

Steering the herd or missing the mark? Navigating the role of research for development projects as innovation intermediaries in the Indonesian cattle sector

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HIGHLIGHTS

- R4D projects can become innovation intermediaries with improved stakeholder engagement.
- Farmers need to be continuously involved in all phases of R4D projects.
- Increase private sector involvement is crucial for R4D projects.
- Capacity buildings activities should incorporate farmers consultation.

GRAPHICAL ABSTRACT



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ABSTRACT

CONTEXT: The growing demand for beef in Indonesia, driven by population growth, urbanisation, and an emerging middle class, provides a significant opportunity for Indonesian smallholder cattle farmers. Effective innovation in the cattle sector is required to meet this demand and improve the livelihoods of local farmers.

OBJECTIVE: This study aimed to understand whether and how Research for Development (R4D) projects can act as innovation intermediaries that enhance the performance of Agricultural Innovation Systems (AIS) in the Indonesian beef sector. As a case study, we used an R4D project conducted in Nusa Tenggara Barat (NTB), Indonesia to explore the best practices and opportunities for improvement.

METHODS: We qualitatively analysed data from the R4D project using six innovation intermediary functions.

RESULTS: This case study partially succeeded in performing intermediary innovation functions. Strengths were noted in capacity building, provision of problem-solving information, and facilitation of collaborative knowledge generation. However, shortcomings were apparent in stakeholder engagement and in effectively addressing farmers' needs. R4D projects play a complex role as innovation intermediaries. A greater focus on participatory approaches, stakeholder engagement, and tailoring strategies to specific local conditions is required to achieve a significant impact.

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SIGNIFICANCE: This research highlights the operational intricacies and success determinants of innovation intermediaries in Indonesia's cattle farming sector. By adopting a recognised functional approach, we elucidate the challenges and potential of R4D projects, emphasising the necessity of sustained engagement and diverse stakeholder involvement.

1. Introduction

The growing demand for beef in Indonesia provides great opportunities for smallholder cattle farmers. This increased demand is driven by population growth, urbanisation, and the emergence of the middle class. Although beef consumption in Indonesia remains lower than the Southeast Asian average, it is rapidly increasing (Agus and Mastuti Widi, 2018; Waldron et al., 2013). This is a valuable opportunity for local cattle farmers to improve their livelihood by strengthening their positions in the domestic beef market. This potential is particularly significant, given the plans to reduce poverty following the economic impact of COVID-19 in rural Indonesia (Olivia et al., 2020; World Bank, 2020, 2022).

Smallholder farmers, which constitute approximately 90% of Indonesia's cattle sector (Moss et al., 2016) faces myriad challenges and opportunities that shape its trajectory. At the core of Indonesia's agricultural sector is the mixed crop-livestock system, widely adopted across diverse regions, which serves as a cornerstone for sustainable livestock farming. This integrated approach not only bolsters diversified income avenues for farmers but also promotes sustainable resource usage and effective waste management. Although the nation boasted an impressive cattle population of around 17 million in 2020, distributed across various islands including a significant portion in the Lesser Sunda Islands (Pertanian, 2021), the sector is often characterized by its inefficiencies. Factors such as low reproductive rates, inefficient farming practices, and a chronic shortage of feed supply compound the challenges (Dahlanuddin et al., 2019).

Innovations in the cattle sector are required to meet the increasing demand for animal products (Godfray et al., 2010). Shifting from linear approaches to more comprehensive and intricate strategies encompassing a broader set of actors, dynamics, and processes is essential (Spielman et al., 2009). The linear approaches emphasise technological advancements often neglects the crucial roles of social, institutional, and collaborative dynamics, which are key to driving sustainable agricultural progress (Klerkx et al., 2012b). Such strategies include the use of Agricultural Innovation System (AIS) approach which allows for a holistic understanding of the sector (Klerkx et al., 2012b). Potential areas for improvement can be identified through analysing the AIS, including technological advancements, management practices, and policy interventions. Collectively, these factors contribute to the overall growth and sustainability of the cattle sector (Spielman et al., 2009). In this context, innovation intermediaries improve the functioning of an AIS by bridging the gaps and facilitating the connections between stakeholders (Klerkx and Leeuwis, 2008a, 2009).

Several Research for Development (R4D) projects have been established to drive innovation in Indonesia's beef sector. However, their capabilities as effective innovation intermediaries boosting the sector's performance and innovation adoption have not been extensively investigated. Van Lente et al. (2003) introduced the term 'systemic intermediaries' to describe actors that operate at a systemic (or sectoral) level, which differs from the traditional view that intermediaries are bilateral agents. Recent studies have explored their role in promoting the transfer of knowledge and innovation intermediation, which is particularly crucial in developing countries. For example, previous studies have shown that intermediaries facilitate solutions and address uncertainties, acting as technology translators and innovation facilitators (Li et al., 2022; Naouri et al., 2020), building knowledge infrastructure and networks (Banda, 2022; Hernández-Socha and Zuluaga-Jiménez, 2022), and enabling sociotechnical transitions (Kivimaa et al.,

2019). This growing research area highlights the role of innovation intermediaries in mitigating constraints across AIS and nurturing these systems in different sectors and developing countries.

Prior studies, such as those by Fukugawa et al. (2018) and Neilson and McKenzie (2016), investigated the role of intermediaries in the AIS in Indonesia. However, a comprehensive analysis has not been conducted yet. Despite the consistent presence of R4D projects targeting innovation in the beef sector in Indonesia, there is limited research on the ability of these projects to effectively act as innovation intermediaries that enhance the sector's performance and productivity. To address this research gap, this study addresses the following questions: Whether and how R4D projects serve as innovation intermediaries to improve the performance of the Agricultural Innovation Systems (AIS) in the Indonesian beef sector? For this study, we utilised qualitative data from the "Improving adoption and scaling of proven beef production technologies in Nusa Tenggara Barat¹" project, which was implemented in six out of eight districts in Nusa Tenggara Barat (NTB) province, Indonesia- a critical hub for Indonesian cattle production. The province plays a crucial role in Indonesian cattle production. By exploring the questions above in the context of project data, this study aims to provide valuable insights into the role of R4D projects as innovation intermediaries in Indonesia's cattle farming sector and to identify best practices for optimising the functionality of the AIS in the beef sector.

Central to our investigation is the examination of R4D projects' efficacy as innovation intermediaries within Indonesia's cattle farming landscape. We aspire to shed light on their role, elucidate the nuances of the AIS, and furnish actionable recommendations that champion sustainable and equitable growth in the sector. The next section reviews the literature, followed by the third section which describes the materials and methods employed in the analysis. The fourth section provides details on the results of the study and associated discussions. The subsequent sections delineate the theoretical and practical implications of this research and conclude by presenting the study's limitations, conclusions, and potential directions for future research.

2. Theoretical framework

2.1. Agricultural innovation systems and the role of intermediaries in rural development

The literature emphasises the need for a holistic lens to analyse the process of agricultural innovation in order to capture the complex interplay among numerous actors and subsystems that encompass agricultural innovations. Klerkx et al. (2012b) argued that innovation goes beyond technological aspects; it represents a comprehensive vision of the future, requiring changes in multiple areas, including the social dimension. One widely used approach is the AIS framework, which the World Bank (2006, p. vi) defines as a 'network of organisations, enterprises, and individuals focused on bringing new products, processes, and new forms of organisation into economic use, alongside the institutions and policies that affect their behaviour and performance.' This framework can be employed to analyse the roles and interactions of actors and institutions in the creation, access, and exchange of knowledge and technologies in agriculture (Turner et al., 2016).

¹ Initially, the project was intended to encompass the Kalimantan area as well, but due to the COVID-19 pandemic, activities in that region were not implemented.

In other words, AIS is concerned with the networks of stakeholders that co-produce innovations. These innovations can be social, institutional, and technological in nature and collaboratively promoting more sustainable food systems (Gaitán-Cremaschi et al., 2019; Herrero et al., 2020). Among the different approaches within the AIS framework, a significant one is the 'functional approach'. This approach assesses a particular sector according to its performance in relation to functions such as entrepreneurship, knowledge development and diffusion, guidance of the search, market formation, resource mobilisation, and support from advocacy coalitions (Hekkert et al., 2007; Klerkx et al., 2012a; Kilelu et al., 2011). These functions together are hypothesised to drive innovation by creating value, promoting knowledge exchange, providing strategic directions, stimulating markets, ensuring resource availability, and overcoming the resistance of established actors.

To enhance the functioning of the AIS, connections between heterogeneous actors should be established to enable more effective interactions in terms of joint learning, changing practices, and shaping new institutional arrangements (Hounkonnou et al., 2012). This requires the participation of actors who span boundaries between different groups, playing the role of systemic 'innovation intermediaries' (Batterink et al., 2010; Horton et al., 2022; Kutter et al., 2023; Morriss et al., 2006).

Over the past few decades, researchers have extensively investigated the roles of intermediaries within the innovation process. Howells (2006) initially introduced the term 'innovation intermediaries' to describe organisations or individuals who facilitate innovation process by connecting various parties, such as companies, research institutions, users, and government agencies. These intermediaries bridge gaps among actors across an AIS by providing information on potential collaborations, facilitating transactions, serving as mediators, and offering advice, funding, and innovation outcomes (Klerkx and Leeuwis, 2008b, 2009; Klerkx et al., 2009).

Although research in this area has expanded since 2009, inconsistencies persist in defining intermediaries and understanding their roles in sociotechnical systems. Kivimaa et al. (2019) characterized innovation intermediaries in terms of emergence, neutrality, goals, context, and action levels and argued that 'systemic' intermediaries are the most important category. Systemic innovation intermediaries operate at the system level and play a vital role in advancing development and innovation by uniting actors from diverse sectors and aligning their interests (Klerkx and Leeuwis, 2009; Van Lente et al., 2003). Furthermore, Klerkx et al. (2015) demonstrated the importance of innovation intermediaries in developing countries with immature innovation systems, using Chile as a case study, illustrating their roles in the development of more mature, networked, or open innovation system. Their study showed that, despite the challenges associated with users' perceptions, these intermediaries effectively guided actors and secured a legitimate position within the Chilean innovation system.

Recent studies examined the role of innovation intermediaries in promoting rural development in developing countries (Banda, 2022; Hernández-Socha and Zuluaga-Jiménez, 2022; Li et al., 2022; Munthali et al., 2018; Naouri et al., 2020; Neilson and McKenzie, 2016). These intermediaries are key in enhancing socio-economic and infrastructural growth by facilitating knowledge transfer, introducing advanced technologies, fostering collaborative frameworks, amplifying learning and institutional support systems, and integrating modern digital tools. For instance, in Zimbabwe's maize industry, intermediaries have significantly contributed to the development of strategic technological capabilities (Banda, 2022). Similarly, in the Sulawesi cocoa sector, commercial farmers have emerged as knowledge brokers due to the existing gap between knowledge and practice (Neilson and McKenzie, 2016). In Algeria, consultants and government staff have been instrumental in translating technology for irrigation purposes (Naouri et al., 2020). In Colombia, innovation intermediaries bridge knowledge sources and users, thereby strengthening emerging innovation systems and underscoring the importance of diversified funding sources and targeted

public policies in enhancing their effectiveness (Hernández-Socha and Zuluaga-Jiménez, 2022). In rural China, Science and Technology Backyards (STBs) have transitioned from being mere knowledge brokers to systemic facilitators, significantly augmenting technology uptake and fostering learning ecosystems within communities (Li et al., 2022). Lastly, the potential of Information and Communication Technology (ICT) platforms as innovation intermediaries within Ghana's agricultural extension has been explored, suggesting that informal virtual platforms may be more effective due to underlying social and organizational factors (Munthali et al., 2018).

Therefore, innovation intermediaries play a pivotal role in promoting rural development in developing countries. By bridging gaps between various actors within the AIS, innovation intermediaries facilitate knowledge exchange and technology adoption and foster collaboration between stakeholders. These intermediaries provide support for the creation of new organizational and institutional arrangements, contributing to more sustainable and inclusive agricultural practices. They prove to be essential for overcoming the challenges associated with underdeveloped innovation systems, strengthening networks, and fostering mature open innovation processes. Several case studies have demonstrated that innovation intermediaries are instrumental in integrating knowledge supply and demand and establishing innovation systems, ultimately driving rural development and improving the livelihoods of smallholder farmers in developing countries.

Recognizing the critical roles of innovation intermediaries in enhancing the AIS, the subsequent section, 2.2 examines the specific functions of innovation intermediaries, illustrating how their roles in knowledge and innovation intermediation directly contribute to and drive agricultural innovation, particularly in the context of cattle farming.

2.2. Functional approach to assess the innovation intermediaries as driving forces in agricultural innovation

Innovation intermediaries facilitate innovation by establishing connections between different stakeholders and aligning their interests, which is particularly important in agricultural extensions, especially in developing countries (Kivimaa et al., 2019). Considering the importance of these players, Yang et al. (2014) and Iyabano et al. (2022) utilised a functional approach to assess the role of organisations as innovation intermediaries. These studies examined the potential functions of the intermediaries and influencing factors, classified the functions of the intermediaries into two main categories. The first category, knowledge intermediation, can be further divided into three sub-functions: (1) expressing and conveying users' needs and demands, (2) providing problem-solving information and catering to users' requirements (typical extension services), and (3) involving and assisting stakeholders in collaborative knowledge generation. The second category, innovation intermediation, encompasses three sub-functions: (4) forming visions regarding the extent and character of innovations (5) establishing and overseeing networks with stakeholders from diverse domains, and (6) aiding and participating in learning process² (Yang et al., 2014).

Our study utilised the approach proposed by Yang et al. (2014) to assess the innovative intermediary role of the project team in our case study. This team included field officers and researchers. Field officers predominantly hold bachelor's degrees in areas related to agricultural sciences, whereas researchers are professionals affiliated with universities and research institutes in Indonesia. This approach allows for a

² The function has been strategically adapted to effectively address the pressing challenges of sustainability in the beef sector. This adaptation aims to comprehensively encompass the role of innovation intermediaries, not only in enhancing operational resilience and competitiveness, but also in actively contributing to broader academic and societal initiatives towards the development of a sustainable and inclusive food system.

comprehensive evaluation of project's role as an innovation intermediary, particularly by scrutinising the project's performance vis-à-vis knowledge and innovation intermediation functions. In this manner, we can gain insights into its contributions to the Indonesian cattle farming sector. We modified the framework of the functional approach developed by Yang et al. (2014) to suit the specificities of the beef sector (Table 1). The modifications were made based on the unique challenges faced when adopting innovation in cattle farming. In addition, we modified the framework to prevent overlaps in functions, thereby ensuring that each function was uniquely identifiable and served a distinct purpose. This resulted in a more efficient framework for diagnosing whether and how the project team played the intermediary innovation role in cattle farming in NTB.

2.3. Case study project: Improving adoption and scaling of proven beef production technologies in Nusa Tenggara Barat project

The R4D project used as a case study was titled “Improving Adoption and Scaling of Proven Beef Production Technologies in Nusa Tenggara Barat and Kalimantan Selatan.” This project aimed to increase the supply of beef from small-scale mixed crop-livestock farms in order to satisfy the growing domestic market demand, by enhancing the

Table 1
Knowledge and Innovation Intermediation Functions: Descriptions and Applications in the Cattle Farming.

Functions		Description of the Functions and Application to Cattle Farming
Knowledge Intermediation	(1) Expressing and conveying users' needs and demands	Gathering and articulating users' needs and demands to relevant authorities (e.g., Agricultural Bureau) for potential support and collaboration.
	(2) Providing problem-solving information and catering to users' requirements	Delivering trainings, consultations, and diagnoses based on users' needs and demands.
	(3) Involving and assisting stakeholders in collaborative knowledge generation	Facilitating the integration and adaptation of new technologies and technical regulations to local conditions and fostering their adoption and use in agricultural production through collaborative knowledge generation.
Innovation Intermediation	(4) Forming visions regarding the extent and character of innovations	Identifying and advocating for new technologies and practices that could solve existing problems and create opportunities for users in the long term.
	(5) Establishing and overseeing networks with stakeholders from diverse domains	Establishing and maintaining relationships with a diverse array of relevant stakeholders (e.g., universities, companies, extension agencies, consumers) to facilitate information exchange, learning, and collaboration across the value chain.
	(6) Aiding and participating in stepping up	Promoting awareness and understanding of sustainable and innovative practices and technologies across stakeholders, as well as supporting the scaling and integration of these innovations into mainstream agricultural practices.

Source: Authors, Based on Yang (2014), Complemented by Leeuwis (2004), and Klerkx et al. (2010).

competitiveness of smallholder beef cattle market chains, boosting cattle weaning and growth rates, and identifying scaling-out strategies to improve innovation adoption. The case study project builds upon a substantial base of ACIAR-funded research projects spanning over fifteen years, specifically focusing on the development and application of the Integrated Village Management System (IVMS). The IVMS consisted of several key interventions. These include the introduction of early weaning, bull selection, controlled natural mating, improved feeding of weaned calves, and fattening of bulls using forage tree legumes. In addition, the project incorporated the fattening of bulls using forage tree legumes as part of its strategy. The project was implemented from 2020 to 2022. Unfortunately, because COVID-19, the project was not fully implemented in Kalimantan, focusing on only in NTB districts including North, Central, and East Lombok, Sumbawa, West Sumbawa, and Dompu.

The project was designed to build on interdisciplinary teams that include public and private sector engagement, ensuring a comprehensive approach to the challenges faced across the beef value chain. Additionally, the core element of the project is its emphasis on capacity building at all levels, leveraging learnings from the previous ACIAR project in the region to inform its current strategies. As mentioned previously, the project team comprises field officers and researchers. Field officers mainly implemented the project activities, working in conjunction with government extension offices. This cooperative approach was used in the execution of project activities to promote the sustainability of the project.

In relation to the adoption scaling aspect of the SRA, progress has been made in site selection and analysis, development of study instruments, and training of field officers in data collection techniques. Despite challenges such as the Covid-19 pandemic, the scaling activities have shown resilience and adaptability. In the area of socioeconomics and gender, the project has conducted extensive surveys to understand the socio-economic context of farming systems, focusing on decision-making processes within households. It has also placed significant emphasis on the role of gender in livestock production and marketing.

The project team delivered a capacity-building program tailored to two distinct groups: extension service staff and farmers. For the extension service staff, the program imparted a deeper understanding of the IVMS, covering areas such as reproductive livestock management, forage tree and legume planting, cattle fattening, and animal health. They also implemented strategies to effectively relay this knowledge to farmers and engage them in group development activities, enhancing group cohesion and facilitating opinion sharing. On the other hand, the farmers' training was tailored towards practical applications, incorporating similar IVMS topics but with a focus on immediate implementation on their farms. The project team also trained the farmers in skills including public speaking, opinion voicing, record-keeping, transparency, marketing, banking access, and networking, but this was unfortunately not fully implemented. All these activities, together with the private sector engagement-related activities, have been significantly affected by the COVID-19 pandemic, hampering the delivery and effectiveness of training. The training for both groups was delivered through hands-on demonstration and group activities, promoting experiential learning wherever possible. Additionally, the project has significantly advanced the beef cattle value chain through detailed sector analyses, spatial mapping of feed resources, establishment of forage banks, and studies on integrated cattle-crop production to boost farm income.

2.4. Stakeholder landscape and interrelations in the Indonesian beef sector

The Indonesian beef sector is characterized by a complex network of diverse stakeholders, each playing a significant role in shaping its innovative landscape. This network encompasses a spectrum of participants from smallholder producers and intermediaries to regulatory

bodies and research institutions. Their combined actions and interrelationships are fundamental to the evolution of the sector, especially in regard the innovation (Retno et al., 2015; Setianto et al., 2014; Waldron et al., 2013; Winter and Doyle, 2008).

Dominating the sector, smallholder farmers account for 90% of Indonesia's beef production (Moss et al., 2016). Despite their contribution, these farmers frequently face obstacles such as financial exclusion and a dearth of entrepreneurial skills. These limitations are significant barriers to fully exploiting the innovative potential within the sector (Valerio et al., 2022; Permani, 2013). Intermediaries, especially brokers and collectors, are key in not only setting cattle prices but also in propagating innovative practices, tools, and strategies. These players hold the potential to improve the economic prospects and innovation access of smallholder farmers (Patrick et al., 2010; Setianto et al., 2014; Waldron et al., 2016). However, the translation of these innovative practices into tangible market and price incentives for farmers is not always evident (Patrick et al., 2010; Setianto et al., 2014; Waldron et al., 2016). For instance, advanced feeding practices may not result in higher market prices, potentially deterring the adoption of further innovations.

The Directorate General of Livestock and Animal Health Services (DGLAHS) functions not merely as a regulatory entity but also as a catalyst for innovation, endorsing initiatives that integrate modern techniques into livestock production (Basyar, 2021). Research bodies, including the Indonesian Agency for Agricultural Research and Development (IAARD), the Centre for Animal Research and Development (ICARD), and the Indonesian Centre for Agriculture Socio Economic and Policy Studies (ICASEPS), represent the intellectual backbone of the industry. They offer technical guidance, spearhead research and development, and ensure innovation remains central to the industry's growth trajectory (Basyar, 2021).

Despite the sector's dynamic engagement in innovative activities, several challenges persist. Financial exclusion of smallholders and a lack of entrepreneurial skills are major hindrances to realizing the full potential of innovation (Valerio et al., 2022). Additionally, although there is an increase in government investment in innovation within the beef sector, there is a need for thorough evaluation of these investments in terms of their direction and impact. It is imperative that these investments address the sector's core challenges, including research gaps focusing on demand and localized underinvestment in innovation (Valerio et al., 2022). Extension workers, vital for disseminating innovations, are often preoccupied with crop-related tasks, leaving beef farmers with inadequate support for technical and organizational development. This lack of support aggravates the challenges farmers face in adopting and benefitting from innovative practices.

The Indonesian beef sector's innovative landscape is sculpted by a variety of stakeholders, ranging from smallholder producers to research entities. While the sector is actively engaged in innovative endeavours, challenges such as financial exclusion and insufficient entrepreneurial skills among smallholders remain. For optimal exploitation of innovation's potential, a comprehensive grasp of the sector's landscape, inclusive of the roles and impact of all stakeholders, is essential. Moreover, it is critical to ensure that government investments are strategically aligned to tackle these prevailing challenges.

3. Methods and materials

3.1. Data collection and analysis

We opted for a case study approach because it facilitated a deeper understanding of the role that innovation intermediaries play in the context of our study. Furthermore, case studies are particularly effective for investigating 'how' questions, as examine into the processes and dynamics behind observable phenomena (Yang et al., 2014; Yin, 2017). The researcher used thematic analysis to examine the data, a common qualitative method in the social sciences that focuses on finding, studying, and documenting patterns in the data (Fereday and Muir-

Cochrane, 2006). This approach allowed a thorough and detailed understanding of the research topic, enabling researchers to gain important insights from the data gathered.

The fieldwork was conducted in 2021, covering six project-targeted districts: Central Lombok, Dompu, East Lombok, North Lombok, Sumbawa, and West Sumbawa (Fig. 1). We applied two methods for data collection. First, we collected primary data from farmers ($n = 28$) and government staff within extension services agencies ($n = 37$) within the districts engaged with the project using key informant interviews (KIIs). Second, we used the data project team members, including the project's field officers ($n = 6$) and researchers ($n = 12$), who participated in two workshops, the first held in 2021 and the final conducted in 2022. These workshops aimed to identify the impact of the project activities.

Ethical approval was obtained from the Human Research Ethics Committee prior to data collection from the farmers and extension service staff. Semi-structured guides were used for the KIIs. The farmer interviewed in this study were actively engaged in the case study project. The government staff interviewed were from the Department of Livestock and related services and represented district and subdistrict levels across the six districts involved in the project. Data was collected in Bahasa, transcribed, and translated into English by a certified translator. The workshops were conducted in several stages, including the presentation of project outcomes, participant discussions and feedback, extraction and synthesis of shared insights, and systematic analysis to evaluate the impact of the implemented activities. NVIVO version 12 software was used for coding. The data analysis began by becoming familiar with the data, which was the first step in thematic analysis. The researcher then proceeded through the following stages to enhance the overall structure: (1) developing initial codes, (2) investigating potential themes, (3) reviewing themes, (4) defining and naming themes, and (5) producing a final report (Bryman, 2016; Nowell et al., 2017). Following these steps, the researcher systematically organised the codes into separate categories and established a comprehensive understanding of the main themes found in the data.

3.2. Description of the case study area and targeted intervention

The NTB province, which forms the western part of the Lesser Sunda Islands (Fig. 1), spans an area of approximately 20,000 km² and is home to around 5 million people. Lombok is the most densely populated island in NTB. The province is divided into eight rural districts, namely North Lombok, Central Lombok, East Lombok, West Lombok, Bima, Dompu, Sumbawa, and West Sumbawa, and two city districts, Mataram and Bima. With a cattle population of 1.3 million in 2020, NTB was ranked as the fourth largest cattle-holding region in Indonesia, followed by East Java (4.8 million), Central Java (1.8 million), and South Sulawesi (1.4 million), as reported by the BPS (2020). NTB holds an important position in the national beef industry because of its breeding activities and supply of cattle for fattening in other regions of Indonesia (Waldron et al., 2013). The project districts of Central Lombok, East Lombok, North Lombok, Dompu, Sumbawa, and West Sumbawa collectively represent 72% of the NTB cattle population, with approximately 936,000 animals (BPS, 2022). In NTB, smallholder farmers, who own less than ten heads per farm, account for 93% of cattle production, while 79% of cattle farms focus on cow-calf operations (Sudrajat et al., 2019).

4. Results and discussion

Table 2 summarises the results of our study. Following the theoretical guide outlined in Section 2.2, this section presents our findings. This section provides an overview of whether R4D projects can serve as innovation intermediaries to enhance AIS performance in the Indonesian beef sector. The organisation of this section is based on an examination of the results, using the six-function framework as a reference point.

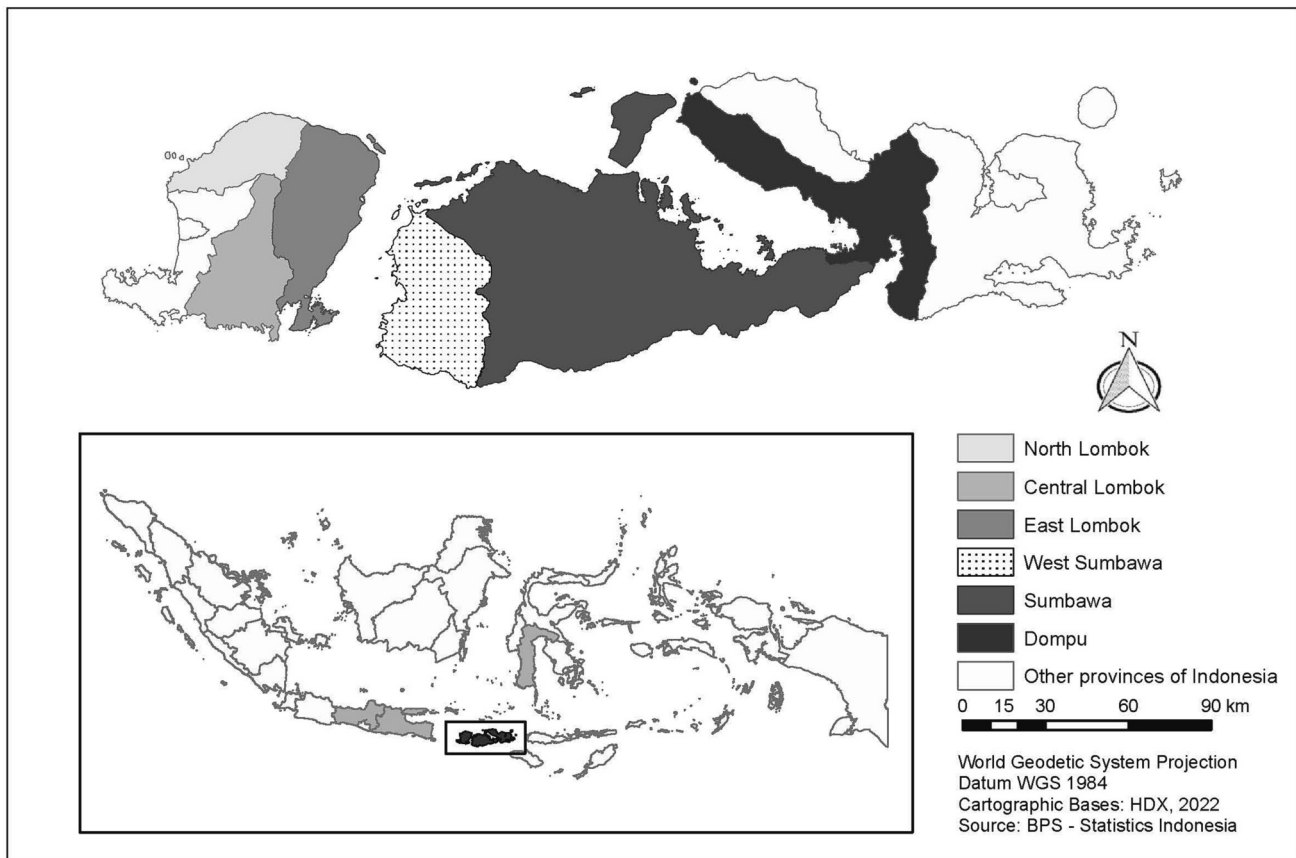


Fig. 1. Localisation of districts in Nusa Tenggara Barat Province selected for this case study.

Table 2

Assessment of innovation intermediary functions in an R4D project.

Functions		Fulfilment (Yes, No, Partially)	Explanation
Knowledge Intermediation	(1) Expressing and conveying users' needs and demands	No	The project team had limited involvement of farmers during the project's lifecycle, failing to adequately express and convey their needs and demands.
	(2) Providing problem-solving information and catering to users' requirements	Partially	The team provided training and consultation, enhancing the technical capacity of extension service staff and farmers. However, there is no evidence that farmer groups were consulted regarding the capacity-building opportunities relevant to them.
	(3) Involving and assisting stakeholders in collaborative knowledge generation	Partially	The project team facilitated the integration and adaptation of new technologies to local conditions. However, the changes largely stemmed from the project's interventions, with minimal involvement of farmers and other relevant stakeholders.
Innovation Intermediation	(4) Forming visions regarding the extent and character of innovations	No	The team formulated a vision but struggled to establish the necessary engagements to effectively position the smallholder cattle in targeted high-end markets.
	(5) Establishing and overseeing networks with stakeholders from diverse domains	Partially	The team fostered collaboration and facilitated information exchange among extension agencies, local research institutions, and farmers' groups. However, there was a lesser degree of engagement with the private sector and a narrow focus on the field.
	(6) Aiding and partaking in stepping up	No	Waste management emerged as a significant activity, and its benefits for improving environmental sustainability and livelihoods were recognised among stakeholders. However, this activity was not sufficiently emphasised by the project team, thus not aiding or partaking in stepping up towards a broader set of societal and environmental challenges.

4.1. Knowledge intermediation

4.1.1. Expressing and conveying users' needs and demands

The function 'expressing and conveying users' needs and demands' refers to how effectively the project team can identify and articulate cattle farmers' requirements. Considering that the case study is on an R4D project, to access this function, we could use the lens of participatory approach - specifically, how well the farmers were included in every phase of the project. Specifically, we look at the degree of farmers' participation throughout the project, whether their needs were

captured, and if necessary, how activities were adapted in response to these needs.

Our results show that the project team did not advocate for farmers' needs, and farmers had very little involvement in the project, such as in project monitoring and evaluation. Project documents revealed that the project team carried out initial consultations with farmers during the design phase; however, our analysis revealed a gap in sustained farmer engagement in consultations or decisions regarding the project. The outcomes of interviews conducted with farmers and government staff showed that, despite farmers being actively involved in project

activities, their influence on the project's implementation was largely insignificant. The analysis of workshop reports bolsters this observation, indicating the absence of dialogue with farmers and the lack of participation in the monitoring of project activities. As mentioned earlier, the project team was designed to work in conjunction with government extension offices using a cooperative approach for implementing project activities. However, it seemed that due to the prioritisation of consultations with extension service officers, the project team unintentionally sidelined farmer participation throughout the implementation of the project.

The limited engagement was largely influenced by two significant factors: the unforeseen challenges posed by the COVID-19 pandemic and certain limitations in our team's implementation of participatory approaches. The pandemic brought unprecedented logistical and communication hurdles, restricting our ability to conduct in-person meetings and workshops, which are typically vital for comprehensive stakeholder involvement. Additionally, we acknowledge that there were shortcomings in effectively applying participatory methodologies across all phases of the project. This was partly due to gaps in our team's experience and capacity in managing such approaches under the rapidly changing circumstances. The combination of these factors inevitably shaped the project's methodology, leading to a more focused yet constrained stakeholder interaction. This limitation had a direct impact on the breadth of feedback and inputs incorporated into the project, subsequently influencing its outcomes and conclusions.

Based on the data analysed, the project team was unable to perform this innovation intermediary function. This finding is similar to that of Yang et al. (2014), who analysed three case studies and revealed that only one of them effectively expressed and conveyed users' needs and demands, highlighting the cooperative's successful liaison with the Agricultural Bureau to communicate issues regarding non-polluting rice technology and the development of a regulatory framework in collaboration with the agency.

Several studies have highlighted the positive impacts of participatory monitoring and evaluation on farmers' social learning, network building, and the effectiveness of innovation adoption and scaling in various agricultural initiatives. For example, Luján Soto et al. (2021) found that participatory M&E fosters farmers' social learning and network development for sustainable land management. Kisumbi et al. (2022) demonstrated a positive association between participatory monitoring and evaluation, and the effectiveness of mango farming initiatives. Sangole et al. (2014) concluded that farmer groups that incorporated participatory approaches had superior social capital indices and performance metrics in their operations.

In the context of a development project with a focus on innovation, it is important to involve all stakeholders, especially farmers, to ensure that they participate in decision-making across all phases of the project in order to address their needs properly. However, the findings of the workshops and interviews revealed an imbalance in stakeholder engagement. This imbalance hampers the innovation intermediary function of expressing and conveying user needs and demands.

4.1.2. Providing problem-solving information and catering to users' requirements

This section assesses whether the project team, acting as an innovation intermediary, succeeded in providing problem-solving information, training, and consultations to the target groups. Our results indicate that to some extent, the team fulfilled this function, enhancing the capacity of extension service staff and farmers in livestock husbandry. Interviews with extension service staff revealed that the project facilitated training sessions aimed at building capacity for practical field applications in animal production, which significantly improved the officers' knowledge of livestock husbandry. Field officers and researchers delivered targeted training sessions in areas relevant to the IVMS (see Section 3.3). The interviewees reported that these activities improved their technical capacity, leading to a more efficient livestock

sector in the region. An example quote from an interviewee illustrates this.

"Not everyone in our department, including myself, had prior experience in the livestock sector. I have an agricultural science background. Thanks to the project, I have gained valuable knowledge in the area of livestock management, and I can say it has improved the quality of my work and the services I provide to the farmers I attend." (Extension service staff - Central Lombok).

Moreover, our results showed that the project team enhanced the capacity of cattle farmers by establishing demonstration farms. These sites serve as practical learning platforms, exposing cattle farmers to successful feed management practices. By observing these techniques and strategies, farmers gained valuable knowledge and skills, enhancing their ability to effectively manage their livestock's nutritional needs. The following quote illustrates this point.

"We have organised farm visits for our farmers to understand the practices of successful groups in diverse locations and acquire valuable insights. Upon witnessing the achievements of others, we noticed that they started questioning their own methods and became eager to embrace new practices." (Extension service staff Central Lombok).

"When the farmers came to our group, they couldn't believe their eyes. They saw the forage, wanted to learn more, and asked if they could have some seeds too." (Farmer, Dompu).

In addition, the analysis report from the workshop showed that another intermediary activity was provided by the project team. Our findings revealed that the project team played a crucial role in enhancing extension capacity and offering on-site consultations and advisory problem-solving assistance to farmers to overcome specific challenges. These interactions provide farmers with practical solutions and encourage the adoption of IVMS.

However, we noted a limitation of this study. There was no evidence from the analysed data that the farmer groups were consulted regarding the capacity-building needs that they deemed relevant within the scope of the project. This observation suggests the importance of incorporating farmers' perspectives, as their experiential insights can greatly contribute to creating and delivering more meaningful, practical, and efficient capacity-building initiatives.

Training and consultation in agriculture are crucial capacity-building tools. They enhance knowledge, skills, and resilience, leading to improved productivity, sustainability, and decision-making. Supporting the findings of previous studies (Fukugawa et al., 2018; Klerkx and Leeuwis, 2008a; Li et al., 2022; Neilson and McKenzie, 2016), our findings revealed the significant role of the project team in enhancing the capacity of extension services and farmers to some extent. As Klerkx and Leeuwis (2009) argue, innovation intermediaries play a crucial role in stimulating capacity building, particularly in developing countries.

In summary, the project team's performance demonstrates a combination of accomplishments and limitations. They have successfully enhanced their knowledge and practical applications in livestock husbandry, improving the capacities of both extension service staff and cattle farmers. However, this finding highlights the importance of involving end users in the planning and decision-making stages because their experiential knowledge can greatly enrich the effectiveness and appropriateness of capacity-building initiatives.

4.1.3. Involving and assisting stakeholders in collaborative knowledge generation

This section examines the role of the project team in facilitating the integration and adaptation of new technologies to suit local conditions in cattle farming.

Our findings indicate a shift from traditional cattle feeding practices, stimulated by extension methods, such as field demonstrations and involving local champions, to showcasing forage performance. The

project team, in collaboration with the extension service staff, effectively communicated the nutritional benefits of various forages, particularly a local variety known as turi (*Sesbania grandiflora*, commonly used in human nutrition). The team members encouraged farmers to explore new practices by demonstrating the potential of these forages for cattle nutrition. As a result, farmers became more inclined to cultivate higher-quality forage for their livestock, presenting a viable alternative to conventional grazing in extensive systems or random feed collection in intensive systems. The subsequent improvement in the quality and consistency of feed supply is a testament to this shift. Two quotes highlight this change:

“Getting started was tough, especially for [field officer name]. But when someone successfully grew Lamtoro (Leucaena leucocephala), other farmers saw that it worked and wanted to try it too. Local officials joined in, showing their support. When this took off, it spread to other areas. Bottom line, farmers need to see something work on a small scale before they’re willing to give it a go.” (Extension service staff, Sumbawa).

“Before, cattle farmers around here didn’t know Turi [Sesbania grandiflora] could feed cattle. They thought it was just for people to eat or for goat feed. But when the project started working in the villages, people learned that Turi actually has more protein than regular grass [...] The Turi plant is found everywhere, from North to South. If you ask people if they know Turi, they’ll say no. But show them the plant, and they’ll recognize it, calling it Ketujur”, which is Turi’ in the Sasak language.” (Extension service staff, East Lombok).

While these findings underscore a certain degree of user involvement (via local farmer champions) in the demonstration fields, a different picture emerged when viewed against the backdrop of the broader innovation intermediary function analysed in this study. The extension service staff acknowledged the project team’s role in changing farming practices, but our study indicated that these changes largely stemmed from the project’s interventions, with minimal involvement from farmers and other relevant stakeholders. That is, the lack of collaborative knowledge generation for new technologies and practices contrasts with the expected role of innovation intermediaries. Our analysis showed that farmers were targeted as recipients of new practices rather than partners, and important stakeholders, such as input providers, were absent. By not actively involving farmers in the developmental phase of these technologies, the project overlooked a valuable opportunity to integrate traditional and indigenous knowledge and localized adaptations, which could have led to more sustainable and contextually appropriate technological solutions.

Our study shares similarities with that of Li et al. (2022) regarding the role of intermediaries in knowledge dissemination. Li et al. (2022) demonstrated that intermediaries, represented by farmers’ groups in their case study, typically engage in knowledge intermediation through traditional extension methods such as field demonstrations. However, in contrast to their findings, our study reveals that the intermediaries in our case did not actively involve farmers or other key stakeholders, such as input providers, in the process of knowledge generation and adaptation.

Furthermore, our findings diverged from those of Williams et al. (2022), who highlighted the potential for integrating diverse stakeholders into Indonesia’s innovation process. Williams’ case study affirmed that each partner contributes unique skills and resources, emphasising the value of collaboration beyond the narrow focus on the agricultural production challenges observed in previous research projects.

Moreover, our results suggest that the project approach mainly focused on farmer persuasion (top-down) rather than collaboration, and thus deviates from the principles advocated by Pretty (1995) and the study by Klerkx et al. (2012a) on agricultural innovation systems which highlight the importance of engaging stakeholders as partners in knowledge generation and adaptation.

4.2. Innovation intermediation

4.2.1. Forming visions regarding the extent and character of innovations

This innovation intermediation function involves the recognition and endorsement of emerging technologies and methods that not only tackle existing problems but also unveil new possibilities. Our results revealed that the project team initially planned to elevate the market standing of smallholder cattle by targeting selected high-end markets, such as those found in tourist-area hotels and restaurants within the region. Utilising the IVMS approach detailed in Section 3.3, the project aims to improve beef production in terms of both quantity and quality to satisfy local market demands. According to the documents, the project aimed to promote participatory agro-enterprise development and to identify and leverage market opportunities for income generation and diversification, value addition, and access to high-end markets. However, the workshop findings imply a marginal contribution from the project team towards this goal.

Our results illustrate that attempts were made by the project team to enhance the reputation of local cattle for high-end niche markets, culminating in a program known as the ‘Special Bali Beef’, launched by the Ministry of Agriculture in 2020. However, the sparse evidence in the material analysed suggests that the team struggled to establish the necessary engagements with other significant stakeholders, such as input providers, supermarkets, hotels, and others, to build the vision promoted by the project. This lack of engagement could potentially impede the effective positioning of local cattle in targeted markets. Hence, although the initial vision was commendable, its execution appeared to have fallen short, particularly in terms of stakeholder collaboration and network development.

Previous research has demonstrated that innovation intermediaries can significantly influence the transformation and intensification of smallholder livestock production (Millar and Connell, 2010; Mount and Smithers, 2014; Stür et al., 2013). They facilitate access to innovation and help farmers meet the rigorous quality standards of niche markets. For instance, a study in Vietnam discovered that innovation intermediaries, in conjunction with other factors, such as farm-grown fodder and a participatory, systems-oriented innovation process, enhanced smallholder beef cattle production (Stür et al., 2013). Intermediaries have successfully helped farmers and local traders access urban markets, empowering them to rear cattle that fulfil the quality standards of these markets. Creating a loosely structured coalition of local stakeholders facilitates and manages the innovation process (Stür et al., 2013). Another study in Laos proposed strategies for expanding the impact of agricultural system changes, including the role of intermediaries (Millar and Connell, 2010). The study found that a facilitated learning environment coupled with regular follow-up visits and on-the-job mentoring for extension staff fostered the adoption of forage and livestock production practices among farmers. This expansion was supported by intermediaries that provided institutional backing and promoted local innovation (Millar and Connell, 2010). Despite its robust initial vision, the project’s execution appeared inadequate, primarily because of ineffective stakeholder collaboration and network development, indicating the project team’s shortfall in fulfilling its role as an innovation intermediary.

4.2.2. Establishing and overseeing networks with stakeholders from diverse domains

This section demonstrates the role of the project team in establishing and maintaining relationships with various stakeholders in the cattle farming industry to facilitate information exchange, learning, and cooperation throughout the beef value chain. Members of the project team were sourced from different local research institutions (BPTP and UNRAM), placing the interaction between academia, extension services, and farmers at the core of the project implementation. The results from the workshop highlighted that the team actively fostered collaboration and facilitated information exchange among extension agencies (at

various levels), local research institutions, and farmer groups. Furthermore, the results from the interviews indicated that the project team played a crucial role in organising events which included researchers, extension service staff, and farmers, such as training sessions and demonstration site visits. Interview participants remarked on the visible improvements in farmers' capabilities and group cohesion as a result of these activities.

“Farmer groups in our area are progressing well. They exhibit increased unity and cooperation. I believe their skills in raising livestock have most definitely improved. This positive shift could be associated with the project and modifications in the local government's programme.” (Extension service staff, North Lombok).

Nonetheless, our analysis revealed a lesser degree of engagement with the private sector (inputs and processors, retail, etc.), suggesting a limited ability of the project team to fulfil its intermediary role. While the team's field presence was instrumental in strengthening local farmer groups, it may have neglected a broader range of stakeholders.

Extensive literature has emphasised the role of systemic intermediaries in facilitating network building (e.g., Kilelu et al., 2011; Yang et al., 2014; Kishioka et al., 2017; Kivimaa et al., 2019; Kutter et al., 2023; Iyabano et al., 2023; Iyabano, 2023; Van Lente et al., 2003). For example, Yang et al. (2014) explore the role of farmer cooperatives in China's agricultural innovation system, emphasising their potential as coordinators. However, for optimal effectiveness, the study suggests that these cooperatives should adopt a systemic approach, incorporating all relevant stakeholders. Moreover, Iyabano (2023) highlighted the essential intermediary role of Farmers' Organisations (FOs) in Burkina Faso for promoting agroecological innovations. For maximum effectiveness, the study emphasised the need for FOs to adopt a systemic approach, engaging comprehensively with all relevant stakeholders. These studies suggested that for an innovation intermediary to effectively adopt a systemic approach, it should incorporate all relevant stakeholders. Our findings show that despite the project team's efforts to foster networks among farmer groups, insufficient engagement with the private sector obstructed the comprehensive execution of this function.

4.2.3. Aiding and partaking in stepping up

This section presents an analysis of the project team's role in promoting sustainable and innovative livestock practices that address societal and environmental challenges, including environmental sustainability, climate change mitigation, animal welfare, social inclusivity, land and water management, and food safety. Our analysis focused on how the team's activities stimulated such understanding and acceptance among farmers and government staff. Analysis of the data collected from interviews and workshop reports indicated that manure waste management initiatives emerged as the only significant activity in this category. Both farmers and government officers identified waste management as a prime opportunity not only for improving environmental sustainability but also for enhancing livelihoods, especially for women. These reports reflect the critical role of waste management initiatives in bridging the gap between environmental responsibility and socioeconomic progress.

Our findings also revealed a critical gap in teams' efforts to promote and integrate sustainable and innovative practices. For example, despite the perceived benefits of manure waste management initiatives and recognition of their potential among farmers and extension service staff, there appeared to be inadequate emphasis on this activity by the project team. Manure waste management is particularly relevant in the districts of North Lombok, Central Lombok, and East Lombok, where farmers engage in more intensive production systems. In these areas, cattle are often kept in pens, which facilitate the efficient collection and processing of manure. The team did not seem to drive waste management initiatives with a robust or focused approach matching their potential for positive change, thereby limiting their potential impact.

The literature demonstrates the significant role of innovation

intermediaries in engaging farmers in driving initiatives aimed at enhancing sustainable practices and improving their livelihoods (Kanda et al., 2020; Olde et al., 2016). The study conducted by Kanda et al. (2020) investigate the involvement of innovation intermediaries in sustainability transitions and eco-innovation. The findings revealed that these intermediaries played a pivotal role as catalysts for transitions towards sustainable sociotechnical systems by articulating new visions, demands, and expectations (Kanda et al., 2020). Moreover, Olde et al., 2016 demonstrated the positive impact of collaboration between livestock farmers and innovation intermediaries. Such collaborations have resulted in the emergence of smart and innovative solutions that offer valuable support for the development of more sustainable farming practices (Olde et al., 2016). Our analysis indicated a shortfall in the intermediary role of promoting innovative practices, such as manure waste management, with the potential to increase beef production despite its recognised potential.

5. Theoretical and practical implications

The theoretical implications of this research illuminate the operational challenges and success factors of agricultural innovation intermediaries, with a nuanced application to the Indonesian cattle farming context. Building upon the functional approach by Yang et al. (2014), this study extends the current understanding of innovation intermediaries in agricultural projects, particularly in Research for Development (R4D). We refine and adapt the existing framework to the distinct circumstances of the Indonesian cattle farming sector, while also considering its potential applicability in other similar contexts. This approach enables a detailed exploration of the roles, challenges, and adaptations innovation intermediaries undertake amidst local cultural, economic, and agricultural dynamics. Our findings deepen the theoretical understanding of participatory innovation in agricultural projects, highlighting areas of underperformance that reveal potential pitfalls and underscore the significance of sustained user engagement and broader stakeholder involvement. This study emphasises the comprehensive role of innovation intermediaries, advocating for a balanced focus on all their potential functions, especially in championing farmers' needs and integrating sustainable practices. In addressing operational challenges, such as limited stakeholder integration and resource constraints, our research recognises these issues are not unique to the Indonesian beef sector. Similar challenges are evident in other developing countries, albeit with different sectors, stakeholder dynamics and market structures. This realization paves the way for applying our insights to broader contexts, offering a framework for tailoring interventions in diverse agricultural settings.

Furthermore, our study contributes actionable insights for the enhancement of R4D projects within Agricultural Innovation Systems (AIS). It proposes a roadmap for future initiatives, highlighting the pivotal role of these projects as innovation intermediaries. By pinpointing key areas identified in our research, R4D projects can substantially aid in developing sustainable, inclusive, and effective agricultural innovation systems. The foremost practical implication is the need for enhanced farmer engagement and customised approaches in agricultural R4D projects. We emphasise sustained farmer involvement throughout the project lifecycle, advocating participatory decision-making and adaptive management responsive to real-world challenges. Additionally, the study recommends capacity building tailored to specific contexts and groups, in collaboration with farmer communities. It also endorses participatory methods in integrating new technologies and practices, ensuring technical soundness while maintaining cultural and contextual relevance through active stakeholder involvement. Broadening stakeholder engagement, especially with the private sector, is crucial for fostering diverse networks essential for systemic agricultural innovation. Lastly, integrating sustainability and environmental stewardship as core objectives in R4D projects is imperative, focusing on areas like waste management and promoting

eco-friendly practices. These collective recommendations aim to enhance the effectiveness, relevance, and sustainability of agricultural R4D initiatives globally.

This study contributes to the theoretical and practical understanding of innovation intermediaries in agriculture, with a specific focus on R4D projects. While rooted in the Indonesian cattle farming sector, our insights and recommendations have broader implications, offering a versatile framework applicable to similar agricultural contexts worldwide. This generalizability underscores the study's relevance beyond its immediate setting, providing a valuable reference for future agricultural innovation endeavours. By addressing both theoretical advancements and practical applications, this research paves the way for more inclusive, effective, and sustainable agricultural practices on a global scale.

6. Conclusions

This study examined whether and how an R4D project team, using an R4D project as a case study, acted as an innovation intermediary to improve AIS performance in the Indonesian beef sector. By analysing the six innovation intermediary functions identified by Yang et al. (2014), this study provides valuable insights into how R4D projects can effectively perform these functions and the challenges that might arise.

In the domain of knowledge intermediation, our study revealed a nuanced performance by the R4D project team. While there were commendable efforts to articulate farmers' needs and demands, a consistent gap in farmer engagement was evident throughout the project's lifecycle. This shortfall highlights a critical need for more robust mechanisms and strategies that not only involve farmers from the outset but also sustain their active participation and influence over the project's direction. The importance of such sustained engagement cannot be overstated, as it directly impacts the relevance and effectiveness of the interventions.

In terms of innovation intermediation, the project's ability to form visions for the extent and character of innovations showed limitations, particularly in effectively positioning smallholder cattle in high-end markets. Although there were initiatives such as the 'Special Bali Beef' program, the project struggled in establishing vital collaborations with key stakeholders like input providers, supermarkets, and hotels. This gap in stakeholder engagement reflects a broader challenge in innovation intermediation — the need for a more systemic and inclusive approach. Additionally, while the project fostered collaboration among extension agencies, research institutions, and farmer groups, its engagement with the private sector was notably insufficient. This underscores the importance of a comprehensive network that spans across various domains, ensuring that all relevant stakeholders contribute to and benefit from the innovation process. Moving forward, R4D projects should aim to develop and maintain such diverse networks to enhance their impact and reach.

The study's findings on the facilitation of collaborative knowledge generation and the engagement in sustainable practices such as waste management highlight significant areas for improvement. Despite successful shifts in traditional cattle feeding practices, the project's approach was primarily top-down, with limited participatory involvement from farmers and other stakeholders in generating and adapting new technologies. This indicates a missed opportunity for leveraging local knowledge and fostering a culture of innovation from the ground up. Furthermore, while waste management initiatives were recognised for their potential in enhancing environmental sustainability and livelihoods, there was a lack of emphasis and proactive implementation by the project team. These insights underline the imperative for R4D projects to not only identify but also actively promote and integrate sustainable and innovative practices, ensuring they are effectively implemented and scaled up. In terms of future studies, employing a synergistic approach that couples functional-structural AIS analysis is crucial for achieving more comprehensive insights. This is exemplified by the study conducted by Kebebe et al. (2015) which successfully

implemented this approach.

In light of these findings, it is recommended that future R4D projects adopt a more holistic approach to stakeholder engagement, involving farmers and other key players in a more meaningful and participatory manner. This approach should extend beyond mere consultation to actively involving these stakeholders in decision-making and innovation processes. Additionally, a greater focus on sustainability initiatives, with a proactive stance towards implementation and scaling, is crucial. Such strategic shifts can significantly enhance the impact of R4D projects, ensuring they effectively contribute to sustainable agricultural development and address the multifaceted challenges faced by the sector.

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CRediT authorship contribution statement

Erika Valerio: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing, Validation. **Nurul Hilmiati:** Investigation, Validation, Writing - review & editing. **Julian Prior:** Investigation, Writing - review & editing. **Tanda Panjaitan:** Investigation.

Declaration of Competing Interest

The authors declare that they have no conflicts of interest.

Data availability

Data will be made available on request.

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References

- Agus, A., Mastuti Widi, T.S., 2018. Current situation and future prospects for beef cattle production in Indonesia – a review. *Asian-Australas J. Anim. Sci.* 31, 976–983. <https://doi.org/10.5713/ajas.18.0233>.
- Banda, G., 2022. Evolution of Zimbabwe's maize innovation ecosystems: building an institutional innovation infrastructure that supported food security. *Afr. Dev.* 47, 167–195. <https://doi.org/10.57054/ad.v47i3.2679>.
- Basyar, B., 2021. Beef cattle farm development policies to overcome beef distribution problem in Indonesia: a literature review. *Am. J. Anim. Vet. Sci.* 16 (1), 71–76. <https://doi.org/10.3844/AJAVSP.2021.71.76>.
- Batterink, M.H., Wubben, E.F.M., Klerkx, L., Omta, S.W.F., 2010. Orchestrating innovation networks: the case of innovation brokers in the agri-food sector. *Entrep. Reg. Dev.* 22, 47–76. <https://doi.org/10.1080/08985620903220512>.
- BPS, 2022. Cattle Population by Category in NTB 2017–2019. <https://rb.gy/mzomq>.
- Bryman, A., 2016. *Social Research Methods*, fifth ed. Oxford University Press.
- Dyah Retno, P., Dhiar Niken, L., Ratu Fani, R., 2015. In: Marhaeni, H. (Ed.), *Analisis Rumah Tangga Usaha Peternakan di Indonesia Hasil Survei Rumah Tangga Usaha Peternakan 2014 (Analysis of Livestock Farmer Household in Indonesia, Survey of Livestock Farmer Households 2014)*.
- Fereday, J., Muir-Cochrane, E., 2006. Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *Int. J. Qual. Methods* 5, 80–92. <https://doi.org/10.1177/160940690600500107>.
- Fukugawa, N., Ambashi, M., Suhud, Y., 2018. Division of Labour Amongst Innovation Intermediaries in Agricultural Innovation Systems: The Case of Indonesia.
- Gaitán-Cremaschi, D., Klerkx, L., Duncan, J., Trienekens, J.H., Huenchuleo, C., Dogliotti, S., Contesse, M.E., Rossing, W.A.H., 2019. Characterizing diversity of food systems in view of sustainability transitions. A review. *Agron. Sustain. Dev.* 39, 1. <https://doi.org/10.1007/s13593-018-0550-2>.

- Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M., Toulmin, C., 2010. Food security: the challenge of feeding 9 billion people. *Science*. 327, 812–818. <https://doi.org/10.1126/science.1185383>.
- Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., Smits, R.E.H.M., 2007. Functions of innovation systems: a new approach for analysing technological change. *Technol. Forecasting Soc. Change*. 74, 413–432. <https://doi.org/10.1016/j.techfore.2006.03.002>.
- Hernández-Socha, Y., Zuluaga-Jiménez, J.C., 2022. Innovation intermediaries, knowledge infrastructure and technological opportunities in emerging markets: the case of research and technological centers in the Colombian agricultural sector. *Innov. Dev.* 1–31. <https://doi.org/10.1080/2157930X.2022.2133380>.
- Herrero, M., Thornton, P.K., Mason-D' Croz, D., Palmer, J., Benton, T.G., Bodirsky, B.L., Bogard, J.R., Hall, A., Lee, B., Nyborg, K., Pradhan, P., Bonnett, G.D., Bryan, B.A., Campbell, B.M., Christensen, S., Clark, M., Cook, M.T., de Boer, I.J.M., Downs, C., Dizyee, K., Folberth, C., Godde, C.M., Gerber, J.S., Grundy, M., Havlik, P., Jarvis, A., King, R., Loboguerrero, A.M., Lopes, M.A., McIntyre, C.L., Naylor, R., Navarro, J., Obersteiner, M., Parodi, A., Peoples, M.B., Pikaar, I., Popp, A., Rockström, J., Robertson, M.J., Smith, P., Stehfest, E., Swain, S.M., Valin, H., van Wijk, M., van Zanten, H.H.E., Vermeulen, S., Vervoot, J., West, P.C., 2020. Innovation can accelerate the transition towards a sustainable food system. *Nat. Food*. 1, 266–272. <https://doi.org/10.1038/s43016-020-0074-1>.
- Horton, D., Devaux, A., Bernet, T., Mayanja, S., Ordinola, M., Thiele, G., 2022. Inclusive innovation in agricultural value chains: lessons from use of a systems approach in diverse settings. *Innov. Dev.* 1–23. <https://doi.org/10.1080/2157930X.2022.2070587>.
- Hounkonnou, D., Kossou, D., Kuyper, T.W., Leeuwis, C., Nederlof, E.S., Röling, N., Sakyidawson, O., Traoré, M., van Huis, A., 2012. An innovation systems approach to institutional change: smallholder development in West Africa. *Agr. Syst.* 108, 74–83. <https://doi.org/10.1016/j.agsy.2012.01.007>.
- Howells, J., 2006. Intermediation and the role of intermediaries in innovation. *Res. Policy*. 35, 715–728. <https://doi.org/10.1016/j.respol.2006.03.005>.
- Iyabano, A., 2023. Unravelling the Positions, Roles, and Agency of Farmers' Organizations in the promotion of Agroecology in Burkina Faso. PhD dissertation. Wageningen University and Research, the Netherlands. <https://doi.org/10.18174/631067>.
- Iyabano, A., Klerkx, L., Faure, G., Toillier, A., 2022. Farmers' organizations as innovation intermediaries for agroecological innovations in Burkina Faso. *Int. J. Agric. Sustain.* 20, 857–873. <https://doi.org/10.1080/14735903.2021.2002089>.
- Iyabano, A., Leeuwis, C., Lie, R., Toillier, A., Waters-Bayer, A., 2023. Making decisions about agroecological innovations: perspectives from members of farmers' organizations in Burkina Faso. *Int. J. Agric. Sustain.* 21 (1), 2239056. <https://doi.org/10.1080/14735903.2023.2239056>.
- Kanda, W., Kuisma, M., Kivimaa, P., Hjelm, O., 2020. Conceptualising the systemic activities of intermediaries in sustainability transitions. *Environ. Innov. Soc. Transit.* 36, 449–465. <https://doi.org/10.1016/j.eist.2020.01.002>.
- Kebebe, E., Duncan, A.J., Klerkx, L., de Boer, I.J., Oosting, S.J., 2015. Understanding socio-economic and policy constraints to dairy development in Ethiopia: a coupled functional-structural innovation systems analysis. *Agr. Syst.* 141, 69–78. <https://doi.org/10.1016/j.agsy.2015.09.007>.
- Kilelu, C.W., Klerkx, L., Leeuwis, C., Hall, A., 2011. Beyond knowledge brokering: an exploratory study on innovation intermediaries in an evolving smallholder agricultural system in Kenya. *Knowl. Manag. Dev. J.* 7 (1), 84–108. <https://doi.org/10.1080/19474199.2011.593859>.
- Kishioka, T., Hashimoto, S., Nishi, M., Saito, O., Kohsaka, R., 2017. Fostering cooperation between farmers and public and private actors to expand environmentally friendly rice cultivation: intermediary functions and farmers' perspectives. *Int. J. Agric. Sustain.* 15, 593–612. <https://doi.org/10.1080/14735903.2017.1374321>.
- Kisumbi, C.K., Mulwa, A.S., Mbugua, J.M., 2022. Participatory project monitoring and evaluation and performance of mango farming projects in Makueni County, Kenya. *Eur. Sci. J. ESJ*. 18, 84–105. <https://doi.org/10.19044/esj.2022.v18n12p84>.
- Kivimaa, P., Boon, W., Hyysalo, S., Klerkx, L., 2019. Towards a typology of intermediaries in sustainability transitions: a systematic review and a research agenda. *Res. Policy* 48, 1062–1075. <https://doi.org/10.1016/j.respol.2018.10.006>.
- Klerkx, L., Leeuwis, C., 2008a. Balancing multiple interests: embedding innovation intermediation in the agricultural knowledge infrastructure. *Technovation*. 28, 364–378. <https://doi.org/10.1016/j.technovation.2007.05.005>.
- Klerkx, L., Leeuwis, C., 2008b. Matching demand and supply in the agricultural knowledge infrastructure: experiences with innovation intermediaries. *Food Policy* 33, 260–276. <https://doi.org/10.1016/j.foodpol.2007.10.001>.
- Klerkx, L., Leeuwis, C., 2009. Establishment and embedding of innovation brokers at different innovation system levels: insights from the Dutch agricultural sector. *Technol. Forecasting Soc. Change*. 76, 849–860. <https://doi.org/10.1016/j.techfore.2008.10.001>.
- Klerkx, L., Hall, A., Leeuwis, C., 2009. Strengthening agricultural innovation capacity: Are innovation brokers the answer? *Int. J. Agric. Resour. Gov. Ecol. UNU* 8 (5–6), 409–438. <https://doi.org/10.1504/IJARGE.2009.032643> (Ed.). Maastricht, The Netherlands.
- Klerkx, L., Schut, M., Leeuwis, C., Kilelu, C., 2012a. Advances in knowledge brokering in the agricultural sector: towards innovation system facilitation. *IDS Bull.* 43, 53–60. <https://doi.org/10.1111/j.1759-5436.2012.00363.x>.
- Klerkx, L., Van Mierlo, B., Leeuwis, C., 2012b. Evolution of systems approaches to agricultural innovation: Concepts, analysis and interventions. In: Darnhofer, I., Gibbon, D., Dedieu, B. (Eds.), *Farming Systems Research into the 21st Century: The New Dynamic*. Springer, pp. 457–483.
- Klerkx, L., Álvarez, R., Campusano, R., 2015. The emergence and functioning of innovation intermediaries in maturing innovation systems: the case of Chile. *Innov. Dev.* 5, 73–91. <https://doi.org/10.1080/2157930X.2014.921268>.
- Kutter, L., Wolf, P., Rothbarth, C.S., 2023. Shall we dance? How systemic intermediaries coordinate interaction within local sustainability initiatives over time. *Creativity Innov. Manag.* 32, 340–356. <https://doi.org/10.1111/caim.12544>.
- Li, J., Leeuwis, C., Heerink, N., Zhang, W., 2022. The science and technology backyard as a local level innovation intermediary in rural China. *Front. Agr. Sci. Eng.* 9, 6. <https://doi.org/10.15302/J-FASE-2022465>.
- Luján Soto, R., Cuéllar Padilla, M., Rivera Méndez, M., Pinto-Correia, T., Boix-Fayos, C., de Vente, J., 2021. Participatory monitoring and evaluation to enable social learning, adoption, and out-scaling of regenerative agriculture. *E&S*. 26. <https://doi.org/10.5751/ES-12796-260429>.
- Millar, J., Connell, J., 2010. Strategies for scaling out impacts from agricultural systems change: the case of forages and livestock production in Laos. *Agric. Hum. Values* 27, 213–225. <https://doi.org/10.1007/s10460-009-9194-9>.
- Morriss, S., Massey, C., Flett, R., Alpess, F., Sligo, F., 2006. Mediating technological learning in agricultural innovation systems. *Agr. Syst.* 89, 26–46. <https://doi.org/10.1016/j.agsy.2005.08.002>.
- Moss, J., Morley, P., Baker, D., Al-Moadhen, H., Downie, R., 2016. *Improving methods for estimating livestock production and productivity*. In: *GO-11-2016* (Ed.), Technical Report Series. University of New England.
- Mount, P., Smithers, J., 2014. The conventionalization of local food: farm reflections on local, alternative beef marketing groups. *J. Agric. Food Syst. Community Dev.* 101–119. <https://doi.org/10.5304/jafscd.2014.043.002>.
- Munthali, N., Leeuwis, C., van Paassen, A., Lie, R., Asare, R., van Lammeren, R., Schut, M., 2018. Innovation intermediation in a digital age: comparing public and private new-ICT platforms for agricultural extension in Ghana. *NJAS Wageningen J. Life Sci.* 86–87, 64–76. <https://doi.org/10.1016/j.njas.2018.05.001>.
- Naouri, M., Kuper, M., Hartani, T., 2020. The power of translation: innovation dialogues in the context of farmer-led innovation in the Algerian Sahara. *Agr. Syst.* 180, 102793. <https://doi.org/10.1016/j.agsy.2020.102793>.
- Neilson, J., McKenzie, F., 2016. *Business-oriented outreach programmes for sustainable cocoa production in Indonesia: an institutional innovation*. In: Loconto, A., Poisot, A. S., Santacoloma, P. (Eds.), *Innovative Markets for Sustainable Agriculture: How Innovations in Market Institutions Encourage Sustainable Agriculture in Developing Countries*. Food and Agriculture Organization/INRA, pp. 17–36.
- Nowell, L.S., Norris, J.M., White, D.E., Moules, N.J., 2017. Thematic analysis: striving to meet the trustworthiness criteria. *Int. J. Qual. Methods* 16 (1). <https://doi.org/10.1177/1609406917733847>, 1609406917733847.
- Olde, E.M.D., Carsjens, G.J., Eilers, C.H., 2016. The role of collaborations in the development and implementation of sustainable livestock concepts in the Netherlands. *Int. J. Agric. Sustain.* 15 (2), 153–168. <https://doi.org/10.1080/14735903.2016.1193423>.
- Olivia, S., Gibson, J., Nasrudin, R., 2020. Indonesia in the time of Covid-19. *Bull. Indones. Econ. Stud.* 56, 143–174. <https://doi.org/10.1080/00074918.2020.1798581>.
- Patrick, I.W., Marshall, G.R., Ambarawati, I., Abdurrahman, M., 2010. *Social Capital and Cattle Marketing Chains in Bali and Lombok*. Indonesia. Canberra, Australia, Australian Centre for International Agricultural Research (ACIAR).
- Permani, R., 2013. Determinants of relative demand for imported beef and a review of livestock self-sufficiency in Indonesia. *J. Southeast Asian Econ.* 294–308. <https://doi.org/10.1355/ae30-3e>.
- Pertanian, K., 2021. *Livestock statistics*. In: *Outlook Daging Sapi*. Portal Epublikasi Pertanian.
- Pretty, J.N., 1995. Participatory learning for sustainable agriculture. *World Dev.* 23, 1247–1263. [https://doi.org/10.1016/0305-750X\(95\)00046-F](https://doi.org/10.1016/0305-750X(95)00046-F).
- Sangole, N., Kaaria, S., Jemimah, N., Lewa, K., Mapila, M.A., 2014. Community based participatory monitoring and evaluation: impacts on farmer organization functioning, social capital and accountability. *J. Rural Community Dev.* 2 (3), 29–43.
- Setianto, N., Cameron, D., Gaughan, J., 2014. Structuring the problematic situation of smallholder beef farming in Central Java Indonesia: using systems thinking as an entry point to taming complexity. *Int. J. Agric. Manag.* 3. <https://doi.org/10.22004/ag.econ.236908>, 1029-2016-82299.
- Spielman, D.J., Ekboir, J., Davis, K., 2009. The art and science of innovation systems inquiry: applications to sub-Saharan African agriculture. *Technol. Soc.* 31, 399–405. <https://doi.org/10.1016/j.techsoc.2009.10.004>.
- Stür, W.W., Khanh, T.T., Duncan, A., 2013. Transformation of smallholder beef cattle production in Vietnam. *Int. J. Agric. Sustain.* 11, 363–381. <https://doi.org/10.1080/14735903.2013.779074>.
- Sudrajat, G., Mulatsih, S., Asmara, A., 2019. Technical efficiency of beef cattle production in West Nusa Tenggara. *IJSRSET* 6, 498–510. <https://doi.org/10.32628/IJSRSET196196>.
- Turner, J.A., Klerkx, L., Rijswijk, K., Williams, T., Barnard, T., 2016. Systemic problems affecting co-innovation in the New Zealand agricultural innovation system: identification of blocking mechanisms and underlying institutional logics. *NJAS Wageningen J. Life Sci.* 76, 99–112. <https://doi.org/10.1016/j.njas.2015.12.001>.
- Valerio, E., Hilmia, N., Prior, J., Dahlanuddin, D., 2022. Analysis of the agricultural innovation system in Indonesia: A case study of the beef sector in Nusa Tenggara Barat. *Agricultural Systems* 203, 103529.
- Van Lente, H., Hekkert, M., Smits, R., Van Waveren, B., 2003. Roles of systemic intermediaries in transition processes. *Int. J. Innov. Manag.* 07, 247–279. <https://doi.org/10.1142/S1363919603000817>.
- Waldron, S., Dahlanuddin, D., Mayberry, D., Mulik, M., Quigley, S., Dp, P., 2013. *Eastern Indonesia Agribusiness Development Opportunities: Analysis of Beef Value Chains*.

- (Canberra, AU: ACIAR, Prepared by Collins Higgins Consulting Group Pty Ltd), p. 222.
- Waldron, S., Halliday, M., Shelton, M., Ngongo, J., Nulik, J., Kusuma Putri Utami, S., Panjaitan, T., Tutik Yuliana, B., 2016. Economic analysis of cattle fattening systems based on forage tree legume diets in eastern Indonesia. *Trop. Grassl.- Forrajes Trop.* 7 (4), 437–444. [https://doi.org/10.17138/tgft\(7\)437-444](https://doi.org/10.17138/tgft(7)437-444).
- Williams, L.J., Jaya, I.K.D., Hall, A., Cosijn, M., Rosmilawati, S., Sudirman, W., Suadnya, W., Sudika, I.W., 2022. Unmasking partnerships for agricultural innovation: the realities of a research-private sector partnership in Lombok Indonesia. *Innov. Dev.* 12, 417–436. <https://doi.org/10.1080/2157930X.2020.1857949>.
- Winter, W.H., Doyle, P.T., 2008. Increased profitability and social outcomes from livestock in smallholder crop-livestock systems in developing countries: the ACIAR experience. *Aust. J. Exp. Agric.* 48, 799–805. <https://doi.org/10.1071/EA08013>.
- World Bank (Ed.), 2006. *Enhancing Agricultural Innovation: How to Go beyond the Strengthening of Research Systems*. The World Bank, Washington, District of Columbia.
- World Bank, 2020. *No One Left behind: Rural Poverty in Indonesia*.
- World Bank, 2022. *The World Bank in Indonesia: Overview*. Retrieved 11/04. <https://www.worldbank.org/en/country/indonesia/overview>.
- Yang, H., Klerkx, L., Leeuwis, C., 2014. Functions and limitations of farmer cooperatives as innovation intermediaries: findings from China. *Agr. Syst.* 127, 115–125. <https://doi.org/10.1016/j.agsy.2014.02.005>.
- Yin, R.K., 2017. *Case Study Research and Applications: Design and Methods*, sixth ed. SAGE Publications.
- Dahlanuddin, et al., 2019. Adoption of Leucaena-based feeding systems in Sumbawa, eastern Indonesia and its impact on cattle productivity and farm profitability. *Trop. Grassl. Forrajes Trop.* 7, 428–436. [https://doi.org/10.17138/tgft\(7\)428-436](https://doi.org/10.17138/tgft(7)428-436).