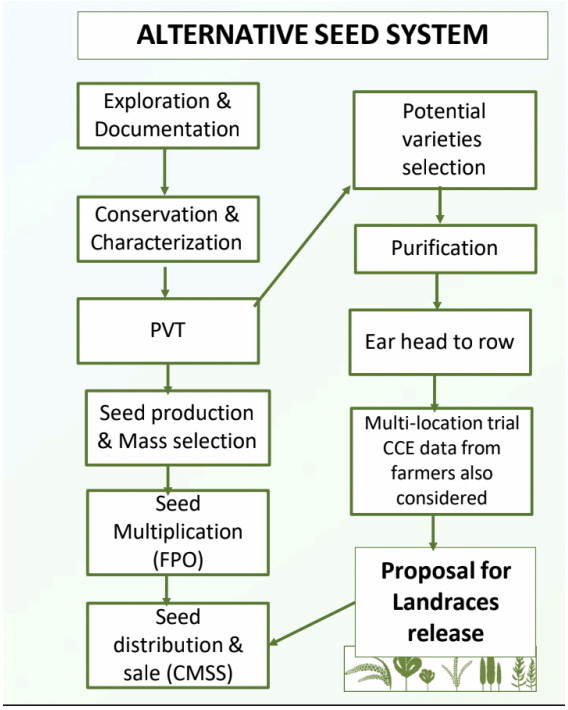

Figure 3 - Informal seed system and Alternate seed system developed under the Odisha Millets Mission (Choudhury, 2023)

This is a mixed-source approach, where the NGO in collaboration with the government understands the increasingly felt impacts of climate change. Farmers have already started facing the brunt of extreme temperatures and the importance of preserving different varieties of seeds to ensure crop resilience. Increased use of genetic variety within and across crops, may yield a number of benefits, including more secure and healthy diets, tolerance to climatic changes and illnesses, and long-term food system sustainability (Hiemstra and Sipke, 2023). This mixed system leverages **access to genetic resources**

through strengths of both modern agricultural advancements in terms of research and technology along with government-led processes and traditional farming practices. Farmers may maintain agricultural biodiversity, which is essential for long-term sustainability while reaping the benefits of enhanced crop types and yield by incorporating seeds that are obtained through local farmers and kept through generational expertise.

Preserving seed varieties is essential for several reasons, including managing the resilience of pests to certain pesticides or fertilizers. Interview 1 with an employee from a grassroots NGO in Odisha highlighted the critical importance of preserving seed **varietal diversity** across the country. He emphasized that farmers with lower incomes are disproportionately affected by climate change and its consequences. Millets, being hardy crops, are well-suited to adapt to both drought and excessive water, making them ideal for cultivation and financial risk management. Additionally, millet, being highly nutritious, can play a crucial role in addressing the significant issue of nutrition in India, particularly benefiting diabetic and heart patients.

Currently, the government has asked implementing NGOs to distribute free seeds of the four approved millet varieties—Mami, Kalia, Bhati, and Bharati (local Odiya names) to farmers. These seed varieties have been/ or are in the process of being **registered and released** by the collaborative efforts of research foundations, some selected farmers, and governmental entities. These seeds are provided at no cost because they are in the process of official registration and release by research foundations in a multi-stakeholder designed process (involving farmers and implementing agencies), which is a lengthy procedure that takes over three years to complete. By guaranteeing that farmers have access to these varieties while the seeds go through the required validation and approval stages, the OMM project seeks to support farmers throughout this transitional period.

A Community Resource Person (CRP) is appointed by the government to each block in order to ensure a smooth running operations including packaging and processing (as seem in Image 7 & 8) for the program implementation, the CRP's are employed on the official government payroll. For a farmer to be part of the Odisha Millets Mission there is a prerequisite to have certain documents in place, these documents include, bank account details, voter ID, land documentation, Aadhar card (a unique identity document of India), and passport picture.

In response to the need for **early-generation seed production** and the preservation and restoration of seed varieties, the government has allocated 30 acres of land in a region called Chitrakonda, Odisha, for a collaborative effort involving research foundations, farmers, and scientists. Currently, 5 acres are actively used for cultivating diverse millet seeds collected from farmers, which are then stored in a seed

bank. This collaboration aims to test and approve millet seeds for cultivation through the Landrace Varietal Release Committee (LVRC). The LVRC constitutes representatives from the Agriculture Department, Odisha State Seed and Organic Products Certification Agency, Odisha State Seed Corporation, State Seed Testing Laboratory, Odisha University of Agriculture and Technology, ICAR-IIMR, custodian farmers, Farmers' Producer Organisations, and a Working Group on Seeds who are in charge of ensuring a wide array of resilient seed varieties are available for future generations (Mohanty, 2023). The LVRC will advise the Odisha government on integrating millet landraces, review the implementation of approved standard operating procedures, and submit periodic reports (Mohanty, 2023). It will also assess and release millet landraces based on farmer preferences, review seed assessments, and plan for certified foundation seed requirements across different regions of the state.

These released varieties are **multiplied using a decentralized approach** via a third-party extension, the NGO working on the ground. *"The Odisha Millet Mission has come up with a smooth running process to ensure seed availability, collection and financial security for all farmers without discrimination" - NG*O 1. The farmers need to request for new seeds well in advance to ensure timely delivery from the many third-party entities. Many farmers integrate these NGO-distributed released varieties with their traditional seeds. The released varieties are often sold to the Odisha Millets Mission (OMM) for further distribution and cultivation, promoting agricultural sustainability and enhancing food security in the region. This blend of traditional and modern practices is crucial for maintaining agricultural biodiversity, supporting farmers' livelihoods, and ensuring the resilience of food systems in Odisha.

In the case of the mixed seed system, farmers have started gravitating towards cultivating millet as a commercial crop while growing paddy and other grains for their own consumption. As of today, the current rate of **product sale and home- consumption** of millet crops is approximately 50%-50%. The easy availability of these seeds encourages farmers to sell a larger portion of their harvest to the market, in this case, the government-run Odisha Millets Mission, as they can confidently plan for the next planting season. In Odisha, locally grown ragi has been included in the Integrated Child Development Services (ICDS) where it is a part of the preschool meal, Further, the state agriculture department has selected 14 areas that will offer ragi through the Public Distribution System (PDS) and in the coming years integrated in government-run hostels (Shalya, Chinmayi 2020). Therefore providing farmers with enough demand for the crop and an incentive to cultivate.

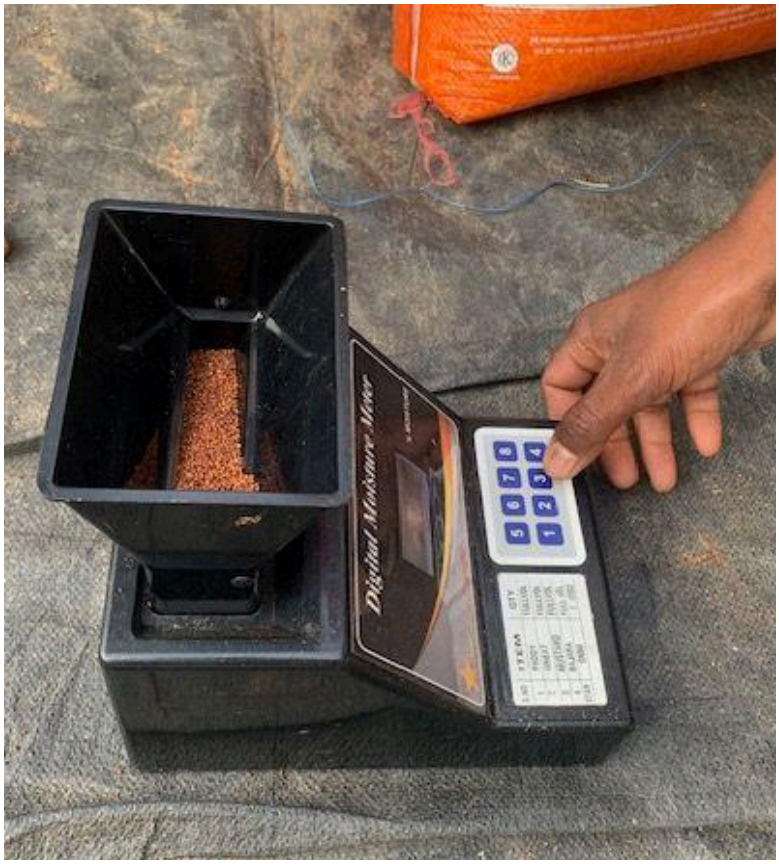

Image 6 -Moisture detection machines for testing grain quality

Images 7&8 - Decentralised packaging, and sealing of the millet grains for the Odisha Millets Mission

The cultivation methods in Odisha incorporate a blend of traditional and modern techniques. Farmers continue to use age-old practices such as using Neem to repel pests and storing seeds in clay pots. However, cultivation practices have evolved. Ground-level NGOs now regularly conduct training sessions for rural farmer populations, introducing them to more effective practices like line cultivation. This method, which involves planting seeds in straight lines, results in higher yields per acre compared to the traditional method of free broadcasting seeds. Broadcasting seeds technique require 30-40% more seeds than line cultivation (HelpforAG, 2018). Local NGOs, guided by governmental bodies, also establish and support local Self Help Groups (SHGs) to transform grain into value-added services for millet crops. These groups focus on creating a variety of high-shelf-life food products and packaging them in a marketable manner, making, packaging, and selling products like biscuits, bread, sugary desserts, and millet batter.

Despite these benefits, there are concerns about the potential dependency on free seed distribution may provide agency to the farmers but does not give them the power to forfeit dependency on the Mission. The role of **power and agency** in this seed system is more diffused than the others. Without a formal mechanism for incentivizing seed distribution among farmers, providing seeds for free might lead to a reliance that could undermine long-term agricultural self-sufficiency. Currently, farmers receive seeds based on their requests to the NGO (extension agency of the government), with no limit on the quantity per household, which could exacerbate this dependency. The seeds undergo rigorous testing for moisture content and contamination by the NGO collection points in each district before being packaged and distributed, ensuring high-quality standards are met. A moisture mapping machine (as shown in the Image 6) is used by the CRP along with members of the Farmer Producer Organization.

The overarching **regulatory regimes** are curated through a combined effort from the government in consultation with local NGOs. These regimes ensure that the processes of regulatory regimes such as seed certification, distribution, and utilization are carried out effectively, promoting agricultural sustainability and resilience. In my opinion, the processing of these seeds still needs improvement. Government-donated machines, intended for dehusking finger millet (Ragi), have been tried and tested but have failed miserably. While these machines are effective for certain crops, they often end up increasing the workload for farmers, as noted by Farmer 3. Additionally, access to electricity is very limited in the village, making electrically powered dehusking machines impractical and not always a good use of time.

The cultivation of millets is largely driven by the incentives provided by the government's initiative which creates **market and food system influences** to introduce millets in the PDS, MDM, ICDS, etc.. The MSP along with the smooth running demand and sale processes gives the farmers incentive to switch from other commercial crops such as wheat and rice to millet crops. The larger goal of food & nutrition security, resistance to climate change, and steady incomes is overcome easily by undergoing the aforementioned processes.

Seed System C

The third and final type of seed system observed in Odisha is a government-driven seed system in collaboration with private and public seed companies. This system focuses on the distribution of high-yielding varieties (HYV) of seeds developed by research foundations and officially released by government agencies and sold by seed companies. These seeds are sold to farmers at pre-set prices through government centers located in village blocks, aiming to make "improved" seed varieties, (as per their claim), accessible to a wide range of farmers, including those living below the poverty line. The HYV seeds are designed to increase the use of chemical inputs while also increasing yield per acre. Access to these seed varieties takes place via third-party market centers working on the ground that act as messengers for government bodies and seed companies to distribute high-yielding millet seeds. In addition to this, some private seed companies have their own methods of marketing and outreach to farmers.

The process of releasing HVY seeds in India includes a collaborative effort between Crop research institutes of ICAR (Indian Council of Agricultural Research), SAUs (State Agricultural Universities) and private seed companies are the main entities that support the development of improved varieties in India. (Chand et. al., 2020). As a general rule, the enhanced variety needs to yield more than the current one (national and state check varieties), and multiple multilocational assessments at various levels are used to guarantee this. This government-driven seed system relies on a network of government agencies and local agricultural centers to produce, distribute, and promote HYV seeds. These agencies work in collaboration with local farmers where **access to genetic resources** is derived from farmer populations and then studied and used to create more resilient and better-quality varieties. *"It becomes easy for the private sector to access these diverse seed varieties but challenging for the farmers to intern reap benefits from their donation" - Organic Seed company 1*

The seeds known as High Yielding Variety Seeds (HYV seeds) are of higher quality than regular seeds (Singh, 2016); they yield more produce than regular seeds; they are a better choice of seeds to obtain a

healthy and surplus crop; they have a good immune system to fight off insects and other diseases; they require very little care in the form of irrigation; and they were a major factor in the introduction of the green revolution in India.

The HYV seeds are developed through extensive research and breeding programs conducted by government research institutions. These programs focus on creating seed **varietal development** that offer higher yields compared to traditional varieties. The primary goal is to boost agricultural productivity and improve the economic conditions of farmers. Saying this, we have seen a number of detrimental impacts of HYV seeds as well inlcuding requirement of significant amount of fertilizers, pesticides, and irrigation, increasing costs and pollution, making them inaccessible and unbeneficial to the poorest farmers (BBC, n.d.).

The high-yielding varieties undergo a rigorous process of **registration and release** before they are made available to farmers. This process involves multiple stages of testing and validation to ensure that the seeds meet the required standards for yield, resilience, and suitability for the local climate. The approval and release process ensures that only the best-performing seed varieties are distributed to farmers. The release and registration of HYV seeds in India involve multi-location trials conducted by the Indian Council of Agricultural Research (ICAR) to assess performance. Successful varieties are recommended by the Variety Identification Committee, registered with the Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA), and approved by the Central Sub-Committee on Crop Standards. Once notified in the Gazette of India, seeds are certified and made available for commercial cultivation *(Organic Seed company -1)*.

Early generation seed production is managed by government research stations and private scientific bodies where the initial batches of HYV seeds are produced. These seeds are then multiplied through a controlled process to maintain their genetic purity and quality. The government ensures that these seeds are produced in sufficient quantities to meet the demand from farmers.

To facilitate widespread access, the **multiplication of HYV seeds is decentralized**. Local agricultural centers and government-supported seed farms play a crucial role in multiplying the seeds and distributing them to farmers across various regions as stated by NGO interviewee 1. This decentralized approach ensures that seeds are readily available in local markets, making them accessible to farmers without significant logistical challenges.

The marketing and the minimum support price (MSP) offered to farmers play a significant role in the large-scale multiplication of these HYV seeds. Providing an MSP gives both small and big farmers who

can afford to buy HYV seeds and wealthier farmers with large tracts of land, an incentive to purchase HYV seeds. This encourages the production of a higher quantity of millet, allowing farmers to earn a larger sum of money from their harvests.

Farmers purchase HYV seeds from government centers and use them for cultivation. These seeds typically produce a higher yield, around 10 quintals per acre, compared to the 7-8 quintals from traditional varieties (The Indian agricultural system calculates in quintals which amounts to 1 quintal being equal to 100 kilograms (GG, 2024). For farmers living below the poverty line, even a small increase in yield can significantly impact their ability to pay off debts and improve their standard of living. However, HYV seeds often have lower nutritional content than traditional varieties, which is a trade-off that farmers must consider. In the case of HYV finger millet seeds, these seeds typically produce around 9-10 quintals of millet per hectare, compared to non-HYV varieties, which yield 6-7 quintals per hectare, according to Farmer 7. However, reports indicate a more significant difference, with HYV finger millet seeds yielding 15-18 quintals per hectare during testing, compared to 7-8 quintals per hectare for traditional varieties (Dash, 2021).

There has been an interesting shift the **home-consumption** of millets. Since the crop is considered a "poor man's crop" the richer farmers tend to shift towards more socially accepted consumption crops such as paddy and wheat and sell their millet harvest which brings them higher income than the other crops, whereas other less affluent farmers cannot afford to cultivate both rice and wheat and therefore choose the crop that brings them a higher income and also consume the same crop. Paddy and wheat cultivation is too costly when it comes to inputs.

Despite the benefits of higher yields, HYV seeds present challenges in processing. The seeds are often too small to be effectively dehusked using existing machinery, complicating their handling and **processing**. "*When the grain is not properly dehusked by the machine, we have to run it through the manual stone mill for a second time, this is double effort for us" - FGD 2.* This issue emphasizes the need for improved infrastructure and equipment to efficiently process larger quantities of millet seeds. Additionally, HYV crops may require more pesticide application due to their susceptibility to diseases and pests, posing risks to both the environment and human health.

One of the issues with the existing machinery provided by the government is that electrical machines (as seen in Image 9) are not designed to dehusk or process such small seeds as millet. Furthermore, in remote rural locations across India, electrical machines are not the best option as electricity is not

guaranteed to be available throughout the day. In fact, as stated by FGD2 most areas experience access to electricity for only 2-3 hours a day.

Image 9 -Government- donated machinery for dehusking millets (Kundra block)

The higher yields from HYV seeds encourage **sale to market**. This system pushes farmers to sell a larger portion of their harvest in the market, thereby increasing their income and improving their standard of living. Government centers not only provide these seeds at low prices but also offer support in marketing and selling the produce. Thanks to initiatives like the Odisha Millets Mission (OMM), which also accepts HYV crop produce, farmers now have clean access to sell their millet harvest to government entities for an assured price. This support helps farmers secure better prices for their crops, ensuring that the benefits of higher yields translate into improved economic conditions. *"Initially, farmers tend to procure luxury items such as clothes, jewelry, and electronics. Once they reach a certain income level, they begin to diversify their spending towards education for their children and healthcare services" - NGO interviewee 1.*

The **regulatory regimes** for this government-driven seed system involves a coordinated effort between various governmental bodies and research foundations to ensure quality control, certification, and distribution of HYV seeds. Regulatory regimes are in place to monitor the production, multiplication, and sale of seeds, ensuring that farmers receive high-quality seeds that meet established standards.

This government-driven seed system seeks to improve agricultural production by combining cutting-edge farming methods with appropriate regulatory control, all the while addressing the particular difficulties faced by Odisha's farmers. Through continuous improvement and adaptation, the system strives to provide farmers with the resources they need to achieve sustainable and profitable farming practices.

The **market influences** on this seed system play a pivotal role in its progression and sustenance. This seed system is governed mostly by the government's demand for millets in their PDS, MDM, and ICDS schemes and the cultivation by farmers is largely for sale rather than self-consumption. Due to the government incentives provided by the millets mission, aside from the Adivasi populations, recent years have even seen an uprise in the number of non-Adivasi populations cultivating millets (Basu, 2024). In Mayurbhanj, the district with the third highest population in Odisha, the proportion of female farmers engaged in millet farming has increased by 104% since 2019 (Mohanty, 2022).

In the case of seed system C, the **power as well as the agency** lies with private companies and governmental agencies who are aiming to promote HYV seeds and also intern increase the usage of external chemical inputs.

Results consolidated

	Seed System A	Seed System B	Seed System C
Access to plant genetic resources	Safeguarding over generations, close community exchange	A combination of research centers and NGOs along with traditional seeds handed down over generations	Research foundations in collaboration with the government
Varietal Development	In-situ, barter, exchange with neighbors, religious practices	Ex-situ, research foundations in collaboration with local farmers	Ex-situ, government agencies in collaboration with research foundations
Registration and release	No official registration and release	Approved seeds Released by research foundations after a 3-year testing period	Officially released by the government
Early generation Seed Production	(Unofficial) Generational knowledge used for quality assurance	(Official) Quality testing conducted by research foundations prior to release	(Official) Quality enhancement conducted by research foundations while developing HYV varieties
Decentralized Multiplication	Barter, exchange with neighbors, religious practices	Third-party extension service agencies such as ground-level NGOs etc.	Government-approved entities such as seed banks, markets, and government-owned stores.
Product sale and home consumption	Largely home consumption, leftovers sold to local mandi's, middlemen, and if	50%-50% distribution for home consumption and sale to OMM	Largely sales to OMM, small share for self-consumption

	applicable, OMM		
Processing, transformation, and secondary use	Processed manually by farmers, used for making food items for festivals and other occasions	Processed manually by farmers, used for making food items for festivals and other occasions	Processed manually and sometimes with machines. Value-added services combined and sold to markets
Sale to market	Remaining produce to local mandi's middlemen (both non-fixed price entities) and if applicable to OMM	Sold to OMM	Sold to OMM
Regulatory regimes	Self-regulated	Regulated by NGOs and government policies	Regulated by government agencies
Market and food system influences	Low influence from external markets	Influenced by government policies regarding reintroducing millets	Influenced by government policies regarding reintroducing millets
Power and agency debates	Power in the hands of the individual farmer, agency - traditional community systems	Power in the hands of research foundations and government policies, agency-NGOs	Power in the hands of the government bodies - agency- government entities
Development pathways	N/A	N/A	N/A

Table 2- Differences between seed systems A, B, and C

Activities and processes of the OMM

Through the process of field data collection, it was found that the Odisha Millet Mission uses a decentralized approach to enhance millet cultivation. Research foundations collect genetic material from farmers statewide, conduct field trials, and select millet varieties based on criteria such as high productivity, better yield, easier harvesting, processing, and demand. These selected varieties are officially released and scaled up by the research foundations. NGOs and ground-level entities are in charge of ensuring the smooth operations of the mission and are also appointed by the Odisha state government to distribute seeds free of cost to registered farmers, who must provide documents like bank account details, voter ID, land documentation, Aadhar card, and a passport picture. Registered farmers can request seeds through a Community Resource Person (CPR), a government-appointed member from their village. Most farmers, however, practice individual seed saving because of what they have seen their forefathers do. Post-harvest, farmers process the millet using household methods and hand over the grain to a state-appointed weekly pickup truck. At the district center, the grain is checked for quality, quantity, and moisture, then packaged and sealed in jute bags tagged with village information, and sent to government storage units. The Minimum Support Price (MSP) which is rupees 39 per kilogram (at the date of data collection, 09.03.2024) is directly transferred to the farmers' bank accounts within seven days, eliminating middlemen and increasing farmers' income opportunities.

Preserving different Landrace varieties, and genetically diverse populations influenced by a region's climate and soil conditions (Choudhury, 2023) is one of the main goals of the OMM. Landraces are ecotypes cultivated in pristine environments over long periods, selected by farmers for desired traits such as taste and cooking preferences (Azeez et. al., 2018). These varieties adapt specifically to their local environments and traditional practices, showing unique characteristics only in their native settings. Under the direction of government line departments at the district and block levels, FPOs would be in charge of the entire project with the assistance of neighborhood NGOs.

Analysis of the OMM's support for seed systems in Koraput

Data collection and analysis revealed that there is no clear distinction between formal and informal seed systems in the Koraput region of Odisha. Instead, the region features a mix of different processes, particularly evident through the Odisha Millet Mission. Consequently, it is difficult to categorize the seed system into a singular form.

By analyzing the processes of the OMM using the process-based value chain framework, we can observe that certain elements that are well-supported, a few that do not support, and some that merit further investigation. For instance, the first element of the framework which talks about **access to plant genetic resources** seems to be effectively managed by the OMM program. The OMM employs a streamlined process for collecting genetic resources from farmers and storing and preserving them at a central seed bank in Chitrakonda, Odisha. Employees at the seed bank are placed to ensure that existing seed varieties, are preserved and maintained over time.

Product sale and home consumption are agreeable with the OMM's criteria. Farmers have no obligation to the mission and the quantity or percentage of harvest that needs to be sold to the mission. The farmer may sell as little as 1 kilogram of millet if he/she prefers, this benefits the farmers in times when they are not able to afford to buy food products. They always have the option to consume the millet on a household level.

Another well-supported element is the **sale to market**. The OMM provides a smooth, decentralized process with various government-appointed employees and organisations (such as FPO's, CRP's and NGO's) that allows farmers to share their produce directly with the market, bypassing middlemen and local mandis where price negotiations come in the way of the farmer gaining a fair income.

Additionally, the OMM has a comprehensive process for the **decentralized multiplication** of seed varieties. This involves organizing Community Resource Persons (CRPs) for village-level logistics and complaints, as well as Farmer Producer Organizations (FPOs) for district-level perspectives and actions towards self-sustainability and reducing seed dependency. These local organizations support the decentralized multiplication of quality seeds by mobilizing people and resources within communities.

In addition, the Odisha Millet Mission's **regulatory regimes**, initiated by the state government, involve collaboration with numerous partner agencies, including NGOs, research foundations, and community resource persons. The mission is inclusive of farmers who adhere to traditional seed methods, ensuring no discrimination against those who wish to sell their harvest to the OMM. There is a standardized process for farmer registration and seed requests, facilitating equal access and participation.

The OMM cushions the impacts of the **market and food system influences** on the farmer thereby incentivizing them to find the motivation to cultivate millets. This is done by the Minimum Support Price and guaranteed sale of the harvest ensured by the government.

On the other hand, some elements of the framework showcase a grey area and merit further investigation. One such element is the **Varietal development** of the seed. While the OMM advocates

the preservation of diverse seeds at its main seed bank in Chitrakonda, it still abides by testing and segregating certain varieties for the farmers to cultivate. While these varieties may be chosen by the research foundations based on certain criteria, they may not always be suitable for the farmer to cultivate, depending on factors like methods for processing, cook time, religious significance, etc. Another important factor under varietal development is the competitive sale of HYV seeds which promise higher yields thereby enticing richer farmers into procusing them. This can prove contradictory to the purpose of varietal development since HYV seeds only focus on single-variety cultivation. For instance, HYV finger millet seeds are said to yield approximately 9–10 quintals per hectare, while non-HYV types yield just 6-7 quintals as per millet farmers in the Koraput region. Dash Samir's research from 2021, however, shows a more notable difference: in testing, HYV finger millet seeds produced 15–18 quintals per hectare, while traditional cultivars produced 7-8 quintals per hectare (Dash, 2021).

Early generation seed production which also entails quality testing of the seed is done by research foundations and is tested on a piece of land donated by the government, therefore the land might not have ideal conditions suitable to all farmers, and this blanket variety might not be the best form of testing. Even with the occasional multi-locational trials for millet varieties, access to resources is never consistent across farmers. The significance of perfect settings in research trials—which might not fully reflect farming realities in the real world—is highlighted by this disparity. Yield results can be impacted by variables such as seed quality, soil fertility, and water availability

The OMM provides **the Agency** with the individual farmer to make decisions on how much to cultivate, when and where to cultivate as well as what variety to cultivate, but **power** is not completely in the hands of the farmer because they are still dependent on the mission for released varieties of seeds, that are sold free of cost, quality testing as well as smooth running operations and sale of the millet. Free-of-cost seeds increase the dependency of the farmers on the NGOs and the government.

Some elements that require higher support by the OMM are, for instance, the elements of **processing, transformation, and secondary use**. Even with the smooth running operations and a well-structured decentralized system for implementation, the OMM has missed inputs for processing and transformation of the grain. One of the reasons that millet lost its popularity was because it was a very small and coarse grain, which made it difficult to dehusk and process. Although there have been some efforts to train local communities on how to add value to the millet by making sweets and flour to increase the income of the farmer, processing still remains a tedious activity making it hard to motivate farmers to increase the rate of production.

Discussion

The findings from the field data collection and analysis of the Odisha Millet Mission (OMM) highlight several critical aspects of the millet seed systems in Koraput. The mission's decentralized approach to enhancing millet cultivation showcases a well-orchestrated strategy involving various stakeholders, including NGOs, research foundations, and community resource persons (CRPs). This section discusses the implications of these findings in the context of seed system support, agricultural sustainability, and food security.

The OMM's strategy of collecting genetic material from farmers and preserving them at the Chitrakonda seed bank is essential for maintaining biodiversity and preserving landrace varieties. This approach supports genetic diversity, crucial for resilience against pests, diseases, and climate variability, aligning with goals of agricultural sustainability and food security. The OMM's inclusive policy, which does not discriminate based on adherence to traditional or modern seed methods, ensures broad farmer participation, although official legal registration documents may be a deterrent to this. Facilitating direct market access and implementing the Minimum Support Price (MSP) enhances income opportunities and stabilizes farmer incomes, incentivizing millet cultivation.

While the OMM's varietal development aims to enhance productivity, it reveals a complex connection between traditional and modern practices. The conflicting emphasis on high-yielding varieties (HYVs)from government and private entities may overshadow traditional varieties better suited to local conditions. Farmers' dependency on the OMM for free seeds and quality testing limits their autonomy, highlighting the need for a balanced approach that empowers farmers.

Processing and transformation of millet remain significant challenges. While the OMM trains communities in value addition, more substantial support is needed to make processing less labor-intensive. Technological interventions and capacity-building can motivate increased millet production. The missions regulatory framework involves multiple partner agencies, ensuring collaborative millet cultivation. The standardized process for farmer registration and seed requests facilitates equal participation. However, reliance on government and NGO support for seed distribution and quality testing suggests a need for greater farmer self-sufficiency to ensure sustainable agricultural practices and empowerment.

As we observe in the aforementioned analysis, some elements of the PBVC framework are well supported by the OMM while some require additional support and merit further investogation. Holistic insights and understandings of the existing seed systems can help enhance food security. Supporting seed systems in a well-rounded manner directly contributes to food security by increasing

the production of nutritious millet, essential for combating undernutrition and food scarcity in Odisha. Supporting traditional millet varieties is useful in preserving biodiversity and improving farmers' resilience to climate change. Furthermore, ensuring the availability of diverse and high-quality millet seeds can improve the populations dietary diversity and nutritional outcomes.

By giving space for traditional seed system practices to co-exist with formal regulatory systems, the OMM is supporting the preservation of the farmer communities' culture and traditions. Official recognition and legal acknowledgment of these practices are essential to sustain cultivation methods. A well-supported seed system can lead to better crop yields and quality, enhancing market opportunities for farmers. This can result in increased incomes and economic growth for rural communities, contributing to overall regional development.

The applicability of the process-based value chain framework can be gauged by the flexibility provided by Erik Lucien Delaquis, the framework allows for studying the seed system under the broad umbrella taking into account the entire value chain of the seed system which includes the elements or production, consumption as well as umbrella elements that overpower certain activities. The framework offers a holistic approach that encompasses the entire seed system, aligning with the goals of the Odisha Millet Mission (OMM) to enhance millet production for food security and nutritional improvement in the country.

I believe that the PBVC framework can be applied across various agricultural contexts due to its comprehensive and flexible nature. Its holistic approach, recognition of diverse seed systems, and adaptability to local conditions make it a valuable tool for analyzing and enhancing seed systems globally. For instance, the PBVC framework can also be applied to a wide range of studies on seed systems such as the case, *Integrated Seed Sector Development in Africa: A Conceptual Framework for Creating Coherence Between Practices, Programs, and Policies" (Louwaars & Boef, 2012)*. This study discusses the integration of formal and informal seed systems in African contexts. Another such example is the case study "*The situation for quinoa and its production in Southern Bolivia: From economic success to environmental disaster" (Jacobsen, 2011)*. This case study looks at the rapid commercialization of quinoa and its effects on traditional seed systems. Also, *"Maize diversity, rural development policy, and farmers' practices: Lessons from Chiapas, Mexico" (Keleman et al., 2009)*. This study focuses on maize diversity and how policy and practices impact seed systems, relevant to indigenous networks in Central America.

By demonstrating the process-based value chain framework's use in various circumstances, these case studies and authors demonstrate the framework's wider applicability. They show how the framework is a flexible tool for comprehending and enhancing seed systems around the world since it can

incorporate official and informal seed systems, take into account the complete value chain, and adjust to local conditions.

Recommendations

In order to change the mindset of the population to consider millets as popular foods for all sections of society, involving private companies in the process of promotions and marketing could be beneficial for the mission as well, incentivising farmers to cultivate the crop without it having an image of being a "poor mans crop". An interesting article titled "Quinoa, chia seeds and kale: superfoods or supermarketing? describe how private company marketing can have a huge impact on the consumption patterns and indirectly cultivation patterns of farmers across the globe (Shearman, 2014).

The OMM can take initiatives to promote farmer led research. The possibility of giving farmers more power and autonomy on decision making as well as letting them have the final say on what kind of millet variety to preserve, cultivate and promote in the market. An example of this is Farmers in Ethiopia, in collaboration with researchers, are involved in participatory plant breeding to develop barley varieties. The farmers have the final say on which varieties to adopt based on their preferences and field performance (Thijssen et al., 2008). Giving farmers the finl say not only gives value to their generational knowledge but also gives them more responsibility for the larger mission.

Giving legal recognition to traditional religious and superstitious practices is also something to be valued. Similar to the Subak system in Bali, a cooperative water management system for rice cultivation, involving a complex network of irrigation channels, dams, and temples. It is based on the Tri Hita Karana philosophy, which emphasizes harmony between humans, nature, and the gods. (Kumarananda, 2022). The system includes rituals and offerings to deities associated with water and agriculture. This practice of legally accepting superstitions and religious practices as part of the agricultural landscape gives avenue to farmers to feel the sense of ownership and intern motivation.

One extremely important deterrent to millet cultivation among farmers is also the lack of technology designed for processing millet. Provide access to affordable and efficient processing machinery to reduce the labor-intensive nature of millet processing. This can include small-scale dehulling machines and other value-added processing equipment.

As future steps, the OMM can provide resources for continuous monitoring and evaluation thereby regularly assessing the impact of the OMM on farmer incomes, food security, and biodiversity conservation to identify areas for improvement.

To truly benefit the traditional seed systems, it is crucial that the mission continues to recognize and incorporate the strengths of these systems, ensuring that local knowledge, genetic diversity, and farmer autonomy are preserved. Balancing the commercial objectives with the ecological and cultural significance of traditional seed systems will be key to achieving sustainable and resilient agricultural development in Odisha.

Limitations of the study

Some of the limitations of the study include time and geographical coverage. The field visits were restricted to only three blocks in southern Odisha due to time and resource constraints. This limited geographic scope may not capture the entire diversity of millet seed systems across the entire state. In addition to this, Environmental factors such as soil type, rainfall patterns, and local climate conditions vary widely across different regions of Odisha. The study's limited geographic scope might not fully account for how these environmental differences impact millet seed systems. Furthermore, due to logistical challenges, some remote areas with potentially unique seed systems and practices could have not be accessed. This limitation might have excluded significant variations in millet seed systems from the analysis.

The selection of participants was partially influenced by accessibility and willingness to participate, which may have introduced sampling bias. As a result, certain groups or individuals with differing experiences might not be adequately represented in the study. This is a limitation of the snowball method where access to several actors is contingent upon the initial points of contact in the field.

Response from seed companies and governmental institutes was limited, one out of the many seed companies that were contacted responded with a willingness to provide information, while none of the government agencies responded during the research period, restricting the industry and government representation in the study. This limitation may have affected the comprehensiveness of the analysis regarding the commercial aspects of millet seed systems. Another factor here was that the head agencies from the Odisha Millets Mission were not present in the areas of my fieldwork data collection therefore personal meetings were not possible. Only virtual methods of reaching out restricted access to official data and insights, potentially narrowing the scope of the analysis.

During the focused group discussions, crowd mentality was often observed. Typically, one member of the group would highlight certain information, which the rest of the group would then agree upon. Instances where other members refuted the provided information were rare. Another noteworthy

limitation was the need for double translation—from Odiya to Hindi and then to English. This introduced potential inaccuracies and loss of nuanced meanings in the data. This was further complicated by the translation of quotes, which could have affected the tone, authenticity, and clarity of the responses. Cultural and social dynamics (caste, status, occupation in village, etc) may have influenced the willingness of some participants to openly share information. Despite efforts to build trust, there may have been instances where sensitive or critical information was withheld. For instance, farmers from different subcastes reside in the same village, while some farmers from the upper caste have higher privileges and opportunities to voice their opinions, others may not feel as comfortable doing the same.

The Odisha Millet Mission is a recently developed, fast moving program and therefore a large part of my results may have changed over the last 9 months of conducting this study.

Conclusion

The Odisha Millet Mission (OMM) has implemented a decentralized and inclusive strategy for enhancing millet cultivation in Koraput, which involves various stakeholders, including NGOs, research foundations, and community resource persons. This approach has crucial implications for seed system support, agricultural sustainability, and food security.

OMM's efforts to collect and preserve genetic material from farmers at the Chitrakonda seed bank are vital for maintaining biodiversity and landrace varieties. This promotes genetic diversity, essential for resilience against pests, diseases, and climate variability, aligning with goals of sustainability and food security. The inclusive policy of OMM ensures broad farmer participation, although the requirement for official legal registration documents may hinder some farmers. The facilitation of direct market access and the implementation of the Minimum Support Price (MSP) have enhanced income opportunities and stabilized farmer incomes, thus incentivizing millet cultivation.

However, the mission's focus on high-yielding varieties (HYVs) from government and private entities may overshadow traditional varieties better suited to local conditions, creating a complex interplay between traditional and modern practices. The dependency on OMM for free seeds and quality testing limits farmers' autonomy, indicating the need for a balanced approach that empowers farmers while providing necessary support.

Processing and transforming millet pose significant challenges. Although OMM has made strides in training communities for value addition, further support is needed to reduce the labor-intensive nature

of processing. Technological interventions and capacity-building initiatives can motivate increased millet production.

OMM's regulatory framework, involving multiple partner agencies, ensures a collaborative approach to millet cultivation. The standardized process for farmer registration and seed requests promotes equal participation. However, the reliance on government and NGO support for seed distribution and quality testing indicates a need for greater farmer self-sufficiency to ensure sustainable agricultural practices and empowerment.

We observe that some elements of the PBVC framework are well supported by OMM, while others require additional support and further investigation. Supporting seed systems holistically enhances food security by increasing nutritious millet production, essential for combating undernutrition and food scarcity in Odisha. Preserving traditional millet varieties helps maintain biodiversity and improve farmers' resilience to climate change. Ensuring the availability of diverse and high-quality millet seeds can improve dietary diversity and nutritional outcomes for the population.

Overall, the OMM has done well in integrating most aspects of millet cultivation, from recognizing and incorporating the strengths of these seed systems to ensuring the preservation of local knowledge, genetic diversity, and farmer autonomy. By balancing commercial objectives with the ecological and cultural significance of traditional seed systems, the mission is effectively working towards achieving sustainable and resilient agricultural development in Odisha.

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Appendix

Sample of the coding

(They have been pasted in sections vertically due to lack of space on the page)

		Seed						
	Block Name	**Type of seed system**	**Access to plant genetic resources**	**< Quotes (translated)**	**Varietal Development**	**Registration/ Release**	**Early generation seed production**	**Decentralised multiplication**
Farmer 1	Kundra	Traditional	Seeds have been passed down for generations and also diversified through exchange within farmers in the same village	" Our forefathers have been cultivating millets for generations, along with other consumable crops millets have been everpresent in. our diets and therefore the seeds are harvested and preserved every year as part of the tradition"	in -situ - Low level of varietal development through barter system or exchange with neighbours in times of necessity	N/A	Traditional knowledge techniques for quality testing	All multiplication has happened in-situ, traditional seed preservation patterns using clay pots and cow dung or clay pots and banyan tree leaves have been used for the purpose of preservation. Neighbourhood exchange methods amoung people in the village.

Farmer 2	Kundra	Traditional	Seeds have been passed down for generations and also diversified through exchange with farmers	"God has given us this land, water, sun to support life, we have to nuture it in a way that if not just beneficial to human beings but also to the mother earth"	in situ - A priest in the village distributes a stalk of different varieties of finger millet to different households in the village as part of a religious tradition. Thereby continuinng with varietal developme nt of finger killet seeds.	N/A	Traditional knowledge techniques for quality testing	All multiplicati on has happened in-situ, traditional seed preservatio n patterns using clay pots and cow dung or clay pots and banyan tree leaves have been used for the purpose of preservatio n. Neighbourh ood exchange methods amoung people in the village.
Farmer 3	Lakshmip ur	Traditional	Seeds have been passed down for generations and also diversified through exchange with farmers	"We have been growing different varieties of millets for generations"	More variety of millets are grown such as bajra, little millet, pearl millet, sorghum	N/A	Traditional knowledge techniques for quality testing	Preservatio n of seeds from forefathers

Farmer 4	Kundra	Mixed - (Traditional / NGO's)		"After the Odisha Millets mission, we get our millet seeds for free and we can ask for any variety we want and get it within a few days, therefore it is most suitable for us"	The MSSRF is growing 124 varieties from which 4 have been released officially post trial and testing over the period of 4 years. This is based on many factors such as length of the crop, misture in seed etc	Collaborative effort by the government and MSSRF to release 4 official varieties (2023), more yet to come over the span of 3 years.	4 released varieties of seeds tested over the span of 3 years by the research foundations.	The seeds have been procured from neighbours and preserved in jute bags
Farmer 5	Kundra	Mixed - (Traditional / NGO's)	They use their own seeds but also use the traditional released varieties of seeds certified by the OMM	"We trust the NGO's who have told us about the official released varieties, they are the ones who have managed to bring us our money for the millets."	The MSSRF is growing 124 varieties from which 4 have been released officially post trial and testing over the period of 4 years. This is based on many factors such as length of the crop, misture in seed etc	Collaborative effort by the government and MSSRF to release 4 official varieties (2023), more yet to come over the span of 3 years.	4 released varieties of seeds tested over the span of 3 years by the research foundations.	Seeds have been distributed amoung neighbours and also some traditional varieties passed down over generations

Priest	Kundra	Traditional	Sole responsibility of governing the village in the hands of one.	"I have the responsibility to lead my village after death to god, god is present in even the millet seed and therefore we worship it. Anything that gives us health and life is a form of god"	N/A	N/A	Traditional knowledge techniques for quality testing	In charge of decision making, when to grow, how to grow, how to workship the crop and how to nourish it.
Farmer 6	Kundra	Mixed - (Traditional / NGO's)	They use their own seeds but also use the traditional released varieties of seeds certified by the OMM		The MSSRF is growing 124 varieties from which 4 have been released officially post trial and testing over the period of 4 years. This is based on many factors such as length of the crop, misture in seed etc	Collaborative effort by the government and MSSRF to release 4 official varieties (2023), more yet to come over the span of 3 years.	4 released varieties of seeds tested over the span of 3 years by the research foundations.	Seeds have been distributed amoung neighbours and also some traditional varieties passed down over generations

Farmer 7	Jeypore	Government - NGO's/ Government	Government released HYV seed varieties	"We all have to have an income, the HYV seeds give a better income and more bandwidth to experience different luxuries"	Ex-situ - HYV varieties of seeds sold to farmer	-Officially relleased by the governmen t in collaboratio n with research organisatio ns	Private companies and research organizatio ns	Higher yields itself goves incentive to farmers
FGD 1	Kundra	Mixed - (Traditiona l / NGO's)	A combinatio n of ancestral seeds along with released varieties distributed by NGO's (extension agencies for govt)		More variety of millets are grown such as bajra, little millet, pearl millet, sorghum	No registration and release for traditional varieties but officially released by the OMM seeds for NGO given seeds.	4 released varieties of seeds tested over the span of 3 years by the research foundations .	Barter exchange, gifting and neighbour distribution as well as via NGO agencies on ground.
FGD 2	Lakshmip ur	Government - NGO's/ Government	Government released HYV seed varieties in combinatio n with the NGO released varieties	"We prefer rice for self consumpti on, we only grow millets for income"	The 4 types of finger millet released by the NGO's and research foundations as well as high yeilding varieties distributed by the governmen t	Genetic Engineerin g Appraisal Committee along with research foundation through OMM	Private companies and research organizatio ns	Governme nt official sales agencies as well as via NGO agencies on ground.

FGD 3	Lakshmipur	Government - NGO's/ Government	Government released HYV seed varieties in combination with the NGO released varieties	"The government seeds give us more money and we use the money to buy gold, electronic items and other important items for our house"	The 4 types of finger millet released by the NGO's and research foundations as well as high yeilding varieties distributed by the government	Genetic Engineering Appraisal Committee along with research foundation through OMM	Private companies and research organizations	Government official sales agencies as well as via NGO agencies on ground.
FGD 4	Kundra	Traditional - NGO's/ Traditional	Traditional practices of preserving seeds learned from forefathers as well as NGO released varieties through OMM		The MSSRF is growing 124 varieties from which 4 have been released officially post trial and testing over the period of 4 years. This is based on many factors such as length of the crop, misture in seed etc	Release by OMM research foundations and non released seeds passed down over generations	4 released varieties of seeds tested over the span of 3 years by the research foundations.	Through forms of barter exchange and gifting as well as OMM released varieties.
NGO 1		NGO's	We are the extension party that supports research centres in gathering genetic		middle men in collection and distribution of seeds for the purpose of	Not in control of either	No control in this aspect	Main organisation in charge of disseminating released seed

			resources from farmers		varietal development and implementation			varieties to

Product			Regulatory Regimes	Market and food system influences	Power and agency debates
Product sale and home consumption	**Processing transformation and secondary use**	**Sale to final market**			
Largely cultivated for self consumption, not enough crop to sell to markets. Sometimes when there is a boom in the crop then they sell to the local mandi	Processed using stone blocks, manually by the the women in the house. Process includes, harvesting, sun drying, beating with bamboo sticks to de-husk and then finally ginding with stone at home. Used to make a variety of foods.	All surplus produce Delivered to the van which collects millets for the Odisha millets mission and then packaged and sent to the government storage or sold to local mandi's depending on documentation (accessibility of bank accounts)	Self regulated reigmes, governed by traditional knowledge systems	Very low influence from external markets. Dominated by exchange/ barter within the village and small amounts of surplus externally to local mandi's.	Power in the hands of the individual household, mostly women of the house.

A 50-50% division between self consumption and sale to the odisha millets mission. Since the OMM acepts smaller quantities of millets we sell even during poor harvest seasons.	Manual processing in the village and finally used to for self consumption and remaining to sale	All surplus produce Delivered to the van which collects millets for the Odisha millets mission and then packaged and sent to the government storage	Self regulated reigmes, governed by traditional knowledge systems in combination with religious influences.	Not governed by market influences, some times sale of OMM can be of some support.	Power in the hands of self and in some cases in the hands of village priest.
Largely cultivated for self consumption, not enough crop to sell to markets. Sale only for finger millet crop which is accepted by the Odisha Millets mission. finger millet (ragi), little millet, foxtail millet, kodo, and bajra.	Processed on a household level, used for self consumption only	N/A	Self regulated	N/A	Power within the individual household. - changed from men to women over time
A 50-50% division between self consumption and sale to the odisha millets mission. Since the OMM acepts smaller quantities of millets we sell even during poor harvest seasons.	processed using government donated machines, mostly ineffective and therefore manually processed. Sold to OMM through NGO's support	OMM is the last point of contact for them, in some odd cases sale to local mandi	Government	Government policy to distribute millets through PDS drives the millet cultivation	Power in the hands of individual, gathering gency from NGO's

A 50-50% division between self consumption and sale to the odisha millets mission. Since the OMM acepts smaller quantities of millets we sell even during poor harvest seasons.	Manually processed and then used for cooking different food items. everything sold to OMM is only bought from the farmer post a testing processes to check fior adulteration and moisture.	OMM pickup truck is the last oint of contact	NGO's implementing government policies	Government policy to distribute millets through PDS drives the millet cultivation	Power in the hands of individual in combination with ngo's
Villagers and neighbours donate a part of their crop to me in the name of god	N/A	N/A	The priest creates the regulatory regimes		In the priest hands
A 50-50% division between self consumption and sale to the odisha millets mission. Since the OMM acepts smaller quantities of millets we sell even during poor harvest seasons.	Manually processed and then used for cooking different food items. everything sold to OMM is only bought from the farmer post a testing processes to check fior adulteration and moisture.	OMM pickup truck is the last oint of contact	NGO's implementing government policies	Government policy to distribute millets through PDS drives the millet cultivation	Power in the hands of individual in combination with ngo's
Mostly cultivated for sale and not for self consumption, sold to the OMM for 39 rupees per kg	Processing on an individual level and then adding value to millets by creating different foods and sending it for packaging.	Final sale through OMM	NGO's implementing government policies	Dependecy on HYV seeds from the government and government demand for millets for PDS	Power in the hands of the government bodies and HYV seed agencies

A 50-50% division between self consumption and sale to the OMM.	A combination of individual household processing by women mixed with communal processing in the village using complicated machines. Rice deshuskers.	OMM is the last point of contact for sale.	Incentives by the government through OMM, NGO level implementation and self regulated seed systems by traditional methods.	Government policy to distribute millets through PDS drives the millet cultivation as well as increased awareness regarding health benefits of millet consumption for self.	Power in the hands of individual in combination with ngo's
Sale to OMM, hardly any quatity for self consumption	Sometimes use of rice deshusking machines or government goven millet deshuskers, a large portion of manual grain processing	OMM is the last point of contact for sale.	Incentives by the government through OMM, NGO level implementation .	Government policy to distribute millets through PDS drives the millet cultivation.	Power in the hands of the government in combination with ngo's
Sale to OMM, A lesser quatity for self consumption	Sometimes use of rice deshusking machines or government goven millet deshuskers, a large portion of manual grain processing	OMM is the last point of contact for sale.	Incentives by the government through OMM, NGO level implementation .	Government policy to distribute millets through PDS drives the millet cultivation.	Power in the hands of the government in combination with ngo's
50-50% for self consumtpion and sale to OMM	Manually processed with stone grinding method and bamboo beating, other traditional methods	OMM is the last point of contact for sale and at times sold to local mandis	Incentives by the government through OMM, NGO level implementation .	Government policy to distribute millets through PDS drives the millet cultivation as well as awareness of health benefits of millets	Power in the hands of the individual in combination with ngo's

N/A	Acting extension service that supports workshops for value addition and secondary use	Supporting agency helping with operations realted to sale	Implementing agency for government policies and adherement	N/A	Providing agency to farmers

Questionnaire for Farmers

Please note - all questions were translated from English to Hindi and then to Odiya for the purpose of data collection.

1. Can you describe how you obtain seeds for planting?
    - Do you exchange seeds with neighbors or rely on seeds handed down through generations?
    - Do research centers, NGOs, or the government support you in preserving your seed acquisition?
2. How do you decide which varieties of seeds to plant each season?
    - Do you have access to high-yield varieties (HYV) or traditional seeds?
    - What factors influence your choice of seed variety?
3. What processes do you go through to get your seeds officially recognized or approved?
    - Are there any specific testing periods or quality checks involved?
4. How do you ensure the quality of the seeds you use?
    - Are there any official quality tests conducted on your seeds before planting?
5. How do you multiply or reproduce seeds for future planting?
    - Do you rely on barter, exchange, or specific religious practices for seed multiplication?
    - Are there any organizations or agencies that help you with seed multiplication?
6. How do you use the produce from your harvest?
    - What proportion of your millet harvest is used for home consumption versus sale?
    - Where do you sell your millet produce?

7. How do you process your millet after harvest?
    - Do you have access to any machinery for processing, or is it done manually?
8. Can you describe the process of selling your millet to the market?
    - How does the OMM help you in selling your produce?
9. What regulations or policies affect your farming practices and seed usage?
    - How do NGOs and government policies influence your farming activities?
10. How do external market forces influence your farming decisions?
    - Have government policies regarding millet cultivation affected your farming practices?
11. How much control do you feel you have over your farming decisions?
    - How dependent are you on NGOs, research foundations, or the government for seeds and other resources? (change phrasing while asking this question)
    - What support do you need to feel more empowered in your farming practices?
12. Is there anything you would like to ask me?

Questionnaire for NGO's and Organic Seed Company

1. How does your organization facilitate access to plant genetic resources for farmers?
    - What are the main sources of these genetic resourcess?
2. What strategies do you employ to safeguard plant genetic resources over generations?
    - Who all is in this process?
3. How does your organization contribute to the development of new seed varieties?
    - What criteria do you use to select and develop these varieties?
4. How do you collaborate with local farmers in the varietal development process?
5. What procedures are followed for the registration and release of new seed varieties?
    - How long does the testing period usually take before a new variety is released?
6. What challenges do you face in getting new seed varieties officially recognized?
7. How do you ensure the quality of early generation seeds?
8. What role do local farmers play in early generation seed production?
    - Do farmers support in maintaining seed quality?
9. What strategies do you use for the decentralized multiplication of seeds?

    - How do you collaborate with other third-party entities in this process?
10. What challenges do you encounter in decentralized seed multiplication, and how do you address them?
11. How do you support farmers in balancing product sales and home consumption?
12. What market channels do you help farmers access for selling their produce?
    - How do you ensure farmers receive fair prices for their produce?
13. What support do you provide to farmers for processing and transforming their produce?
    - Do you offer training or access to processing machinery?
14. How do you encourage value-added services and secondary uses of the produce?
15. How do you facilitate the sale of farmers' produce to the market?
16. What challenges do you face in market access, and how do you overcome them?
17. How do you navigate the regulatory regimes affecting seed systems and farming practices?
    - What policies have the most significant impact on your operations?
19. How do market and food system influences impact your organization's work with farmers?
20. How do government policies regarding millet cultivation influence your activities?
21. What measures do you take to empower farmers in their farming practices?
    - Follow-up: Can you provide examples of initiatives that have successfully increased farmer empowerment?
23. What improvements or changes would you suggest for the OMM or other supporting entities?