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Characterization of the Guinea Pig Production Chain in Southern Colombia and Identification of Determining Factors for Adequate Provision of Extension Services

Caracterización de la cadena productiva de cuyes en el sur de Colombia e identificación de los factores determinantes para la adecuada prestación de servicios de extensión

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Abstract: The development of agrifood systems in Latin America reflects contrasting policy goals. Most governments advocate that "modernization," measured as increased rates of technology adoption, is the way to address persistent food insecurity. By contrast, peasants' and indigenous people's organizations and social movements propose advancing knowledge co-production and co-innovation to increase the resilience of agrifood systems. Colombia reformed the National Innovation System for Agriculture in 2017. The policy reform instructed transitioning from providing "technical advice" to rural extension services. The research aimed to fill the knowledge gap regarding the transition to rural extension along the guinea pig production chain. In addition to characterizing the production chain, we conducted qualitative and reflectivity analyses to understand better how institutional practices and research cultures hinder or promote transitioning to rural extension. The investigation revealed that small-scale farmers who rely on the production and commercialization of guinea pigs as a livelihood strategy have continued receiving advice to adopt the latest technologies. In closing, besides addressing technological deficits or inefficiencies, a systemic approach that considers cultural context and identity must integrate into rural extension to ensure technological adoption is aligned with the sustainability and resilience objectives of the guinea pig production chain.

Keywords: Guinea pig, innovation, technical assistance, rural extension.

Resumen: El desarrollo de los sistemas agroalimentarios en América Latina refleja objetivos de política contrarios. La mayoría de los gobiernos defienden que la "modernización", medida como mayores tasas de adopción de tecnología, es la forma de abordar la inseguridad alimentaria persistente. Por el contrario, las organizaciones campesinas e indígenas y los movimientos sociales proponen avanzar en la coproducción de conocimiento y la coinnovación para aumentar la resiliencia de los sistemas agroalimentarios. Colombia reformó el Sistema Nacional de Innovación para la Agricultura en 2017, la cual instruyó la transición de prestación del servicio de asistencia técnica al de extensión rural. El propósito de la investigación fue llenar el vacío de conocimiento sobre la transición al extensionismo rural a lo largo de la cadena productiva cuyícola. Además de caracterizar la cadena productiva, se realizaron análisis cualitativos y de reflexividad para comprender mejor la manera en que las prácticas institucionales y las culturas de investigación obstaculizan o promueven la transición hacia la extensión rural. La investigación reveló que los pequeños agricultores quienes dependen de la producción y comercialización de cuyes como estrategia de subsistencia han seguido recibiendo asesoramiento para adoptar las últimas tecnologías. Se concluyó que, además de abordar los déficits o las ineficiencias tecnológicas, se debe integrar un enfoque sistémico que considere el contexto cultural y la identidad al extensionismo rural a fin de garantizar que la adopción tecnológica se ajuste a los objetivos de sostenibilidad y resiliencia de esta cadena productiva.

Palabras Clave: cuy, innovación, asistencia técnica, extensión rural.

Introduction

In Latin America, contrasting visions and contradicting goals coexist regarding how to achieve sustainable agrifood systems. The region is recognized as an early adopter of agricultural biotechnology, including genetically modified organisms (GMOs), bioenergy generation, and the transformation of technological capacities for attending export markets (Hodson de Jaramillo et al., 2021), a seemingly modernizing progression developed upon the "Green Revolution" premise that food security would be attended to through technological innovation. However, critics argued that modernization has been made at the expense of people and the environment through resource plunder, dispossession, and labor exploitation (Levidow et al., 2021).

An expert review of rural extension in Colombia from 2016 concluded that the main obstacle to enabling innovation in the agricultural sector was "that actors building knowledge on rural extension in Colombia have a limited intra and inter-institutional articulation" (Rodriguez et al., 2016, p. 393). Agriculture innovation experts recommended reforming the institutional framework for innovation and agricultural technology transfer to facilitate interaction between biological sciences and other areas of knowledge and strengthen the relationship between scientific research and local knowledge systems (Hodson de Jaramillo et al. 2021).

Santos's administration proposed and obtained parliamentary approval to reform the National Innovation System for Agriculture (SNIA, for its acronym in Spanish; Law 1876/2017). The government's primary aspiration was to reduce the inequality that disproportionally affects rural Colombia. For this, it committed to close the development gap between urban and rural areas following the *Acuerdo final para la terminación del conflicto y la construcción de una paz estable y duradera* (Agreement for Ending the Conflict and Enabling a Stable and Durable Peace between the Colombian government and the Revolutionary Armed Forces of Colombia [FARC] in 2016). With the SNIA reform, the government of Colombia aimed to address the science and technology studies' larger critique that technocentric approaches to innovation in the agricultural sector had continued protecting the interests of biotechnology corporations at the expense of local farmers, making agriculturists from developing countries dependent and controllable (Logan, 2017; Patel, 2012).

Compared to other Latin American countries such as Brazil and Mexico, where different rural extension models were piloted and reformed during the last twenty years (Rendon et al., 2015; Sette & Ekboir, 2013), in Colombia, rural extension was nonexistent before 2017. Law 1876 ordered transitioning from providing "technical assistance" to providing rural extension services. Transitioning to rural extension implies considering the landscape instead of simply advising farm-scale production system development. Unlike technical advice, the rural extension should consider social, environmental, and economic interacting factors of agrifood systems (Garrido-Rubiano et al., 2021). To facilitate reaching agreements between local communities, civil servants, research institutions, and private industry over innovation routes, the SNIA ordered the creation of practical coordination settings called Territorial Innovation Systems (TIS).

The study aimed to fill the knowledge gap regarding effective transitioning from technical advice to rural extension through the guinea pig production chain (GPPC) in Southern Colombia. It was hypothesized that farmers have continued receiving mainly or exclusively technical

assistance and technological advice. The decision to focus on the GPPC in Southern Colombia was made due to its social significance and economic importance in Colombia.

The rearing of guinea pigs is a cultural tradition of Andean peoples dating from precolonial times. Local communities consider these practices identity markers, making the livelihood representative of indigeneity. Considering its cultural significance, it may seem evident that technology adoption to better small animal husbandry, although essential to the livelihood, would likely not be the main factor to consider for improving its sustainability. Nevertheless, the research revealed that advisers, including those from the agencies endorsed by the government to provide rural extension services, continued to ignore non-technical considerations when offering expert advice.

Family agriculture (FA) in Latin America accounts for 60 % of the region's total bovine, porcine, and poultry production. FA also accounts for 99 % of the production of ovine, rabbits, and guinea pigs. Production of guinea pigs is strategically crucial to combating the prevalent chronic malnutrition of infants in South America (Salcedo & Guzman, 2014).

In Colombia, the legal criteria for FA are that family members must produce more than 50 % of labor inputs and reside on a farm or very close by. Legal recognition entitles small-scale farmers to lower-than-market average credit rates and technical advice with a differential focus. "Differential focus" implies that technical advice should be appropriate to the age, gender, ethnicity, sexual orientation, and disabilities of the targeted population (Resolution 464/2017).

The Nariño Province is Colombia's leading producer and consumer of guinea pigs. It accounts for 85.3 % of national production. Records from the Nariño Governor's office show that 89 % of FA units produce, consume, and/or commercialize guinea pigs as part of their livelihoods. In 2019, the GPPC benefited approximately 30,000 families. As consumer demand continues to increase in the South of Colombia, the importance of the GPPC is growing by the day (Organización de las Naciones Unidas para la Alimentación y la Agricultura [FAO] & Agencia de Desarrollo Rural [ADR], 2019). Not surprisingly, the Nariño Governor's office asked for collaboration from research and development institutions to characterize the GPPC to gather the documentation required to obtain its legal recognition (Gobernación de Nariño, 2019).

In Nariño, the GPPC is integral to the livelihood strategies of 30,000 indigenous and peasant households, providing income to 86 % of farms in the province. Pasto municipality, the capital of Nariño, accounts for 50.4 % of production, with 1,269,982 animals commercialized annually (Consejo Nacional de Política Económica y Social, República de Colombia, & Departamento Nacional de Planeación, 2014). UPRA, the rural agricultural planning agency, documented that small animal husbandry, mainly the GPPC, is a priority for farmers of Nariño (Organización Internacional para las Migraciones [OIM] et al., 2018).

A factor that makes guinea pig culture (i.e., the rearing, consumption, and commercialization of guinea pigs) so attractive is the low costs of infrastructure and inputs. Guinea pig culture is also a primary source of income for women, who can attend to the rodents without leaving the household. Women are used to foraging grasses from abandoned plots, public spaces by roadside, and forest reserves to complement feed. According to local producers, another appealing feature of guinea pig farming is sufficient genetic variability amongst breeds to maintain low-rate susceptibility to most diseases.

A 2019 study by FAO and ADR suggested that to make the GPPC sustainable in Nariño, the organizational model must suit small-scale producers. Such a model should consider income generation and other factors contributing to FA's increased well-being (FAO & ADR, 2019; Garcia & Garavito, 2016). The impact assessment of programs for technical assistance must consider technology adoption metrics and their effective contribution to improving long-term social, economic, and environmental sustainability.

The Putumayo Governor's office had suggested that a limiting factor for GPPC expansion amongst family agriculturalists was that most agribusinesses never get legalized. Producers from Sibundoy (Putumayo) began organizing in 2019 to push for official recognition of the GPPC to receive the benefits they would be entitled to (Alcaldía de Sibundoy, 2019). The Governor's office speculated that the benefits available to small agribusiness were reaching very few guinea pig entrepreneurs (Gobernación del Putumayo, 2016).

The research team assembled hoped that the characterization of the GPPC and the assessment of the process of transitioning from technical advice to extension would facilitate civil servants and stakeholders along the GPPC to speed the legalization process of the GPPC and develop an informed strategy to advance rural extension along the chain. The objectives of the research were to characterize the GPPC in southern Colombia and to identify the advances and barriers that facilitate or prevent GPPC transitioning from receiving technical assistance to having rural extension services.

Materials and methods

The National Government, the Ministry of Agriculture (MADR, for its acronym in Spanish), and the Nariño Governors' office have called private industry and agriculture experts to guide the implementation of a rural extension to the GPPC focusing on family agriculturalists. Amongst those called was the Colombian Corporation for Agricultural Research – Agrosavia. A team of professionals, technicians, and researchers from Agrosavia (i.e., animal health experts, agronomists, veterinarians, and social scientists), who were already investigating the efficiency of guinea pig production systems, formulated a proposal to advance inter-institutional cooperation in defining how research and rural extension programs were to advise stakeholders along the GPPC. Mixed, quantitative (survey), qualitative (focus groups, interviews), and specialized (in farm animal husbandry and technology appraisal) tools and instruments were outlined in the proposal that successfully bid for funding. A key component of the proposal that informed all activities was that the research team was to encourage significant participation from all stakeholders along the GPPC: producers, traders, restaurateurs, and farming organizations.

The research was conducted in several stages. First, through desk research, we reviewed previous interventions to strengthen the production chain. The few articles on animal husbandry and guinea pig culture referenced in the proposal were further scrutinized. The chapters of reports from the Putumayo and Nariño Governors' offices regarding the guinea pig value chain or the role assigned to guinea pig agribusiness in province plans were handy. Besides, dispersed web pages and press releases provided helpful information for preparing surveys and sketching interview scripts.

In the second stage, the survey was tested and conducted, and farm visits were made to observe and record the animal husbandry routine on-site. The desk research, a broader literature review on guinea pig rearing and commercialization in the Andean region, and the priorities established by municipal secretaries of agriculture allowed the research team to determine the themes of paramount concern that informed the survey design and interview scripts. Data to be collected would refer to (a) producers, including identity and cultural affiliation; (b) the production unit, including geographical location, infrastructure, management of farming areas, and environmental management; (c) management of production systems, including nutrition, reproduction, health, and sanitation; (d) promotion and commercialization; (e) technical knowledge and technology adoption through the production chain.

In the third stage, interviews and focus groups were conducted. The sketched interview scripts were related to themes of interest to stakeholders along the production chain. The interview scripts were reformed and edited after the survey to approach participants willing to expand and clarify responses or issues that surveyors annotated and that could help qualitative data generation. Reflectivity occurred following activities at stages two and three. No specialized software was used to analyze qualitative information; coding and categorization were done manually, and data interpretation and summary narrative were a collective effort coordinated by an experienced ethnographer.

Three focus group workshops were held to critically discuss previously identified challenges (through the survey and interviews) to providing rural extension service in the GPPC. Participants in workshops included representatives from the Nariño Governor's office, FAO, Colombian Farming Institute (*Instituto Colombiano Agropecuario* [ICA, for its acronym in Spanish]), Agrosavia, Universidad Nacional Abierta y a Distancia (UNAD), Universidad de Nariño, National Learning Services (SENA, for its acronym in Spanish), Pasto Secretary of Agriculture, Center for Social Innovation of Nariño (CISNA, for its acronym in Spanish), producers, traders, and restaurateurs.

Survey

The following formula was used to estimate an adequate sample number:

$$n = \frac{Z^2(\sum W_h S_h)^2}{\varepsilon^2 + \frac{Z^2}{N}\sum W_h S_h^2}$$

Where n: sample size; z: percentage value to achieve 95 % statistical reliability related to standard distribution; Wh: strata relative weight; Sh: estimated standard deviation per strata; h: number of strata; ε: estimation error; N: number of production units.

Considering the total number of guinea pig producers in Nariño and Putumayo, we estimated that to obtain high reliability, 204 producers must be surveyed from Pasto (Nariño) and 200 from Alto de Sibundoy (Putumayo). The survey was then tested and administered.

Guinea pig producers surveyed in Nariño included those from the Pasto and eight adjacent *corregimentos* (administrative units ascribed to municipalities). The number of participants per corregimiento in Nariño was as follows: Cabrera (13), Catambuco (29), El Encano (66),

Gualmatán (7), Mapachico (8), La Laguna (37), Morasurco (24), Obonuco (11). Surveys were administered in four towns of Putumayo: Colon, Santiago, San Francisco, and Sibundoy. The overall number of participants and their percentage weight were: Pasto and eight *corregimientos* of Nariño, 204 (50.5 %); Sibundoy, 109 (26.98 %); Colon, 54 (13.37 %); Santiago, 22 (5.45 %), and San Francisco, 15 (3.71 %).

Results

Responses to the survey were clustered into 11 categories (strata) and input to Microsoft Excel to obtain a descriptive statistical analysis (data processing through IBM® SPSS® Statistic 20.0.0, 2011). The results showed that:

- 28.6 % of producers use a management program for breeding and reproduction

- 28.5 % have built infrastructure specific for guinea pig breeding.

- The predominant feed used is fresh grasses (97 %). Common grass species used are Falsa Poa (*Holcus lanatus*), Kikuyo (*Cenchrus clandestinus H*), Raigras (*lolium sp*), Pasto Imperial (*Axonopus scoparius*), Trébol Blanco (*Trifolium repens*) and Hierba Cinta (*Phalaris arudinacea*). Besides, 84.2 % of producers collect grasses without forage management plans, and 90.8 % did not supply water to keep animals during the survey.

- Reproductive management planning for breeding shows a sex ratio selection of 45.8 % males and 37.0 % females. Only 37.1 % of breeds used are considered improved breeds. Also, 78 % of respondents said to induce reproduction immediately after females give birth.

- On commercialization, 87.6 % of produce is allocated for farm-family consumption with surplus sales; 89.6 % of sales are per unit (one guinea pig). Moreover, 71.8 % of producers have instituted a minimum sales price.

- Percentage of capacity-building themes requested to technical advisers: bookkeeping (35.1 %), feed formulas (98.5 %), breed identification (55.8 %), treatments and medication (49.6 %), cooking recipes (52.7 %), breeding and production system (30.9 %), waste management and organic composting process to get fertilizer for farm cultivars (53.3 %).

Synthesis of survey responses and follow-up interviews

Food and nutrition: Most producers, and all of whom maintain guinea pig culture as a principal livelihood, had followed technical advice regarding (1) replacement of collected herbs and grasses with cultivated grasses; (2) provisioning of feed supplement bought or made within the farms (e.g., hydroponic cultivars); (3) nutritional planning considering animal physiology to increase animal weight; and (4) providing animals with water.

Contravening advice provided (by UMATAs [municipal units of technical agricultural assistance], EPSEAs [agricultural extension service providers], and secretaries of agriculture), farmers have kept the "oreo" tradition, which consists of sun-drying pastures and herbs. They

have documented that *oreo* practices reduce or sustain low morbidity and mortality rates, particularly in preventing tympanic syndrome.

Epidemiology: Advice was followed regarding (1) isolating animals immediately after disease symptoms are detected, (2) supplementing animals with vitamins to prevent diseases, and (3) introducing prophylactic deworming. The advice was rejected regarding replacing traditional medicine with allopathic medicine (4), with a preference to continue treating animals with conventional medicine.

Capacity building: Producers (1) have contracted and attended capacity-building sessions to identify pests and diseases better; (2) have learned and are conducting necropsies to identify causes of morbidity and mortality; (3) having understood the principles and logic of Western medicine, are said to be more inclined to consult with veterinaries; (4) have implemented footbath and other disinfection schemes with chalk and iodine as bio-security measures. They corroborated that all these practices have significantly reduced morbidity and mortality rates.

Genetic improvement: Interest was expressed regarding genetic modification. However, interviewees said they would be prevented from implementing a genetic improvement program due to the lack of availability of quality breeds. Subsequently, the research team corroborated shortfalls regarding the quality and quantity of introduced improved genetic breeds in Colombia.

Infrastructure: The interviewees agreed that infrastructure develops slowly but highlighted that this is not due to lack of interest. Instead, they highlighted significant difficulties in accessing credit and the high credit rates, noting that producers with access to credit have significantly improved their infrastructure.

Waste management: All new infrastructure developments have an appropriate design to manage waste, with manure and urine collected for composting.

Organizational development: Interviewees emphasized that some of the most sophisticated facilities were not funded by wealthy individuals but by an association. These interviewees complained that financial institutions offer lower interest rates to more affluent individuals when compared to the higher interest rates provided for organizations.

Reproductive system: Reproductive care is informed by phenotypic characteristics, age, and sex. Producers aim to reduce endogamy, but they have not corroborated if the measures adopted have been effective. Most producers are now capable of sexing animals, which allows planning based on physiology and reproductive cycles.

Summary of ancillary information from interviews

Ancillary information was obtained from interviewees who volunteered further details following the survey or during interviews. Most are said to be confident of increasing income by improving their business management. Very few are concerned with improving safety standards regarding animal feed and health. Instead, their main concern was improving their management, processing, distribution, and commercialization competencies. Most interviewees highlighted the urgency of improving their marketing and management competencies to place and promote their products and services. Interviewees underscored that guinea pig culture remains their preferred livelihood strategy. They said to have identified the need to adequately communicate

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the importance of guinea pig culture, considering that some public/clients would be attracted to agribusinesses that aim not only to increasing profits but also to preserve traditions. They were convinced that passing that message to consumers would provide opportunities to strengthen their networking capacity and food security and increase their income.

Summary narrative emerging from qualitative analyses and reflexivity

Through the workshop discussions, guinea pig culture's main challenges relate to commercialization and overcoming obstacles preventing legal recognition of the guinea pig value chain. Participants agreed that efforts in developing livelihood strategies from the government had concentrated mainly on formalizing production chains of potatoes and dairy products, neglecting guinea pigs. Stakeholders participating in various links of the production chain complained that the government was encouraging (with direct funding and access to credit) cultivation of promissory and non-established crops such as *uchuva* (*physalis peruviana*) and blackberry (*rubus*) instead of funding the expansion of guinea pigs. Those involved in marketing and commercialization emphasized that such an approach disproportionally and negatively affected rural women, as the commercialization of guinea pigs remains their primary income source. Producers pointed out that government funding for technical assistance and technology advice was precarious, and it rarely reached the village farms, concentrating in municipal centers instead.

Producer participants praised recent research efforts from the Universidad deNariño, Agrosavia, and SENA that have focused on issues of interest to family farmers, something already highlighted by Caycedo et al. in their 2011 assessment.

During focus group discussions, representatives from FA organizations and guinea pig producers contradicted expert suggestions that they lack interest in modernization. They stated to be making serious efforts to adopt technologies. Such statements coincided with responses to the survey and insights provided during interviews, indicating increased technology adoption rates. They also argued that contrary to recommendations by technical assistants or technology advisers, the challenges that the production chain needs addressing relate not only to shortages in technology adoption but also to developing competence for effective commercialization, marketing, and finance management.

A perceived threat, to which epidemiologists agreed with producers, is the dissemination of Yersiniosis, an infectious disease caused by a bacterium of the genus *Yersinia*. Survey results indicated that despite the perceived threat, 74.5 % of respondents had said not to plan for disease management. Epidemiologists argued that not having contingency plans in case of epidemic outbreaks indicates neglect, highlighting that as early as 2007, Jaramillo et al. have identified Yersiniosis as the leading cause of economic losses for producers. During focus groups, some producers and veterinarians speculated that the prevalence of Yersiniosis is caused by poor genetic variability. However, a long-term comparative study of planning and implementation for disease control with and without introduced genetic variability is yet to be conducted. Such research results should indicate if the production process with disease control management without introduced genetic variability is enough to maintain low mortality and morbidity rates. Only with such evidence-based information would producers be able to decide whether an investment in genetic renovation is economically justifiable.

Experts asserted that there has been an absorption of native genetic material into an improved Peruvian genetic line introduced in Colombia. These experts recommended establishing a conservation plan to preserve the native genetic line from Nariño. Additionally, they recommended organizing genealogic bookkeeping and using this information to plan for the reduction of endogamy rates, echoing previous recommendations by Burgos Paz et al. (2011).

More extensive research is needed to detail market segmentation and to develop commercialization strategies. Some producer participants, distributors, and traders considered increasing the production scale desirable. However, there is no evidence that enlarging the business in terms of volume and intensification could improve the sustainability of guinea pig culture livelihood. Several producers and distributors are said to be interested in exporting. They argued that it is necessary to mobilize to pressure the government to begin issuing "food safety certificates," without which they are legally impeded to export. Issuing such certificates is the responsibility of ICA, which has neglected its duty.

According to participant stakeholders along the production chain, their prominent knowledge deficits are related to marketing and management. Consequently, they request capacity-building sessions to develop competence and capacity in agribusiness marketing and management.

Discussion

Annotated observations when applying the survey, notes from farm visits, interviews, focus group discussions, and reflective analysis sessions were coded, categorized, and reassembled into the following summary narrative.

For GPPC stakeholders, maintaining cultural traditions is equally vital to accessing technology and acquiring business competencies. Research participants related to different links of the production chain confirmed that guinea pig culture favors income generation for rural women. Therefore, they insisted that extension services, planning for economic development, and capacity-building programs related to this production chain should consider women's specific needs and circumstances.

Analysis revealed consensus amongst stakeholders along the GPPC that modernization is not, as suggested by experts, enabled by technology adoption alone. Instead, adaptation and adoption must ensure that local knowledge and traditions are integral to such processes and conducive to increased sustainability of their livelihoods.

Producers surveyed and interviewed, and stakeholder participants in workshop discussions highlighted that those who have become specialized traders were producers of humble origin. These traders, it was recalled, like to maintain a low profile in their communities, sharing knowledge and expertise, which makes other traders and producers listen to their advice. Some stakeholders and coordinators of the workshop suggested that this type of experience should be systematized and considered when designing rural extension programs.

Reflectivity notes revealed consensus amongst participants who have personally benefitted from specializing in marketing and, more importantly, that the communities they belong to have also been helped. In effect, they said, profits have been reinvested in family farms and FA

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organizations. When reflecting on the socio-political impact of promoting technology adoption, it was the view of most stakeholders that assessing and developing strategies for increasing collective benefits has been neglected by advisers and that it has been of no concern to investors.

Representatives of producers and FA organizations agreed that investors, rural extension providers, and even researchers have focused their investigations and interventions on advising individuals to increase economic gains. Representatives of FA and farmers' organizations called researchers, technology advisers, and rural extensionists to participate in the focus group workshops to advise on developing strategies that would benefit families and communities instead.

Qualitative data analyses, including summary narratives from reflective practice, revealed a common interest of stakeholders in the production chain obtaining legal recognition. However, it appears that different actors/links of the chain are uncertain about how, or to what extent, they would benefit from such recognition. Reflecting on the discussion about this issue during focus groups, the research team agreed that producers have yet to realize that government investment in developing chain goods is limited. It was noted that some stakeholders, particularly family farmers, seem unaware that organizational costs in planning, asset mobilization, and investment would need to be footed by stakeholders of the production chain.

A significant concern reflected in the discussions of workshops is that most family agriculturalists are said to be disappointed that their children and grandchildren show no interest whatsoever in production know-how or in getting involved in the guinea pig business. However, the data collected through the survey and interviews, as well as that generated through workshop discussions, is insufficient to assert that this lack of interest is exclusive to guinea pig culture or is generalized toward FA livelihoods.

One important finding is that researchers, rural extensionists, and FA organizations agreed that guinea pig culture is a resilience strategy. Interviewees explained that when facing (environmental or economic) shocks, they cannot rely upon income from cultivars such as potatoes and peas, as larger agriculturalists do. Some interviewees illustrated resilience with some examples. For instance, they have experienced environmental shock due to droughts; following drought, their cultivars grow to a lower standard than what is required by retailers. They also experienced economic shock when the national government allowed the suspension of levies to imports of basic food supplies, in which case retailers' buying prices of FA products were lower than production costs (agricultural inputs, labor, and transactional costs). During these crises, family agriculturalists have sold available guinea pigs and increased production to attend to urgent necessities or pay credits. Available guinea pigs are sold when extra expenses are incurred following personal emergencies. In all these cases, family agriculturists have managed to absorb shock and adapt through increasing guinea pig sales. In some cases, they have increased the guinea pig volume using available farm space or by aggregating numbers of animals through small landholder associations.

During interviews and workshops, it was discussed how to make production systems more sustainable and efficient. Small animal husbandry experts and technicians departed from proposing improving communication strategies to promote modernization. In their view, the challenge was to make producers understand the importance of technology adoption to achieve

productivity gains. Although aware that producers have sometimes questioned or ignored some of the advice offered, these experts and professionals seem to have failed to understand the rationale of stakeholders. Social scientists from the Agrosavia team encouraged producer participants to reply to experts in the workshops. As a result, some stakeholders argued that advice of modernization contradicted traditions and that some types of technology adoption were not economically worthy, considering low return over investment. It was revealed that animal husbandry experts and technology adoption advisers, including extensionists, have continued claiming that the current production systems suffer from varied deficits: investment deficit that prevents modernization, knowledge deficit in food safety, and interest deficit from producers.

Reflecting over the way argumentation developed regarding the modernization of the GPPC suggested that the technical/technology adoption advice provided incorporates no assessment of the sustainability of livelihood strategies of family agriculturalists. This analysis revealed that experts and professionals who provided technical assistance or technology advice during the study found it difficult to address the challenge of increasing the sustainability of livelihood differently than by advising technology adoption.

Although some producers agreed with technicians and experts that they could benefit from reaching technological optimal, they said they are restricted in adopting new technology due to a lack of financial capital and high credit rates. Therefore, the modernization promoted by experts and rural extensionists is not business-optimal. They argued that technology-optimal does not equate to sustainability optimal for livelihood, which needs to consider social context and cultural appropriateness. Evaluating all these considerations and the amount of work necessary to reach the advised technology optimal has caused some producers to desist from modernizing.

Following the workshop discussions, farmers, experts, and technicians agreed that financial burden significantly restricts technology adoption. The research team believes this agreement is vital to improving expert advice and facilitating a transition to rural extension. The research team also noted that promoting technological adoption and adaptation will encounter other obstacles related to local beliefs or cultural adequacy. However, it should be considered a significant advance, having producer organizations acknowledge that cultural inadequacy is less challenging than financial hurdles. The team anticipated that the agreement has the potential to positively influence planning for rural extension programs targeted to family agriculturalists.

It was revealed that advice from animal husbandry experts to replace traditional medicine with allopathic medicine for the treatment of animals has been, and more likely will continue to be, ignored by peasants and indigenous peoples. Stakeholders agree that such advice disregards cultural practices fundamental to most family agriculturalists. Before focus group workshops, in the questionnaire responses, most producers had already highlighted that traditional medicine is better for them not only because it is far cheaper or readily available for free but also because of the bitter taste guinea pig meat acquires when animals have been treated with "Western medicine." Participant traders and restaurateurs in workshop discussions agreed with producers that they should use allopathic medicine only when unavoidable—particularly considering their efforts to attract environmentally conscious consumers. These traders and restaurateurs are said to be willing to collaborate with producers to obtain organic certificates. The representatives

from producers immediately agreed and corroborated that this effort also aligns with recommendations made by traditional authorities and the elders. They asserted that taking the advice of using "Western medicine" will only increase dependency, diminishing the resilience of family agriculturalists' livelihood strategies. In their view, embracing Western medicine would harm guinea pig culture traditions. Besides, they argued that guinea pigs' morbidity and mortality rates are already low.

In summary, the case study of guinea pig culture seems to suggest that in the provision of technical advice and current rural extension services, advisers continue to aim at reaching the technology optimal instead of focusing, as stakeholders demand, on increasing sustainability (environmental, economic, socio-political) and resilience of livelihoods.

Worryingly, at present, the notion of technical innovation deficit is a joint base of public policy for advancing rural development. This ubiquitous discursive trope legitimizes institutional biases by both government and research institutions (Pfotenhauer et al., 2019). Such prejudice has the pervasive effect of marginalizing non-Western epistemologies, traditional knowledge, and social functions that do not prioritize technical innovation when aiming to enhance sustainability and increase resilience.

This analysis confirmed that livelihoods' economic, environmental, and cultural sustainability increases when an integrated approach considers technological adoption, local knowledge, and traditions. The main lesson learned from the reflectivity of this research is that professionals, experts, and those currently providing technical advice and rural extension services have found it very challenging to accept that decision-making regarding production systems and innovation paths must consider variables that they have been ignoring until now. It has been difficult for advisers to accept that what they deem "technically optimal" is informed by a rationale that is embedded within a system of values (culture and traditions), that such rationale may differ significantly compared to that of technology end-users, and that it cannot be deemed as superior or unbiased. The tendency to intuitively or unconsciously deem a technoscientific system of knowledge as superior has been found in many other technical adoption and adaptation studies. The case of guinea pig culture seems to corroborate that expert advice continues with pro-innovation prejudice (Pfotenhauer et al., 2019).

Confronting the main challenges

After presenting results from the survey and questionnaire to participants of the workshops, the Agrosavia team prompted discussion amongst stakeholders and advisers to reach a consensus over the main challenges. Participants agreed to work together to draft an action plan.

The Agrosavia team proposed creating a research and innovation facility for continuing research to identify the more technically suitable and culturally appropriate paths for enabling the transition from technical advice to rural extension regarding the guinea pig value chain. Researchers and stakeholders agreed to this proposal. However, designing a program for the innovation facility proved difficult.

Initially, experts proposed defining and developing capacity-building programs to advance knowledge gaps in epidemiology, breeding, and infrastructure. However, while agreeing that

these themes were important, producers, traders, and restaurateurs said they are now more interested in marketing, management, and commercialization issues. Stakeholders were particularly keen to acquire capacities and competencies to understand consumer cultures better and devise matching strategies to add value to products and services. They also argued that developing marketing and management capacities would make a better case to pressure the government to legitimize the guinea pig value chain.

Agrosavia's team suggested that for the facility to identify research and networking activities effectively, all parties needed to trust each other, ensuring that all stakeholders participate in the decision-making process and that benefits obtained from research or from developing new goods and services were shared. Regarding technology adoption and adaptation, the facility would ensure that advice and recommendations would be informed by all stakeholders' needs, interests, knowledge, and expertise.

The working plan consensually agreed upon included the following:

(1) pulling together, networking, and liaising with the Governor's office and the MADR to facilitate legal recognition of the guinea pig value chain;

(2) liaising with the Governor's Office to inform the UMATAs and EPSEAs on current and future research results, advising on the most promissory paths for transitioning to rural extension. The facility would issue specific recommendations for enabling a cross-sectoral approach to rural extension, considering limitations and opportunities available to family agriculturalists involved in guinea pig agribusiness, with particular attention to developing capacities and capabilities amongst women;

(3) mobilizing available assets to improve the promotion and commercialization of guinea pigs, focusing on accessing markets for consumers interested in environmental sustainability and preserving cultural traditions. Regarding marketing, stakeholders expressed confidence that better communicating the importance and richness of guinea pig culture would help enlarge domestic and export markers;

(4) designing and implementing a conservation plan to preserve the native genetic line from Nariño. Moreover, producers would benefit from organizing genealogic bookkeeping to have breeding plans to reduce endogamy.

The facility effectively entered into operation by December 2018. An exchange of promotion and marketing enabled a platform for online purchases. Agrosavia organized the liaison with the FAO (February 2019), and they provided funding for a platform.

A critical outcome of the research was that stakeholders could lobby the MADR for prompt legalization of the guinea pig value chain. Effectively, the MADR acknowledged that all requirements for formalizing the production chain have been met. In compliance with the national law, the MADR issued Resolution 00203/2022, whereby the organization of the production and agro-industrial chain of the guinea pig in Colombia was recognized and registered (MADR, 2022). During the launching ceremony, the MADR thanked the Agrosavia team for communicating the research results (that informs the current article), as it facilitated legal procedures for issuing the resolution.

The issue of government responsibility towards guinea pig agribusiness development following legal recognition of the production chain remains unclear and merits further investigation. A surgent hypothesis is that stakeholders, family agriculturalists in particular, seem to take for granted that following legal recognition of the chain, the government will provide the funding required to realize the potential of chain goods.

Conclusions and recommendations

Linear technology transfer models mistakenly conceive knowledge as a unidirectional process from experts to clients. So-called users/clients resent approaches based on that premise. Our study showed that in the case of the GPPC, stakeholders are unlikely to follow expert advice if their interests, knowledge, and expertise are not considered. It has been made explicit from our findings that any strategy for transitioning from technical advice to rural extension needs to enable meaningful participation of all stakeholders and ensure knowledge exchange. Knowledge exchange was possible in this research because non-hierarchical dialogue was encouraged. Acknowledging that animal husbandry experts and those providing technical advice have found it challenging not to focus mainly (or exclusively) on technology adoption, it is recommended that rural extension programs include training to enable teams to have a systemic approach that carefully considers identity and cultural context in the design of knowledge exchange and capacity building programs. Agronomists, veterinarians, and animal husbandry experts, who have until now provided technical advice, are ill-prepared to provide rural extension services. They need improving capacities and capabilities to assess livelihood resilience, understand and characterize cultural traditions, and enable co-innovation.

Our study confirmed that rural extension end-users would be willing participants in the design of culturally appropriate paths. For this to happen, research and development practices must acknowledge that other epistemic must be considered to broaden co-innovation possibilities. Therefore, it is advised that those currently involved in defining how entities providing rural extension services will be accredited to conduct a systemic review and learn from accreditation experiences in countries where extension services have been functioning for longer.

Further research

It was learned that flexibility in rural extension programs is needed, allowing for research on agroecosystems particularities and sociocultural context to inform the implementation of programs. There is a need for further research regarding the adaptation and development of pedagogical tools and instruments for facilitating the implementation of rural extension programs.

Regarding the challenge of epidemiological management of the production systems of guinea pigs, a long-term study comparing management with a plan for disease treatment without genetic improvement against one with introduced genetic variability needs to be conducted. To this aim, it is important to document and systematize information regarding conservation initiatives to preserve the native genetic line of guinea pigs from Nariño.

As highlighted in the results and discussion sessions, producers, distributors, and restaurateurs indicated that two principal challenges to making the GPPC sustainable relate to marketing competencies and overcoming obstacles preventing legal recognition of the guinea pig value chain. Having obtained the legal recognition of the GPPC, the second challenge remains. Therefore, rigorous, long-term research is needed to implement long-term commercialization strategies.

Contributions from authors

Rocio E. Patiño designed the research "*Escalonamiento de la investigación regional y de la innovación de pequeños productores de cuyes en la escala de valor,"* coordinated research bidding, and administered research grant after funds were awarded. Paola A. Portilla and Luz Dary Carlosama conducted and analyzed a survey/questionnaire and evaluated animal husbandry performance on sites. Oscar A. Forero led qualitative data generation (interviews, focus groups, workshops) and coordinated qualitative data analyses. Presentation and dissemination of results and writing up of the reports and the current manuscript comprised a collective effort coordinated by Oscar A. Forero.

Conflicts of interest

We, the authors of the manuscript, hereby declare that we had not, and currently have no conflict of interest regarding the research "Escalonamiento de la investigación regional y de la innovación de pequeños productores de cuyes en la escala de valor," which informed this article. The authors declare no affiliation to any business for-profit organization or contractual employment agreement that could influence the research process, treatment of data, or obtention of results to the reference project. The authors thereby confirm that we have not and will not receive any payment or financial benefit by publishing the manuscript.

Ethics approval

The authors declare that ethics approval was obtained and that IFAD and Agrosavia ethical procedure guidelines were consistently followed during the research process. We, the authors, hereby confirm that that manuscript does not contain any data from a person; therefore, consent for publication is not applicable.

Consent to participate

We, the authors, hereby confirm that research participants attending workshops, responding to the survey, or being interviewed participated voluntarily, were informed of the objective of the research, and completed the standard consent form that Agrosavia requests in compliance with all the laws and regulations of Colombia, where the research activities took place.

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