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# **Development of an Agricultural Innovation Ecosystem for Rice: The Case of the Rice Revival in Reunion Island and the PAPRiz Project in Madagascar**

Rova Razananaivo, Jérôme Vellayoudom, Évelyne Lande, Hasina Rasolonjatovo

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Rova Nantenaina Razananaivo, Jérôme Vellayoudom, Evelyne Lande and Hasina Jean Aimé Rasolonjatovo

## Chapter 5

# Development of an Agricultural Innovation Ecosystem for Rice: The Case of the Rice Revival in Reunion Island and the PAPRiz Project in Madagascar

**Abstract:** Rice is the staple food of the populations of two islands in the Indian Ocean: Reunion Island and Madagascar. To guarantee their food autonomy, these islands have carried out agricultural innovations around rice farming: PAPRiz in Madagascar and Riz Reunion in Reunion Island. These innovations are similar in the dimensions covered (process, product, and organizational innovations) but differ in their scope. The study explores how an agricultural innovation is diffused to stakeholders and how they are involved in. With documentary analysis and interviews, the comparison of the ecosystems of these two agricultural innovations shows some differences in structuring: the Reunion ecosystem is in the creation stage, whereas the ecosystem of Madagascar is in the maturity stage. The evolution of these ecosystems shows the importance of the structuration of the ecosystem. Public institutions can play this role to converge the interests of stakeholders. These stakeholders must be enrolled in the ecosystem via actions by a legitimization of the knowledge.

**Keywords:** agricultural innovation, innovation ecosystem, knowledge diffusion, Indian Ocean, Madagascar, Reunion Island, Stakeholders enrolment, case study, innovation characteristics, rice farming

## Introduction

Rice is the staple food of the local population in two Indian Ocean Islands: Madagascar and the Reunion Island with an annual rice consumption of 50 kg per capita (INSEE, 2021) in Reunion Island and 103 kg per capita<sup>1</sup> in Madagascar, the second-

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<sup>1</sup> Report from the World Food Programme Country Office in Madagascar on April 28, 2019 about the rice sector in Madagascar facing fortification (Accessed on June 28, 2023, at <https://madagascar.un.org/fr/download/5149/26548>).

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Rova Nantenaina Razananaivo, Jérôme Vellayoudom, Evelyne Lande, Université de Poitiers, France  
Hasina Jean Aimé Rasolonjatovo, INSCAE, Madagascar

largest rice consumer in the world. To meet their needs, both islands must import rice (over the period 2013 to 2018, Madagascar imported 374,000 tons on average and Reunion imported almost all its rice consumption, i.e., 44,000 tons in 2021). Local rice production is therefore a major issue, which explains the implementation of strategies to increase local production through agricultural innovations. In Reunion Island, the innovation has been initiated by non-profit associations with the objective of reviving the rice farming. In Madagascar, the issue of food self-sufficiency is a major political concern. The Malagasy government has therefore included the *Velirano*<sup>2</sup> or the promises to increase rice production and improve regional production capacities in the Initiative Emergence Madagascar program. Along with these national policies, agricultural innovation projects have been initiated, including the Rice Productivity Improvement Project (PAPRiz), which has increased yields by 5.53 tons per hectare, exceeding the objective set by the project (Agence Malagasy de Presse, 2019). The development of these innovation ecosystems can be a subject of study about innovation ecosystems. In addition, as most of the research explain the motivations of farmers in adopting new practices to identify the favorable support to the adoption of these innovations (Bouزيد et al., 2020), this study focuses on the agricultural innovation system, less explored in the literature (Rajalahti et al., 2008a). The objective is to explore how an innovation is diffused to the stakeholders and how they are involved in.

To reach this objective, the first part of the chapter presents the conceptual and theoretical framework. Then, a presentation of the methodology is followed by the results. Finally, a comparative analysis of the two cases is carried out to highlight the lessons that can be learned from the cases.

## Conceptual and Methodological Framework

Baregheh et al. (2009) have identified six attributes to delimit innovations: (1) the nature of the innovation, (2) its type, (3) the stages, (4) the social context, (5) the means, and (6) the purpose of the innovation. These attributes can be grouped into two categories: those related to the characteristics of the innovation (nature, type, and purpose) and those related to the construction of the innovation (stages, social context, and means) detailed below.

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<sup>2</sup> Velirano is a Malagasy word that can be translated to “promises.” Velirano represent the promises made by the government to the population and to the development of Madagascar (Accessed on June 28, 2023, at <https://www.presidence.gov.mg/realisations.html>).

## Agricultural Innovation

Innovation is a multifaceted concept that has been defined and understood in various ways across different disciplines. According to the OECD, innovation is “the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization, or external relations.” One area of innovation is the agricultural innovation, they are mainly designed to increase production and to improve product quality, growing conditions, and the production process (Van Der Veen, 2010).

As this agricultural innovation is influenced by spatial factors and regional contexts. The spatial spillover effect of agricultural science and technology innovation on agricultural green development has been observed in different regions (Zhang et al., 2022). This specific innovation can be characterized according to Table 1.

**Table 1:** Summary of the characteristics of an agricultural innovation.

Characteristics	Elements	Authors
Categories	Process innovation Product innovation Marketing innovation Organizational innovation	Gault (2013)
Domains	Education Research Demand Intermediary Support structures	Rajalahti et al. (2008b)
Triggers Dynamics Scale Results Impact		Triomphe et al. (2016)

In the innovation process, stakeholders can influence the innovation in various ways. They can take on brokering, intermediating, and co-creating roles in an innovation ecosystem. In addition, stakeholders’ acceptance and support of an innovation can shape its spread and impact (Todak et al., 2018).

## Stakeholder Enrolment and Knowledge Diffusion

An innovation ecosystem is “the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors” (Goodman et al., 2017). According to the quadruple helix model, four types of stakeholders are involved in the development of an innovation ecosystem: the industry, the government, the research centers, and the public.

For Hekkert et al. (2007), several processes or functions are critical to the performance of an innovation ecosystem. These functions include entrepreneurial activities, knowledge development, knowledge dissemination through networks, research orientation, market formation, resource mobilization, and legitimacy creation to counteract resistance to change.

Indeed, an innovation ecosystem involves many actors and therefore poses the problem of the alignment between actors throughout the life cycle of innovation ecosystems (Dos Santos et al., 2021). These actors may have different interests and it is therefore necessary to interest them to mobilize a growing number of allies and get them to participate actively in the construction of innovation (Durand et al., 2018). In the same way, Peillon (2001) has shown the need for partner companies in cooperation to use means to effectively coordinate their actions and their decisions within the cooperation. The enrollment of stakeholders in an innovation ecosystem is conditioned by the value that they gain whether it is business and/or political and/or research and/or societal value. In addition, a communication is needed to attract new participants and expand the network (Cunningham & Ekenberg, 2015).

## Research Methodology

The study of the agricultural innovation ecosystem is based on a multiple holistic case study methodology (Yin, 2013). The agricultural innovation in Madagascar and Reunion Island were chosen by the specificities of the social formation and the geographical space (Gu-Konu, 1999).

First, the innovation is described for each case. Second, the innovations are compared using the dimensions stated by Triomphe et al. (2013), the typology developed by Arnold and Bell and adapted by Rajalahti et al. (2008a) to agricultural innovations.

Finally, the strengths of each ecosystem are highlighted by studying the functions of innovation ecosystems (Hekkert et al., 2007) with a focus on the diffusion of the innovation and the stakeholders' involvement.

Table 2 summarizes the method of data collection method.

The use of axial coding can be justified based on several reasons. Firstly, axial coding allows for a more structured and systematic analysis of qualitative data (Löf-

**Table 2:** Summary of empirical materials collected.

Collection method	Nature of materials/contact persons
Documentary analysis	<p><b>Réunion Island:</b> institutional documents, associative documents, post on associative social networks, personal archives of stakeholders, press articles, audiovisual reports.</p> <p><b>Madagascar:</b> institutional documents, institutional posts on social networks, project reports and press articles, audiovisual reports from project actors (ministers, experts, farmers).</p>
Interviews	<p><b>Reunion Island:</b> farmers, civil society activists, territorial institutional actors, cultural actors, citizens not involved with associations (consumers, the curious, etc.). The interviews were done in July 2022.</p> <p><b>Madagascar:</b> videos of interviews of farmers and institutional actors (Minister of Agriculture, Livestock and Fisheries on July 10, 2019; Japanese expert PAPRiz in 2012; Minister of agriculture in 2011 and the speech for the presentation of the educational film “Voly Varin-d’Rajao sy PAPRiz” on October 18, 2011).</p>

fler et al., 2012). This process helps in organizing the data and identifying key themes or concepts that emerge from the analysis.

## Case Study of the Innovation Ecosystem of Rice Farming in Reunion Island

Reunion Island is a French island with 868,800 inhabitants. Its surface area is 2,512 km<sup>2</sup>, 75% of which is in a natural protection zone and a large part of it is classified as a UNESCO World Heritage Site. The exploitation of land is limited by its relief and the presence of an active volcano. The useful agricultural surface is 42,000 km<sup>2</sup> in 2021. About 55% of it is occupied by the sugar cane farming.

### Presentation of the Case

The project to revive rice farming in Reunion Island has its origin from citizen initiatives in the 1970s. It gained new momentum after the movements of protestation against the inflation 2018 in France. One of the farmers said:

It is an extension of the discussion forums and debates held in the roundabouts. Rice was not the subject. We were talking about purchasing power issues and as supplies were blocked with the movement, we came to talk about producing locally what we eat. And rice came on the table. But there were discussions of many other things: manioc, potatoes, corn. In short, all that was done here before that people turned away to eat things from outside [The notion of outside comes

from the use of Reunionese Creole. Here, it is necessary to understand what is outside the island, in this case what is imported. The term challenges the notion of Reunionese identity. This aspect of identity will make sense when we reinscribe it further into the system of values and knowledge construction of the innovation ecosystem of the project to revive rice in Réunion.]. [. . .] when the protests stopped, we said to ourselves that it was interesting to continue to think about these subjects.

Another farmer confirms that this was the trigger for the reflection:

[. . .] during the protests, we had set up a lot of forums on social networks, [. . .]; we kept the pages and the discussions continued. That's how a lot of projects have developed, including rice.

This is the starting point of the revival of the rice in the Reunion Island.

## Stakeholders

The observations and the interviews allow us to identify six categories of stakeholders: (1) the growers, (2) the associations, (3) the institutions, (4) the cultural actors, (5) the media, and (6) the consumers.

The farmers are not homogeneous, there are many categories:

- Historical farmer-passers from the farming community of the 1970s who ensure the transmission of the technics to the current revival project leaders.
- Historical farmers who do not share the knowledge.
- Farmers who start growing rice with an only objective of economic profitability.
- Opportunistic farmers or occasional farmers from civil society.
- Motivated farmers who are attentive to the knowledge transmitted and who often engage in a training process.

## Description of Innovation Processes and Interactions Between Stakeholders

The economic tensions have created the initial conditions for the launching projects promoted by associations.

Aware of the project, the politicians have made the revival of rice a strategic priority. However, the territorial institutional stakeholders did not structure the projects. The process was managed directly by the associations with the financial support from Europe and the French government targeting the farmers.

Three associations were working on the rice project. They have no interaction or coordination between them. Any knowledge circulated between them. In addition, there even seems to be rivalry, resulting in a withholding of information.

In each association, the knowledge building and innovation processes are similar. They all contacted the planter-passers, often the same ones, to understand the technics. These visits were punctual, short and did not give rise to any feedback, leading the planter-passers to deplore the fact that the associations did not take advantage of “what we have already tried and tested. They do things that we know don’t work.” However, the knowledge built up in the 1970s and updated by some planter-passers is easily available through publications and studies. Thus, they have been responsible for several technological innovations (recalibrating a seeder designed for a different seed to plant rice, inventing a more efficient weeding tool, etc.) and process innovations (defining an optimum standard deviation between plantings for better yield, etc.).

When the farmer-passers learn that training is being provided by professionals, they make critical comments: “They came just for a moment, they knew nothing about the subject, and now they are giving training. But what are they training on?” This attitude from associative institutions causes distrust among the planter-passers who become hesitant to pass on their knowledge.

For their part, the associations engage in a process of knowledge building through a test-and-error process, recording their observations and results with a view to improve. Despite the lack of consultation between the associations, they all work with the same objective: seed production.

## Case Study of the Innovation Ecosystem of Rice Farming in Madagascar

Madagascar is an island of 587,000 km<sup>2</sup> which puts it in the 48th position of the world’s largest states in terms of area. Its GDP in 2020 is 13.72 billion USD which, when compared to the population of 27.69 million (2020), gives a GDP of \$495.49 per capita.

Food self-sufficiency is a strategic and political challenge for a country with a growing population. In 2007, the number 3 in Madagascar Action Plan was the launch of a sustainable green revolution aimed at doubling rice production (from 3,420 thousand tons in 2005 to 7,000 thousand tons in 2012). In 2013, the National Development Plan aimed to achieve food self-sufficiency and make Madagascar the breadbasket of the Indian Ocean and sub-Saharan Africa.

### Presentation of the Case

The Rice Productivity Improvement Project (PAPRiz) is a technical cooperation project between two institutional actors: the Japanese government via the Japan International Cooperation Agency (JICA) and the Malagasy government via the Ministry of Agricul-

ture. The objective of this project is to help in the development of a rice-growing techniques adapted to the Central Highlands of Madagascar, and to strengthen links within organizations involved in rice production.

The first phase lasted 6 years (2009–2015) and involved five regions of the Central Highlands (Alaotra Mangoro; Bongolava; Vakinankaratra; Analamanga; Itasy). In July 2015, a joint JICA-Ministry of Agriculture final evaluation concluded that the project was a success in terms of its relevance, effectiveness, efficiency, impact, and sustainability. The project resulted in an increase in rice productivity of one ton per hectare in the target areas through improved rice techniques; a variety selection; a promotion of seed multiplication and distribution systems; a design of technical instructions; a strengthened linkages among stakeholders; and a provision of agricultural materials for farmers. This set of elements is referred as the “technical package.”

The second phase of the project lasted 5 years (2015–2020) and involved six new regions (Analanjirifo; Boeny; Betsiboka; Antsinanana; Amoron'i Mania; Menabe) benefiting from the technical package developed in the first phase.

The third phase is currently in gestation and aims at improving productivity and strengthening the rice industrialization through a provision of agricultural inputs.

## Stakeholders

The stakeholders behind the project are two institutional stakeholders: the government of Madagascar and the government of Japan.

For the Malagasy government, the project contributes to the challenge of food self-sufficiency. During an interview of the Minister of agriculture on a local television, he stated “The project helps us a lot in the achievement of the objectives of the President of the Republic which is the self-sufficiency in rice in Madagascar.” The government contributes to the financing of the project by covering the operational expenses for the implementation of the project (offices, travel, etc.). It also provides human resources (a project director, a project manager, project staff certified by the Ministry and administrative staff).

The Japanese government intervenes through JICA and finances the project, the technical expertise, the training of local technicians and the delivery of equipment (vehicles and office materials).

In addition to these two institutional stakeholders, other actors gravitate around the project, whose number and scope of actions vary according to the phases described below.

## Description of Innovation Processes and Interactions Between Stakeholders

The phase 1 of the project begins by connecting and strengthening the links between stakeholders under the leadership of the Ministry of Agriculture.

At each region, the regional office of agriculture (ROA) oversees designing the technical package adapted to the agroecological and social conditions of the area, to provide the appropriate services to rice farmers. The technical package developed is then tested and validated at the FOFIFA research center's model sites.

The basic seeds produced by FOFIFA are transferred to Seed Multiplication Centers (SMCs), seed farmer groups (SFGs), seed farmers (SFs) or directly to the farmer. SMCs, SFGs, and SFs contribute to the production of improved seeds in the same way as FOFIFA. Farmers using improved seeds can also select the most productive seeds. Technical support for seed producers is provided by the Agriculture and Livestock Circumscriptions (CirAE) and the Official Service of Control (SOC) of seeds and plants ensures the monitoring and control of seed production until certification.

This combination of seed selection and adapted tools have increased yields, as one farmer noted:

With the traditional method, we had 3 tons of rice per hectare. Since we started working with Papriz, we only need 6kg of seeds, compared to one bucket before [ . . . ] the season has been good, as our yield has increased by 4 tons per hectare.

The success of the first phase of the project is undeniable: about 3,000 farmers have benefited from the new technique. The Japanese expert PAPRiz described the first phase of the project as a “success” which allowed the Minister of Agriculture to initiate the second phase of the project aiming to bring the technique to other regions of Madagascar. To widely disseminate the successful experience of Phase 1, a film was produced, and the cascade extension model was mobilized.

The film features two stars of Malagasy cinema: Rajao and Pasitera. This educational material mixes entertainment and teaching through sketches and explanations of the method. It facilitates the understanding of the new rice growing techniques promoted by the project and convinces the viewers of the advantages of the PAPRiz method in terms of yield. It was shown free of charge in the regions in Phase 1 (15,000 VCDs and 500 DVDs were distributed).

The PAPRiz 2 cascade extension model involves three levels of trainers: master trainers (MTs), PAPRiz trainers (PTs) and farmer trainers (FTs). In each region, master trainers provide training and support to PAPRiz trainers. At their turn, the PAPRiz trainers provide technical support to the farmer trainers. These farmer trainers provide theoretical and practical training in PAPRiz techniques to farmers in their area with the support of master trainers and PAPRiz trainers.

The provision of the technical package at the level of the farmers' plots are completed by the granting of PAPRiz bags containing improved seeds and mineral fertil-

izers necessary for two rice growing seasons. Afterwards, the farmer trainers provide the farmers with PAPRiz bags in return for a percentage of the price of the PAPRiz bags sold.

## Discussion

To draw lessons from these two cases, a comparison of the characteristics of the innovations will be made. Then, the involvement of the actors and the diffusion of the innovations will be heightened.

### Characteristics of the Innovations

To understand the context of the region and the specificities of each case, the category, and the domain of the two innovations are compared.

#### Category of the Innovations

The PAPRiz Project and the revival of rice farming are composed of three types of innovation. First, process innovations were encountered in both cases. In the case of the PAPRiz project, the process innovation is materialized by the technical package including farming techniques, the use of selected seeds, the use of small agricultural equipment, the economic calculation of yield, etc.<sup>3</sup> Currently, in 16 irrigated perimeters in the Analamanga, Amoron'i Mania and Betsiboka regions, 1,700 farmers are collaborating with the PAPRiz project in the implementation of P-dipping, which is a cultivation method involving the application of phosphorus to the root zone of the rice plant to maximize yields in phosphorus-deficient soils prior to transplanting.<sup>4</sup> In the case of Reunion Island, the process of innovation refers to the manufacture of a furrow-drawing machine, the testing of the impact of the manure variety of production, the development of a device to keep birds away, and the development of a harvesting mechanization. The technical innovation is the result of the research process of a technical itinerary undertaken by one of the associations between 2019 and 2021.

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<sup>3</sup> PAPRiz presentation and “Voly Varin-d’Rajao sy PAPRIZ” educational film (Accessed on June 30, 2023 at [https://www.jica.go.jp/madagascar/french/office/others/pdf/publications01\\_04.pdf](https://www.jica.go.jp/madagascar/french/office/others/pdf/publications01_04.pdf)).

<sup>4</sup> Madagascar: 6 million tonnes of rice by 2023 with PAPRIZ published on local newspaper (Accessed on June 30, 2023 at <https://www.temoignages.re/politique/co-developpement/madagascar-6-millions-de-tonnes-de-riz-en-2023-avec-papriz,104613>).

The product innovation is achieved through the improvement of the seeds used. The PAPRiz project has enabled the design of a national catalog of the species and cultivated varieties to provide farmers with new, more efficient seed varieties.<sup>5</sup> In the case of Reunion Island, a comparative approach between two rice varieties (*le Dourado* and *le petit Chini*) was carried out during the first attempt to revive the rice farming in the 1970s to assess yields and vulnerability to birds.

Both innovations have an organizational dimension. For the case of Madagascar, the project uses the integrated approach of working with local extension agents, the model farmers, to disseminate the technical package (Andriamihajaniaina, 2018). These knowledge dissemination mechanisms are also found in the case of Reunion Island with the construction of communities around rice that will, for example, propose recipes for meals composed solely of local products.

**Table 3:** Comparison of the dimensions of the two innovations.

	<b>Revival of rice farming in Reunion Island</b>	<b>PAPRiz project in Madagascar</b>
Type of innovation	Process innovation Product innovation Organizational innovation	Process innovation Product innovation Organizational innovation
Field of innovation	Agriculture	
The role of pre-existing local practices and knowledge	The knowledge held by the planter-passers was the starting point for the project leaders of the revival	The techniques are not new, but simplified so that most farmers can apply them
Triggers and drivers of innovation	Food self-sufficiency	
The dynamics of innovation	<ul style="list-style-type: none"> <li>- Collecting information and knowledge from the planters</li> <li>- Testing and experimentation</li> </ul>	<ul style="list-style-type: none"> <li>- Testing and development of techniques in 5 regions/design of technical package</li> <li>- Dissemination stage to 6 new regions /focus on increasing productivity</li> <li>- Productivity improvement phase and strengthening of rice industrialization</li> </ul>

<sup>5</sup> <https://midi-madagasikara.mg/2018/01/30/varietes-de-semences-un-nouveau-catalogue-national-pour-redynamiser-les-filieres-agricoles/> (Accessed on June 30, 2023).

Table 3 (continued)

	Revival of rice farming in Reunion Island	PAPRiz project in Madagascar
The scale at which the innovation is conducted	Local	National
The results and impacts obtained	Not yet perceptible: innovations are underway, and the results and impacts will only be visible in the long term	<ul style="list-style-type: none"> <li>– The PAPRiz 2 project has reached more than 27,400 families*</li> <li>– Increased yield per hectare (average yield increase of 2 to 2.5 tons/ha)</li> <li>– Development of effective and efficient teaching materials and development of small agricultural materials (Andriamihajaniaina, 2018)</li> </ul>

Source: Authors.

Note: Article published in the newspaper Madagascar Tribune on November 23, 2020 (Accessed on June 30, 2023 at <https://www.madagascar-tribune.com/Pres-de-5-millions-de-tonnes-de-production-annuelle.html>).

Table 3 summarizes these elements of comparison and shows that in Reunion Island, agricultural innovation is still in progress, as the effects will only be observable in a few years, whereas in Madagascar the innovation is entering a mature stage. Even if the two projects respond to a concern for self-sufficiency, they differ in terms of results (the results are not yet perceptible in the case of Reunion, whereas they are of several kinds in the case of Madagascar) and the scope of the innovation (the innovation carried out in Reunion has a local scope, whereas the Malagasy innovation has a national dimension because of the number of regions concerned and the stakeholders involved).

Finally, agricultural innovation in Reunion Island is local, whereas in Madagascar the PAPRiz project is national.

### Domain of the Innovations

It is possible to compare (Table 4) the two cases according to five domains: the demand domain, the business domain, the education and research domain, the intermediary domain, and the support structures.

The ecosystem of the PAPRiz project is both structured and structuring, with all six domains present. Thus, research results are transformed into marketable seeds by SMC after multiplication. Research on mechanization is transformed by CFAMA into

**Table 4:** Comparison of the structures of the agricultural innovation ecosystem in the two cases studied.

	<b>Revival of rice farming in Reunion Island</b>	<b>PAPRiz project in Madagascar</b>
Areas of application	<ul style="list-style-type: none"> <li>- Non-profit institutional actors: civil society associations</li> <li>- Individual stakeholders: farmers</li> </ul>	<ul style="list-style-type: none"> <li>- Public institutional actors: Malagasy Government and Japanese Government</li> <li>- Individual actors: farmers</li> </ul>
Company's field	Absent	<ul style="list-style-type: none"> <li>- Research center for profit (seed multiplication center and CFAMA)</li> </ul>
Education and research field	<ul style="list-style-type: none"> <li>- Non-profit institutional actors: civil society associations</li> <li>- Individual actors: planters</li> </ul>	<ul style="list-style-type: none"> <li>- Research center for profit (FOFIFA and CFAMA)</li> </ul>
Intermediaries' area	<ul style="list-style-type: none"> <li>- Cultural actors</li> <li>- Media</li> <li>- Public institutional trainers</li> <li>- Consumers</li> </ul>	<ul style="list-style-type: none"> <li>- Non-profit institutional actors: seed farmer group (SFGs)</li> <li>- Individual actors: seed farmers (SF)</li> <li>- Educational actors (trainers)</li> <li>- Media</li> </ul>
Support structures (project funding)	<ul style="list-style-type: none"> <li>- Public institutional actors: Europe, French government, and local authorities</li> </ul>	<ul style="list-style-type: none"> <li>- Technical and financial development cooperation actors: JICA (funding and expertise)</li> </ul>
Support structures (organization and implementation of projects)	<ul style="list-style-type: none"> <li>- Non-profit institutional actors: civil society associations</li> </ul>	<ul style="list-style-type: none"> <li>- Public institutional actors: Agriculture and Livestock Circumscriptions, Official Service of Control, Government of Madagascar</li> <li>- Trainers</li> </ul>

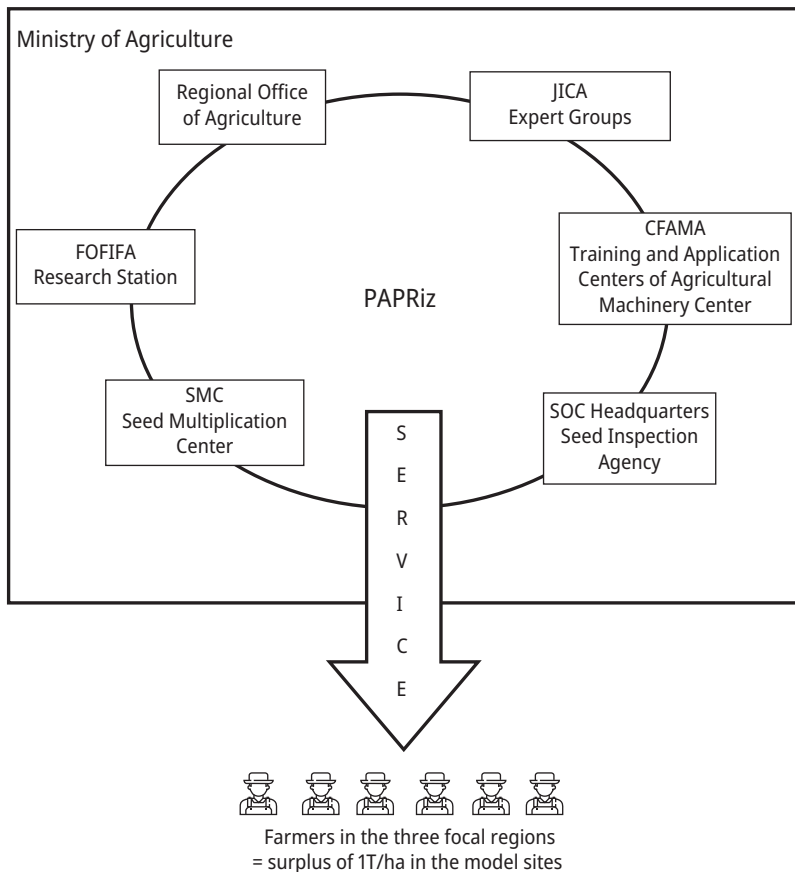
Source: Authors.

machines that are sold directly to farmers or through other farmers. In the case of Reunion Island, there is no company. For Arnold and Bell (2001), the enterprise domain is particularly important because it is where knowledge is translated into goods and services, and thus where wealth is created.

Another difference concerns the place of research within the field of education and research. In Madagascar, research has been entrusted to two specialized organizations (FOFIFA and CFAMA), whereas in Reunion Island, researchers have been solicited but are not involved in the ecosystem. The associations play the role of a project promoter while contributing to the development of the research.

## Knowledge Diffusion of the Innovation and Stakeholder Enrolment

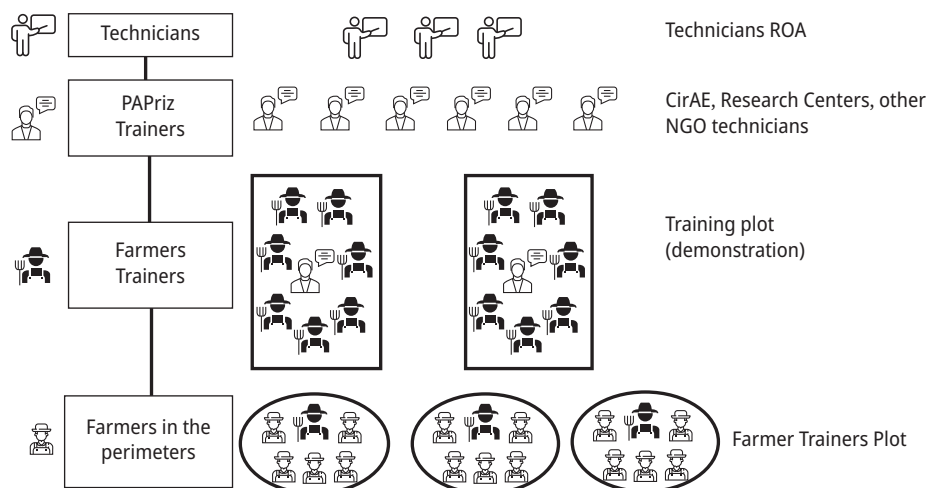
The innovation ecosystem in Reunion Island is not yet structured. The rice revival is carried out by the associations. However, these associations do not have a synergy and tend to be rivals. This rivalry seems to block the development of the innovation. For Madagascar, the involvement of the public institutions has structured the ecosystem. The two phases of the PAPRiz project in Madagascar can be the key to this structuration. The first phase of the ecosystem which involve public and research institution is shown in Figure 1.



**Figure 1:** Concept of the project PAPRiz.

Source: PAPRiz Project Phase 1.

After this first phase, the diffusion is done by cascade. This second phase of extension is shown in Figure 2. As the project is a national project, the cascade extension model helps the knowledge to be spread in large scale.



**Figure 2:** PAPRiz 2 Extension Model.

Source: PAPRiz Project.

In addition, the communication is used to support the extension model and to attract new stakeholders. For Roger (1995), there are two main types of channels: mass media and interpersonal communication channels, which are all relationships involving at least two people exchanging information during informal discussions, seminars, training sessions, etc. Both types of channels were used in both cases with some variations.

In both cases, audiovisual teaching materials (videos) have been developed. However, In Reunion Island, they focus more on the problems encountered, whereas in Madagascar they serve to disseminate the new rice-growing technique and to legitimize it to the target audience. The video attracts the attention of the farmers, and they are interested in watching it. Table 5 presents the content of the teaching material.

**Table 5:** Content of the audiovisual teaching material “Voly varin-dRajao sy PAPRiz.”

Script	Duration	Content	Message/objective
Introduction	2 min	Sketch with two stars of the Malagasy cinema	Capturing attention
Demonstration / Explanation	3–5 min × 5	Demonstration of each stage of rice production	Explain the new technique
Justification	1–2 min × 5	Sketch demonstrating the advantages of the new technique	Incentive/legitimation
Conclusion	2 min	Sketch on the increase of the yields	Incentive/legitimation

Source: Adapted from PAPRiz documents (Japan International Cooperation Agency).

This educational material involves two movie stars in a successful saga in Madagascar: Rajao and the Pastor or *Pasitera*. The use of stars is important because it allows the farmers' attention to be captured while at the same time valorizing the profession of farmer. The use of the figure of the Pastor is not insignificant: the Pastor inspires confidence, and his words have a certain authority with the public. These stars even go into the field to participate in animations on the PAPRiz technical package [23].

Other audiovisual productions have been developed. These different audiovisual productions allow to demonstrate the efficiency of the innovation while being vectors of diffusion of the innovation.

## Conclusion

The results of this study confirm the multidimensional character of agricultural innovation (Bouزيد et al., 2020) and the fact that the diffusion of an innovation is explained by the strengths and weaknesses of the system's structure as well as its fundamental functions. The study also presents multiple contributions.

First, the research has demonstrated the importance of the public institution in the structuring and evolution of the ecosystem. The public institution plays a structuring role and allows the convergence of interests. Its intervention can cover several domains and is decisive for the implementation of the ecosystem's coordination structures.

Second, the case studies confirmed the need to enroll the actors via actions (concrete realizations) and/or proof supports (video, seed production). The dissemination of knowledge and its appropriation requires concrete points of realization that make knowledge tangible to transform knowledge into know-how.

Finally, the evidence supports convince stakeholders and farmers. They legitimize the knowledge. Legitimizing knowledge plays a dual role: it creates a network and it de-institutionalizes old, often strongly entrenched, agricultural techniques.

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