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University-community Partnership Contribution Towards Rural Sustainability: Participatory Action Research in the Rice Farming Community of Paipayales, Ecuador

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Abstract. Rice cultivation is the main economic livelihood for many families around the world. This activity represents several challenges for farmers and community members for rural sustainability, a cross-cutting element of the Sustainable Development Goals (SDGs) of the United Nations (UN). In response, the Polytechnic University (ESPOL), fulfilling its mission of linking with society, implemented a community program where students and professors interact and collaborate with rice farmers in the rural community of Paipayales, located in the Santa Lucia canton, Guayas province. This article explores the impact of university-community projects through the Participatory Action Research (PAR) approach in order to evaluate them as a tool for contributing towards rural sustainability in communities. As a result, it was determined that the main problems faced by most of the farmers of the "Dios con Nosotros" Association are the availability of water in the wells and the commercialization of paddy rice. Considering these problems, the wells were geolocated and a board was designed for proper water management; at the same time, water quality was studied and recommendations were presented according to the problems encountered. Two proposals were also presented to create a rice husker and a rice separator to increase their profit margin by selling rice directly to retailers and wholesalers. As relevant conclusions, the importance of implementing links and relationships between the university community and society was highlighted, guaranteeing the value of working in transdisciplinary teams and achieving a comprehensive intervention that would lead to significant improvements in the community.

Key words: rural sustainability, university-community partnerships, agriculture, Participatory Action Research, rice farming.

Introduction

Universities play an essential role in addressing pressing social issues and fostering growth in wealthy areas (Carrión-Mero et al. 2021); therefore, their community participation is essential to promote rural sustainability and thus achieve the Sustainable Development Goals (SDGs) (Nhamo and Mjimba 2020). Thanks to technological advances, higher education institutions (HEIs) are now networked and can reach even the most remote areas, fostering connections between institutions and local people (Brouwer et al., 2022; Strand et al., 2003). This way, linkages help share information and resources (Weerts & Sandmann, 2010).

Taking this opportunity into account, the Polytechnic University (ESPOL), through the Unit for Links with Society (UVS, Spanish acronym), carries out cooperation initiatives with various communities

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in Ecuador. Among these projects is the work carried out by students and professors from different careers to propose solutions to the problems faced by the Association of rice farmers "Dios con Nosotros" through the project "Evaluation and optimisation of water, energy and logistical sustainability in the community of Paipayales, Santa Lucia".

On the other hand, one of the world's most important staple crops is rice, which provides a livelihood for millions of smallholder farmers. More than 100 nations grow rice, as it is an essential grain for more than half of the world's population (Fukagawa & Ziska, 2019). However, several challenges related to rice cultivation hinder economic growth in rural areas and the quality of life of their community in such a way that the community ensures permanent progress without causing harm to the environment; that is, rural sustainability, in line with the Sustainable Development Goals (SDGs) to reduce poverty, ensure food security and combat climate change. Therefore, to create and implement policies and interventions that promote sustainable rice production, policymakers, researchers, and development practitioners can benefit from knowledge of the constraints faced by rice farmers.

In Ecuador, this grain is one of the staple foods in families. Compared to 2019, the rice sector exported 32.9 MM $ FOB in 2020, an increase of 81%. Moreover, in 2020, 77 companies were engaged in rice production, creating 534 jobs in this industry (Subgerencia de Análisis de Productos y Servicios, 2022). However, the rice chain continues to face significant problems, despite government intervention through the imposition of minimum support prices, production limits and measures for direct and indirect support to producers (Marín et al., 2021; Zambrano et al., 2009).

Consequently, this article investigates the effects of university-community programmes as a tool to contribute to rural sustainability in communities, exploring the various challenges faced by the farmers of the "Dios con Nosotros" Association concerning the rice marketing process and the solutions proposed by academia. Participatory Action Research (PAR) involves teamwork between researchers and project participants to collect data aimed at social change (Pain et al., 2019). Therefore, this article explores the impact of university-community projects through the PAR approach to evaluate them as a tool for contributing towards rural sustainability in communities.

The results indicate that farmers need help regarding water availability in wells. Therefore, the researchers mapped the wells to identify their location and then created two dashboards that obtained real-time information on the amount of water. The dashboards allow them to keep a record so that farmers have first-hand information and can make the respective corrections. Similarly, an investigation was carried out to determine the water quality levels, where it was found that the physical parameters were within the acceptable ranges according to one of the main regulatory instruments that made it possible to build public policy on environmental issues in Ecuador since 2003 is the unified text of secondary environmental legislation (TULSMA), through Executive Decree 3516. However, they could be more optimal for rice cultivation. In addition, there are high chloride concentrations, so creating drying pools is recommended. Similarly, a high alkalinity level was found in the water wells, so using calcium nitrate is recommended to remove excess bicarbonates. In this sense, the solutions proposed, and the tool created include better water management, ensuring safer and more reliable access to water for irrigation and human consumption, contributing directly to *SDG 6: Water and Sanitation* by promoting equitable access to clean and safe water for all.

Similarly, the farmers in the association mentioned that they lack milling equipment; thus, marketing paddy rice is their main problem. This fact is compounded by the fact that 67% of those selling milled rice stated that the service costs are higher than 2.00 USD, while 67% of the farmers selling paddy rice indicated that they believe the milling service costs should be lower than 2.00 USD for them to be able to use it. Considering this issue, the students proposed the development of two machines: a rice separator and a rice husker. By making both machines available to the organisation's members, the farmers are expected to increase their profit margin by selling rice directly to traders and wholesalers.

Consequently, by addressing the challenges related to rice production and marketing, the proposed solutions have the potential to increase the income of local farmers and reduce poverty in this rural community, aligning with *SDG 1: No poverty*. In turn, increasing the productivity and efficiency of rice production can make a big difference in the community's ability to increase food availability, thus contributing to the achievement of *SDG 2: Zero Hunger*. Furthermore, with the implementation of the proposed technology and suggested practices, new jobs can be created and local economic development can be increased, thus contributing to the achievement of *SDG 8: Decent work and economic growth*.

The article is composed of five sections: The introductory section, where the authors present brief information about the context of the research and the objective of the research; the second section of the theoretical framework, where information about rice production in Ecuador and the study site is presented; the third section of materials and methods, where the process and tools that were used for data collection are explained; the fourth section where the main results are shown; finally, the fifth section presents the discussion and conclusions of the study.

Theoretical Framework

Rice production in Ecuador

One of the world's most important grain crops is rice, which contributes significantly to global food demand, demonstrating its relevance to global food security (Chauhan et al., 2017). Asia is said to be where rice first appeared. Of the several varieties of rice, Oryza sativa, the most common, is a Southeast Asian species and one of the world's oldest cultivated species (Mahajan et al., 2017; Molina et al., 2011). This grass thrives in moist soils and requires specific attention to give appreciable yields per hectare at the end of the production cycle (Stuecker et al., 2018).

The soil's geographical, physical and chemical qualities and climate are the basis for ideal crop production circumstances (Valverde-Arias et al., 2018). For example, in the case of rice, its quality and, consequently, market value depend mainly on its production process (Figure 1) (Ford, 2014; Subgerencia de Análisis de Productos y Servicios, 2022). In the case of Ecuador, rice-growing regions have a wide range of climatic conditions, from humid tropical to dry tropical, with temperatures between 20° and 30°C, maximum annual rainfall of 2500 mm and minimum annual rainfall of 500 mm, and typically high humidity, which facilitates rice cultivation (Celi, 2021).

In Ecuador, this grain is a staple food for families; it is estimated that per capita consumption is approximately 53.2 kg per year (Gavilanes-Terán et al., 2019). Consequently, in economic terms, 96% of rice production is for domestic use, while the remaining percentage is exported (Viteri & Zambrano, 2016). Furthermore, the sector of other crops recorded $2,824.19 MM in GVA in 2020, accounting for 4.26% of the GDP (Subgerencia de Análisis de Productos y Servicios, 2022). Specifically, rice cultivation obtained 371.83 MM in sales and exports; while rice production was 1.3 million tonnes, with an 18.2% year-on-year improvement, with the province of Guayas having the highest production and the largest total harvested area with 65% (Márquez, 2021).

In terms of business, 67% of the 87 companies dedicated to rice cultivation in 2020 were located in the province of Guayas. Moreover, of the 658 jobs created by this industry, 62% were represented by small-scale rice producers from the rural population, thus demonstrating their commitment by creating most of the jobs for themselves; they also contributed at least 5% of the total production of goods and services in the country (Castillo, 2021; Subgerencia de Análisis de Productos y Servicios, 2022). Similarly, in the same year, however, there were 18 enterprises engaged in rice milling or piling; 78% of these enterprises were located in the province of Guayas, where large enterprises employed 67% of the labour force (Subgerencia de Análisis de Productos y Servicios, 2022).

In terms of funding, compared to 2019, the financial support provided to the rice cultivation sector decreased by 10% in 2020, being $91.50 MM, while it grew by 31% for the rice milling industry with $42.55 MM. However, private banks provided 92% of the credit volume for the rice farming sector and 98% for the rice milling and stacking sector (Subgerencia de Análisis de Productos y Servicios, 2021). Furthermore, the sector's statistics for 2021

Figure 1. Rice production process.

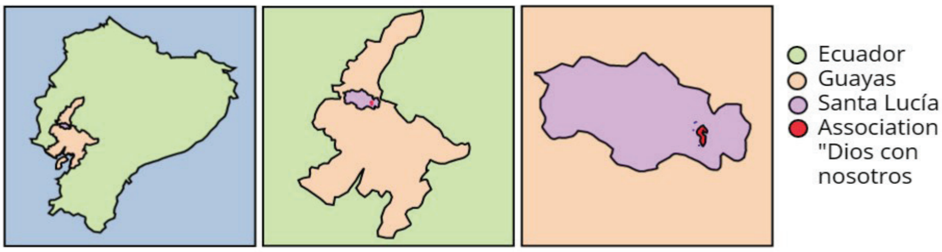


Figure 2. Geographical location of the Association "Dios con Nosotros"

Source: ESPOL (2017)

are optimistic. To begin with, 39% more credit was granted to the rice farming sector than the previous year, with private banks providing 95% of the financing. Meanwhile, private banks provided 84% of the financing for the rice milling industry, taking into account that the volume was $55.19 billion, i.e. 30% more than the previous year (Subgerencia de Análisis de Productos y Servicios, 2022).

Information about Paipayales

In the canton of Santa Lucía, Guayas province is located the community of Paipayales (See Figure 2). The lush area of Santa Lucía supports a variety of tropical crops, including bananas, mangoes, papaya, coffee, cacao, and, most importantly, rice. Excellent quality horses, pigs and cattle are raised, and beekeeping is practised to produce and industrialise honey and beeswax. The extension of this locality is 359 km^2 and is occupied by 45,004 people, divided between rural and urban areas (Prefectura del Guayas, 2022). It has an average annual rainfall of 1962 mm, with February being the wettest month (329 mm) and August the driest (51 mm). It has flat and gentle altitudes between 0 and 7 metres above sea level, although, in high areas, these figures can reach 194 metres above sea level; in addition, its average temperature ranges between 20.1 °C and 30.5 °C (Alvarado Aroca, 2022; Weather Atlas, 2023).

Paipayales has 400 inhabitants. Most of their work is done in rural areas, as the locals are engaged in agricultural work and raising farm animals, such as chickens, pigs, ducks and chickens. One of the leading agricultural activities practised by 40% of the population is rice cultivation. In the commune, there is a group of rice farmers whose association is called "Dios con Nosotros", founded in 2000 and in which 36 farmers participate. Residents sometimes meet here to discuss the rice industry's problems (Paipay, 2021). Due to the biophysical qualities of the soil, as shown in Figure 3, the farmers in this association mostly grow rice, and most of them have been doing so for more than 30 years, in fact, 88% of the soil area is used for agricultural activities, 3% is dedicated to conservation and protection, 3% belongs to the Daule River, 2% is for anthropic, and 2% is for conservation and production. Finally, 1% is used for mixed farming (ESPOL, 2017).

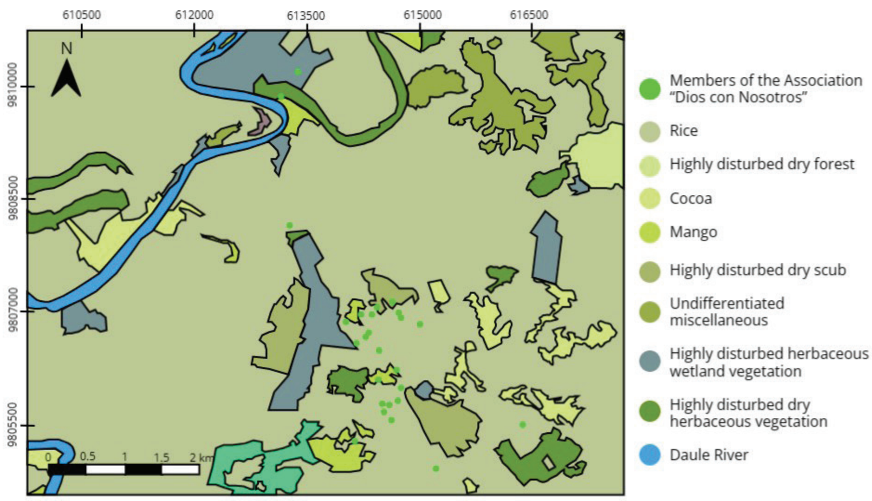


Figure 3. The land cover map of the Association "Dios con Nosotros"

Source: ESPOL (2017)

Materials and Methods

Participatory Action Research (PAR)

This study employs Participatory Action Research (PAR), a research approach involving collaborative action between researchers and people who are affected by a problem and take the initiative to solve it (Chevalier & Buckles, 2019). Being a collection of ideas, techniques and practices that drive the research process, PAR is more than a framework (Pain et al., 2019). Underpinning PAR is the notion that decision-making and research should involve the people most affected by a problem or issue (Cohen et al., 2017; Méndez et al., 2017). Through their participation in the research process, communities and individuals can achieve constructive social change (Cahill, 2007; Kindon et al., 2007).

PAR is a method for merging research and instruction in a cooperative learning experience and problem-solving environment (Carrión-Mero et al., 2021; Van Peursem et al., 2016). While students benefit from the Service-Learning programme, PAR allows institutions to produce meaningful research for communities (Bodorkós & Pataki, 2009; Winkler, 2013). In this case, this approach is used for a joint project between students and teachers of ESPOL together with the farmers of the Association "Dios con Nosotros" in Paipayales. It is worth mentioning that students from different careers, such as mining and petroleum engineering, electronic and automation engineering, and business administration, participated in this programme. Furthermore, for this project, various activities were carried out in each of the 4 stages: planning, investigation, analysis and reflection (Ayantunde et al., 2024).

Planning

In the first instance, as this study is part of a larger community programme, a literature review was conducted based on the project reports in its different phases and areas to contextualise the present work. Reports, papers and records generated throughout the different stages of the project in Paipayales were studied in detail. In this way, the research allowed us to identify areas that need to be continued, as well as opportunities for the development of this project. From this, the project stakeholders elaborated guiding questions to find out more about the current problems of the farmers in this association.

Investigation

During this research phase, the researchers and students had the first contacts with the Paipayales community with the aim of developing an open and comprehensive discourse to determine their existing challenges and requirements. These encounters provided a solid basis for the development of measurement methods adapted to the unique conditions of the community, allowing for an accurate assessment of the problems they face. Firstly, at this stage, based on the socialisation of the project with the leader of the association and the beneficiary community, the researchers and students locate 22 water wells in Paipayales with their respective states of activity; in turn, they collect samples from 11 wells in order to subsequently carry out the respective water quality analysis.

Similarly, during these approaches with the community, the farmers of the association expressed their discomfort at not being able to sell the final product but only selling the rice without pillars due to the lack of financial resources to pay for this service and to transport it to the mill. Consequently, from the basis of common understanding, the following questionnaire was developed for the members of the association "Dios con Nosotros", consisting of 27 questions divided into six sections: (i) demographics, consisting of 3 questions; (ii) rice huller machine feasibility, corresponds to 3 questions that respond to the perceptions of the members regarding the creation of a piler machine, (iii) rice production process which contains seven items directed towards information the activities, costs and profits involved in the rice production process, (iv) rice marketing process which has eight questions about the activities that rice farmers carry out to market their product and the costs incurred; (v) level of satisfaction, with four items providing information on rice farmers' perceptions of prices and the difficulties they face, (vi) funding, which has two questions about access to financial credit. On average, respondents took 8 minutes to answer the questionnaire.

Analysis

During the analysis phase, based on the instrument developed in the previous stage, a simple cross-sectional survey was conducted aimed at the 36 members of the association. At this stage, the survey allowed for extensive data collection on the difficulties experienced by the residents of the Paipayales community. After analysing the survey data, trends and critical areas of concern regarding water management and supply chain were found.

Reflection

In this last stage, the information gathered and considering the needs and desires of the farmers led to the identification of two priority areas for intervention: water management and the supply chain. With a clear understanding of these needs, the students, together with the researchers, offered concrete solutions to successfully address each highlighted area, with the ultimate goal of increasing the quality of life and sustainability of the community. These solutions were developed with the active participation of the people of the community, ensuring their relevance and feasibility in the local environment. First, the

Table 1

Demographic Profile of the project beneficiaries (N = 21).

	Frequency	Percent *
Gender		
Male	12	57.14
Female	9	42.86
Age		
18 to 28 years	1	4.76
29 to 39 years	5	23.81
40 to 50 years	8	38.10
51 to 61 years	4	19.05
Over 61 years	3	14.29
Domicile		
Santa Lucía	20	95.23
Milagro	1	4.77

* The use of percentages is for clarity and ease of interpretation of the results of non-statisticians such as most members of the participating communities.

students created well mapping and designed proposals for better water management and water quality. Similarly, the students designed two models of rice hulling machines and a rice separator machine, where the specifications and costs involved in creating each machine were discussed.

Results

This section is divided into two parts. The first one will show the results of the survey that was carried out. In contrast, based on the results, the second part will show the intervention and proposals elaborated by the students of ESPOL Polytechnic University.

Survey Results

The survey was created for the direct beneficiaries of the organisation “Dios con Nosotros”; the results are shown below. Since several members did not attend the assembly on 30 October 2021, it should be noted that data was only collected from 21 questionnaires.

Demographics

Demographic information on the project participants is presented in Table 1.

Rice huller machine feasibility

Concerning the farmers’ perception of the feasibility of a rice huller machine, all the respondents agreed that there should be no middlemen in selling their produce. Therefore, they were asked about the hypothetical case in which the Association “Dios con Nosotros” acquires a community rice milling machine to provide all its members with the milling service, and they were asked at what price they would consider selling the quintal of rice as a finished

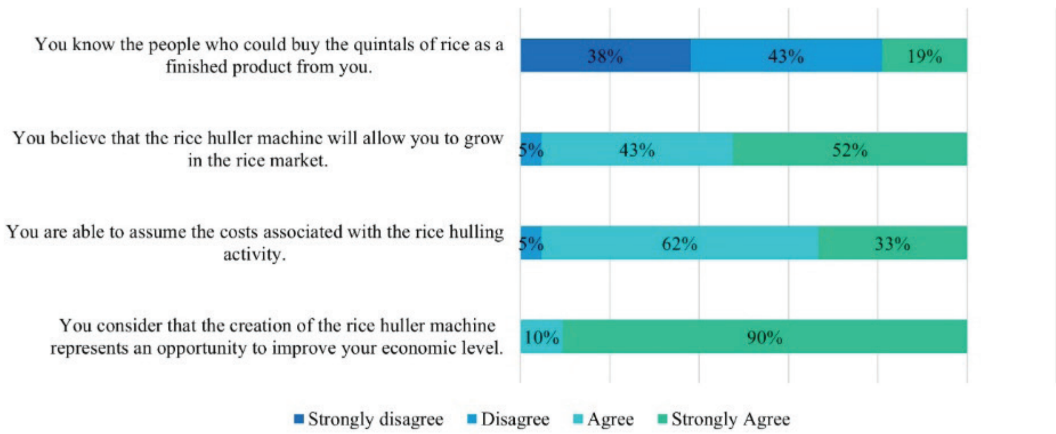


Figure 4. Results of the ratings of the items about the purchase of the rice huller machine.

product. According to the results, 95% considered that a fair price would be above $25, and only a 5% share considered that it could be between $23 and $25.

Similarly, respondents were asked to rate some statements about purchasing the piling machine (Figure 4). As can be seen, the members consider that the creation of the piling machine represents an opportunity to improve their economic level, and 95% agree that it will allow them to grow in the rice market. Furthermore, 95% agree they can bear the costs associated with the rice milling activity. However, only 19% of the farmers know people who could buy the quintals of rice as a finished product from them.

Rice production process

Concerning the rice production process, according to the results, 18 people have between 1 and 4 hectares to plant rice, and only one association member has more than 15 hectares. Furthermore, 62% of the respondents stated that they harvest less than 50 quintal bags of rice per hectare, 29% stated that they harvest between 50 and 60 bags, and 10% stated that they harvest between 61 and 71 bags. In addition, 67% said they harvest every four months, while the remaining percentage harvests every six months.

Regarding crop irrigation, 86% of the farmers irrigate their crops weekly, while the remaining percentage irrigates every two weeks. In addition, 67% say that October and December are the days they turn on the irrigation pump most frequently, while 33.3% say their most frequent days are between July and September.

Regarding costs, 24% spend less than 500 USD per planted hectare, 19% spend between 500 and 699 USD, 10% spend between 700 and 899 USD, while the vast majority (48%) spend more than 899 USD. Specifically concerning rice harvesting costs per hectare sown, 43% indicated that they spend less than 200 USD, 43% indicated that their costs are between 200 and 250 USD, and 14% mentioned that their costs are between 251 and 300 USD.

Rice marketing process

Concerning the rice marketing process, the first question provided information on how the members of the Association “Dios con Nosotros” market rice. According to the results, most members sell paddy rice (76%), while 14% sell milled rice and a lower figure of only 10% represents those rice farmers who market rice in both forms.

Of the respondents who only sell paddy rice, nine mentioned that they do not have enough money to pay for milling. Similarly, eight respondents indicated they did not have the resources to transport their product to the milling machine. Meanwhile, four people indicated that the rice piling companies had selected their suppliers. Also, seven association members stated they do not have the contacts to sell the milled rice. On the other hand, 38% indicated that they sell quintal bags of paddy rice for less than 22 USD, and 63% indicated that they sell it for between 22 and 24 USD. However, only 6% receive payment on the same day, while 44% receive a payment within one week, 44% within two weeks, and even 6% after one month.

On the other hand, regarding the motivations of people who sell only milled rice, one individual mentioned that the milling service suits their capacities, and two people indicated that selling rice in this way allows them to make more profit through grading the quality of the rice. One person pointed out that this type of rice is sold at a higher price than paddy rice. In addition, 33% indicated that the rice milling service costs them between 1.50 and 2.00 USD per quintal bag, while 67% mentioned that it costs them more than 2.00 USD. Similarly, 67% indicated that the price at which they sell their paddy rice is less than 20 USD, and only 33% manage to sell it for between 20 and 23 USD. However, none receive payment on the same day of the sale, but it takes one week and one month.

Meanwhile, those selling both types of rice indicated that the rice milling service for each quintal bag costs them more than 2.00 USD. On the other hand, one of the people indicated that he managed to sell a quintal bag of paddy rice for between 25 and 27 USD, while the other individual stated that he sold it for less than 22 USD. In addition, one individual stated that he managed to sell the quintal sack of paddy rice for more than 27 USD. However, the other individual said he sold it for less than 20 USD.

Level of satisfaction

Concerning the appreciation of the members of the association regarding the piling service, 5% indicated that the cost of this service should be less than 1.00 USD, 14% considered that it should be between 1.00 and 1.50 USD, 47.6% indicated that the cost should be between 1.50 and 2.00 USD. In comparison, 33% proposed a cost higher than 2.00 USD. On the other hand, the respondents were asked about their criteria regarding the premise that the rice business is profitable. 19% strongly agreed, 38% partially agreed, 19% strongly disagreed, and 24% partially disagreed.

Similarly, the association members were asked about their assessment of the level of importance of the difficulties they face concerning the rice production process. As shown in Figure 5, 52% of the respondents agree that water availability in the wells is among the most critical difficulties they face. Likewise, 71% say using chemicals is one of the most critical difficulties. Meanwhile, 33% take a neutral stance on the importance of insufficient machinery or equipment. Furthermore, 33% of the respondents consider that production time is unimportant. In

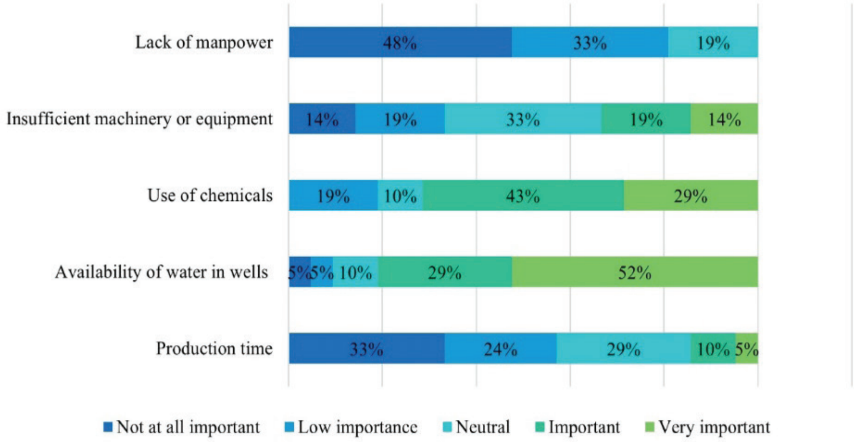


Figure 5. Results of the ratings of the items on the most difficult aspects of rice production.

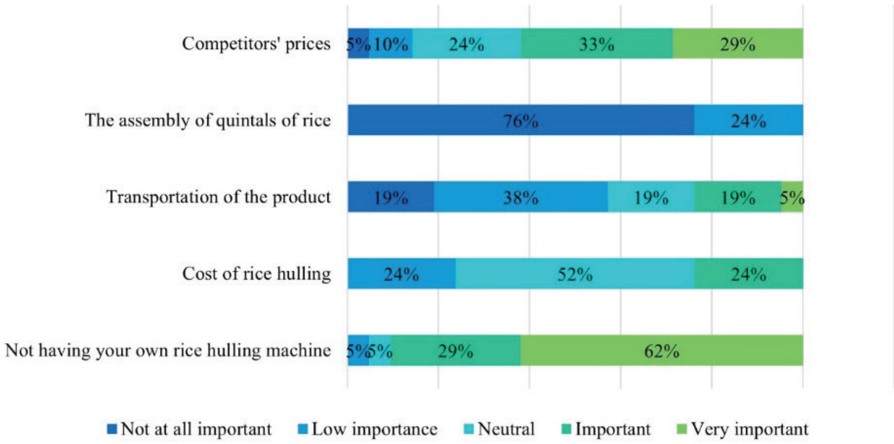


Figure 6. Results of item ratings on the most difficult aspects of selling rice.

addition, 81% agree that the need for more human resources is unimportant.

Similarly, the association members were asked about their assessment of the level of importance of the difficulties they face in selling rice. As seen in Figure 6, 90% of the respondents agree that among the essential difficulties they face is the lack of a rice milling machine. However, 52% consider the cost of the milling service to be of neutral importance. In addition, 57% say that the transportation of rice is a difficulty of little or no importance. Similarly, all respondents consider assembling quintals of rice as of little or no importance. In addition, 62% of the respondents claim that competitors' price is of considerable importance.

Funding

Concerning funding, all the association members, "Dios con Nosotros", stated they did not have financial credit. Some mentioned that they had been refused because of their financial situation. Based on this response, the respondents were asked about the funding source they needed to support their business. Almost all respondents (96%) in the study stated that they feel compelled to turn to independent moneylenders, alluding to loan sharks known as "chulqueros" for financial assistance. Meanwhile, 4% of the respondents chose the option "Other" and specified that their business financing comes from sales of other economic activities they own.

Intervention by the university community

Water management

Consequently, as a first step, the students carried out the geolocation of the wells; in total, 22 wells were found in this community, although four were inactive (Figure 7). Then, with this information, the students created two boards to measure the water flow in a rice field to determine how much water the villagers use to harvest their crops. These boards provide information on water consumption in real-time, as well as a record of water consumption. The beneficiaries were also provided with a manual for the correct maintenance of the board.

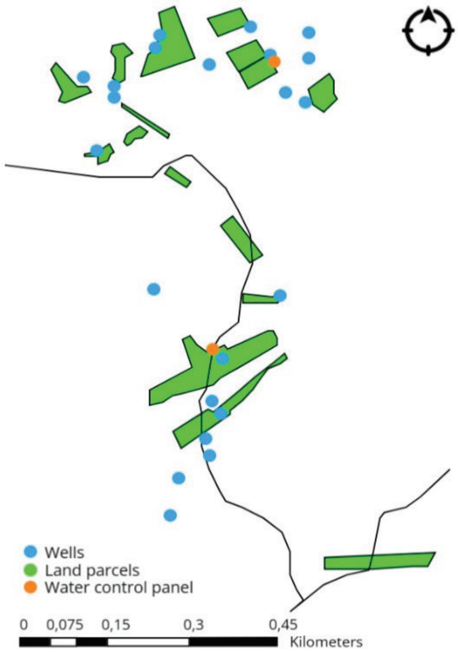


Figure 7. Location of the wells.

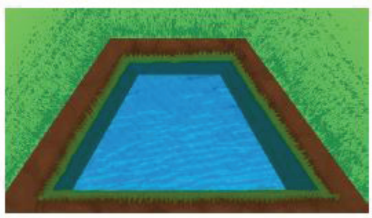
In addition, to determine whether the water quality levels are adequate and permissible for use in rice cultivation, the researchers also took samples from 11 wells to perform the corresponding water quality analyses in the field and the laboratory. According to the results, except for the percentage of dissolved oxygen, the physical parameters measured, such as temperature, pH and conductivity, are within the acceptable ranges established by the Ecuadorian standard TULSMA (Ministerio del Ambiente, 2017) but are not ideal for rice cultivation to achieve maximum efficiency. Similarly, although the concentrations of orthophosphate, sulphate and nitrate in the water samples analysed by the ESPOL water laboratory have concentrations acceptable by TULSMA and water quality is not affected, the presence of chlorides is above the permissible limits, which can eventually damage plant growth and cause prematurity.

Based on these results, the researchers recommend the creation of drying pools (Figure 8), where rice grains are left in the open air, and the sun's rays evaporate chloride ions, which appear from the application of pesticides on rice crops (Dogramaci et al., 2012).

On the other hand, although water alkalinity is common in groundwater, a high level was found in the community's water wells. This high level may be related to seasonal changes and agricultural tools such as fertilisers. Therefore, to solve this problem, a calcium deficit is recommended to remove excess bicarbonates. Calcium nitrate, also known as CaNO3, is used because it dissolves rapidly in water and is quickly absorbed by roots (Duncan et al., 2000).

Supply Chain

Based on the information provided by the farmers through the survey, a graph illustrating the current supply chain model of rice production was produced (Figure 9).



Proposed drying pool	
Dimensions	20 meters x 20 meters
Material	Tarpaulin
Price of the tarpaulin	$20
Pool depth	2.5 meters
Exposure to sunlight	6-8 hours (Clear) 12-16 hours (Partly cloud)

Figure 8. Proposal of the drying pool.

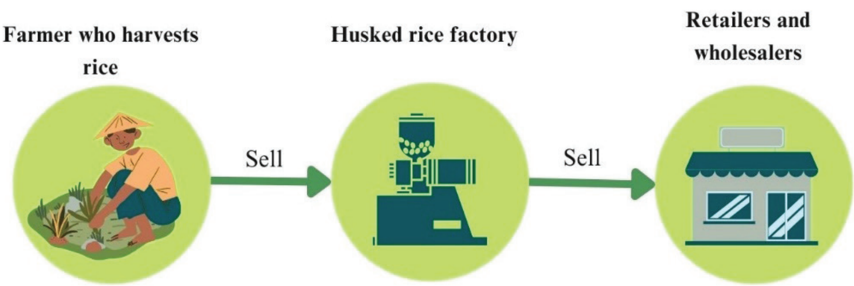


Figure 9. Current model of the supply chain.

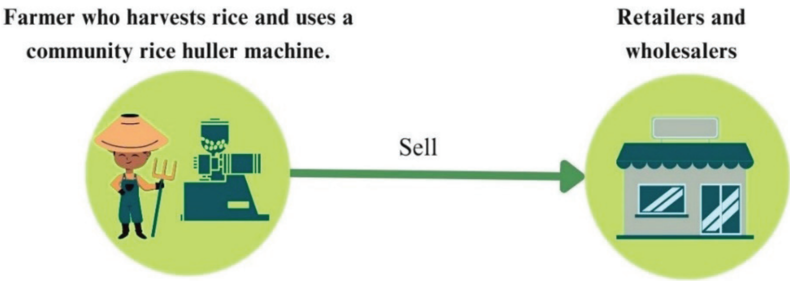


Figure 10. Proposed model of the supply chain.

As seen in Figure 9, the farmers are confronted with the owners of the rice husking factories, who sell the finished product to retailers and wholesalers. However, this situation is marred by a discouraging reality, as the millers, taking advantage of their position of power in the market, impose prices below what is officially stipulated by the Ministry of Agriculture and Livestock (MAG, Spanish acronym). As a result, this predatory practice drastically reduces the profit margin of the farmers, who, deprived of viable alternatives, give in to economic pressure (Gobernación del Guayas, 2017). As a result, the flow of profits is diverted to the millers, who, by obtaining the final shelled product at a lower cost, are able to maximise their profits by selling it to end consumers. Therefore, the students presented two types of proposals; the first corresponds to the community rice huller machine, while the second corresponds to the rice separator machine that will make it possible to generate fewer losses by correctly separating the types of rice. In Figure 10, the proposed supply chain model is presented.

The needs of the beneficiary community were taken into account to create small-scale computer-aided design (CAD) proposals for rice huller machines ensuring that these devices can hull five quintals of rice per hour and can be implemented with nationally traded materials. Figure 11 shows the two rice huller machine models and their characteristics.

Similarly, a separator was created to distinguish between husked and unhusked rice (Figure 12),

Proposal rice huller machine	A	B
Dimensions		
Height	1.7 metres	1.3 metres
Lenght	1.0 metres	0.55 metres
Width	1.0 metres	0.35 metres
Engine speed	1800 RPM	1800 RPM
Fan	-	960 RPN
Frequency inverter	1 HP - NVF300M	-
Material	Chassis frame with galvanized steel. Frame with A3 stainless steel.	The quotation does not include frame price.
Dehulling capacity	5 quintals/hour	5 quintals/hour
Average cost of components	2627 USD	930 USD

Figure 11. Proposals for rice huller machine.

Source: ESPOL (2017)

Proposal rice separator machine	
Dimensions	
Height	1.33 metres
Lenght	1.52 metres
Width	0.93 metres
Engine speed	1750 RPM
Hopper capacity	1.4 quintals
Hopper rice flow	4.6 quintals/hour
Material	ASTM 36 steel
Average cost of components	1008 USD

Figure 12. Proposal for rice separator machine.

Source: ESPOL (2017)

which eliminates contaminants (Food and Agriculture Organization of the United Nations, 2019). In this way, this project contributes to the association's objectives of productive transformation and sustainable development.

Discussion and Conclusions

For many households worldwide, rice cultivation is their primary source of income. However, this activity presents farmers with several challenges that ultimately hinder the achievement of the SDGs. This article, therefore, aimed to explore the difficulties experienced by small-scale rice farmers in the Ecuadorian town of Paipayales in the canton of Santa Lucía. Together with students from the Polytechnic University ESPOL, the rice farmers who are beneficiaries of the community initiative worked on this study using the participatory action research (PAR) methodology. In addition, information was collected through surveys and descriptive statistical methods were used to analyse the results.

According to the results, the main problem most of the farmers of the Association "Dios con Nosotros" face is the commercialisation of paddy rice because they do not have a rice miller machine. As can be seen, some people need more economic resources for the milling service, and others say they do not know people who can buy milled rice. In addition, they wait to receive payment, as 94% receive their payment between the following week and the end of the month, making it difficult for them to buy the materials they use to produce. Regarding prices, most people (67%) consider that the piling service should cost less than 2.00 USD. However, 67% of those selling milled rice mentioned that milling service costs exceed 2.00 USD. Similarly, it is shown that 43% of the farmers who are members of the association "Dios con nosotros" perceive that the rice business is not fully profitable. These facts are in line with the results found by Ramírez Alfonso et al. (2023) when studying the community of "El Mate" also located in the canton of Santa Lucía, indicating that among the main risks faced by farmers is that low prices do not cover production costs.

Taking into consideration the aspects mentioned in the previous paragraph, the students designed two proposals to create a rice huller machine and a rice separator machine, aiming to make both machines accessible to the members of the "Dios con nosotros" Association. Hence, these technological innovation proposals can help farmers reduce their dependency on external factories and maintain a higher percentage of the profit margin by receiving communal rice hulling equipment supporting SDG 1: No poverty, enabling farmers and their families to increase their income. Similarly, by improving water quality and rice production efficiency, the people of this community have the potential to increase the availability of food, thus contributing to SDG 2: Zero hunger. In addition, the suggested technology and practices can help create new jobs and improve the economy of Paipayales, thus supporting the achievement of SDG 8: Decent work and economic growth.

Based on the finding that only 19% of the participants knew people who could buy their quintals of rice as a finished product, it is suggested that Higher Education Institutions (HEIs) could play an important role in providing training in marketing and sales so that people in this rural community can apply the tools and strategies for rice marketing. This suggestion is supported by the research of Kusmulyono et al. (2023), who also used a PAR approach and demonstrated that a community empowerment programme that allows interaction between HEIs and society through the delivery of formal courses enables the transmission of knowledge and social value, as well as the development of micro-enterprises in rural communities by engaging with community partners, thus contributing to sustainability. In addition, it is recommended that government institutions provide spaces, such as fairs, where farmers can sell their products and gain visibility to build their customer base. This fact is consistent with the findings of Strechar et al. (2021), who concluded in their research that the creation of an agroecological fair could bring benefits to farmers, giving them greater visibility, making their work known and increasing profitability by having a space to sell their products.

On the other hand, 81% of the people consider that one of the most critical difficulties they face is water availability in the wells. Likewise, 71% of the people say that using chemicals is also a difficulty with a high level of importance. Therefore, considering the farmers' challenges, the students created two dashboards to obtain information on water consumption from wells. In this way, data recording and optimisation of water use for agricultural irrigation can help farmers manage water consumption better so that water is available for as long as possible throughout the year. Moreover, the water quality was analysed, and a high concentration of chloride and alkalinity was found. These results are in line with Ramírez Alfonso et al. (2023) in finding that among the risks faced by farmers in 'El Mate' is that the water source is not suitable for irrigation.

In view of these problems, to reduce the high concentration of chloride, the creation of drying pools, also known as Alternate Wetting and Drying (AWD), is recommended; moreover, this technique favours sustainability as it is water-saving and eco-friendly (Ishfaq et al., 2020). Also, to manage the high level of alkalinity, the use of calcium nitrate is recommended because it is rapidly absorbed by the roots and dissolves quickly in water (Duncan et al., 2000). Consequently, these recommendations and the instruments (dashboards) that were created help to comply with SDG 6: Clean Water and Sanitation. The delivered dashboards enable sustainable management of water resources, and the information provided helps to detect possible water wastage patterns so that corrective actions can be taken to avoid water wastage. In turn, the proposed methods contribute to better water quality for the inhabitants of Paipayales.

Additionally, as seen in the results, almost all farmers surveyed (96%) stated that they feel compelled to turn to independent lenders for financial assistance. Therefore, farmers in this association are required to have more access to financing through regulated entities. For this reason, a call is made for government entities and financial institutions to implement financial support projects for these small farmers to make both win-win. In this way, farmers do not resort to loan sharks and can have better financial stability for their businesses. At the same time, the academy can provide farmers with the necessary tools in financial literacy to successfully run their businesses.

In conclusion, this work showed the importance of establishing relationships between the student community and society to solve social problems and help meet the SDGs (Sengupta et al., 2020). As mentioned by Buys & Bursnall (2007), university-community partnerships provide many benefits; for example, in the field of research, they provide opportunities to inform practice through applied research, such as this study. Also, through these projects, students put into practice what they learn in the classroom, which allows them to realise the relevance of the teaching curriculum; in turn, they see the need to research to generate solutions.

Ozaki and Shaw (2022) indicate that there is a need to promote citizens' social participation in order to achieve the SDGs and create a resilient society, and among their findings, they mention that there is a possibility that one of the vital issues in promoting citizens' social participation could be the sharing of information. The latter is evidenced through this project, as the people of the Paipayales community were open to dialogue with the university and were vulnerable to present those discomforts they were experiencing; in turn, they became the main actors in the generation of information. Furthermore, as stated by Carrión-Mero et al. (2021) and Usadolo & Caldwell (2016), there is a need to engage diverse stakeholders and promote mutual understanding through collaborative relationships. In this study, the beneficiaries were involved along with teachers and students, and a better understanding of the challenges faced by the community was obtained, resulting in the creation of specific proposals for this society.

Similarly, in line with the results of Orlando et al. (2020), participatory action research fostered the co-creation of knowledge innovation and social cohesion. In our case, local farmers were actively involved in problem identification, solution formulation and decision-making. This participation fostered the co-creation of knowledge, as local knowledge was combined with the academic and technical knowledge of researchers and university students, enriching the research and action process for solutions adapted to the local context.

It also emphasises the value of working in transdisciplinary teams (Hudspeth, 2020). As mentioned by Nix et al. (2019), it is essential to integrate academic disciplines, the community and relevant stakeholders in the co-creation of evidence to formulate effective solutions to challenges. In our case, transdisciplinarity was essential to achieve a comprehensive intervention that resulted in improvements towards the community because, through students and researchers from different careers, solutions were able to be put forward that span multiple strands.

Finally, it is necessary to mention that our study has some limitations that should be considered when interpreting the results. Firstly, there is an absence of controls in this method, which affects the ability to establish clear causal relationships between the proposed interventions and the observed outcomes. In addition, our relatively small sample size, although representative of the community studied, may limit the generalisability of our findings to other farming communities. We therefore emphasise the importance of keeping these limitations in mind when interpreting the results and considering the applicability of our findings in other contexts.

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