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Evaluation of socio-environmental impacts of sustainable agricultural activities: Case study at the Tunshi Experimental Station, Escuela Superior Politécnica de Chimborazo

By

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Abstract

Every human action produces several positive or negative socio-environmental impacts, therefore, it is important to study the socio-environmental impacts resulting from anthropogenic activities, applying appropriate methods to identify, in a technical manner, those significant impacts and the level of affectation they cause on the environment and human societies. In this context, this research aimed to evaluate the socio-environmental impacts of agricultural activities in the Tunshi Experimental Station, an area of the Natural Resources Faculty (EET-FRN) of the Polytechnic School of Chimborazo. For this study, the socio-environmental baseline of the study area was elaborated for applying a survey to 104 students of the Natural Renewable Resources career; semi-structured interviews were applie to four actors within the Experimental Station. The data for evaluating the identified impacts were gathered and analyzed using a modified Lazaro Lagos matrix. This study was carried out in the period March-August 2022. Once the impacts had been identified and evaluated, the environmental management plan was prepared to mitigate or offset the negative impacts and enhance the positive impacts. Through this study, 26 significant socio-environmental impacts were identified, and the total value of the evaluation was 583, of which 446 (76.50%) correspond to positive socio-environmental impacts, while 137 (23.50%) is the value of negative socio-environmental impacts, most of which are favorable since they take advantage of natural resources such as soil, water and flora. In conclusion, the socio-environmental impacts caused by agricultural activities at the Tunshi Experimental Station have been mitigated with new agroecological alternatives developed by the institution.

Keywords: environmental sciences, agroecological practices, socio-environmental impact, environmental management, GIS, sustainability, qualitative analysis.

Introduction

According to Article 2 of the Environmental Management Law, Codification 19, “Environmental management is subject to the principles of solidarity, co-responsibility, cooperation, coordination, recycling and reuse of waste, use of environmentally sustainable alternative technologies, and respect for traditional cultures and practices. Furthermore, the Law is governed towards sustainable development in which the use of natural resources is optimal without harming ecosystems.

According to FAO (2012) [2], agriculture at present is the largest producer of wastewater, as land use has intensified due to the exponential growth of the agricultural area; however, countries have significantly increased the use of synthetic pesticides, fertilizers and other inputs, although these help boost food production, they are an environmental threat, also cause human health problems, biodiversity of landscapes, and soil nutrients are lost [3]. Agriculture is one of the main economic activities in South American countries, where thousands of tons of solid waste are generated, most of which become environmental pollutants without being used [4, 5]. The natural decomposition of this type of waste takes several years if it is not burned on-site after drying. Both disposal methods result in environmental pollution and the loss of significant energy resources. The efficient use of these wastes through biotechnological recycling techniques seems to be an imperative solution that fits perfectly in the perspective of sustainable development, consolidating waste as a real contribution to resource sustainability [6].

The Organic Law of Agrobiodiversity Seeds and Promotion of Agriculture Government of the Republic of Ecuador, 2017 [7] in Art. 48 states that ¨for the application of this Law, sustainable agriculture is understood as agricultural production systems that allow obtaining food in a stable, healthy, economically viable and socially acceptable way, in harmony with the environment and preserving the potential of productive natural resources, without compromising the present and future quality of the soil resource, reducing the risks of environmental degradation and physical, chemical and biological contamination of agricultural products” [8].

The following are sustainable agriculture models: agroecology, organic agriculture, ecological agriculture, biodynamic agriculture, biointensive agriculture, permaculture, synergistic agriculture, food forest, natural agriculture, and others to be established [9]. However, agricultural pollutants are still of concern for human health and natural resources; these are pesticide pathogens, nitrates in groundwater, trace metals and emerging pollutants [10]. Due to the above, a collective effort involving researchers, authorities, students and populations is necessary to raise awareness of the mark people leave on the environment [11,12], seeking a system for the sustainable production of land used for agriculture [13]. For this, it is important to evaluate the positive or negative impacts on nature and human beings, using appropriate methods for this purpose, and thus plan actions to mitigate or compensate for negative impacts and maximize positive impacts to approach a proper sustainable agroecological activity.

Environmental Impact Assessment (EIA) is a tool that enables individuals or organizations to make sound decisions to avoid negative impacts associated with proposed projects. EIAs have become very complex, especially if comprehensive sector-wide policies and programs are applied, although many agricultural projects do not require an EIA [14]. However, they will need to be reviewed by screening procedures described under certain guidelines because where significant potential negative impacts are anticipated in areas that may be of serious concern, a more detailed EIA should be prepared, including full technical justifications and public exposure [15], to obtain EIA studies suitable for implementation and to identify the anticipated impacts.

Materials And Methods

Research design

This research was carried out at the Tunshi Experimental Station in the area of the Faculty of Natural Resources (EET-FRN), located in the parish of Licto, canton Riobamba, province of Chimborazo, Ecuador, 22 km from the city of Riobamba, and consisted of five stages:

a) Elaboration of the socio-environmental baseline of the EET-FRN
b) Interview with actors developing research projects at EET-FRN.
c) Survey on knowledge of socio-environmental impacts to fifth, sixth, seventh and eighth-level students of the School of Natural Resources Engineering, Faculty of Natural Resources.
d) Socio-environmental impact assessment using the Lázaro Lagos matrix
e) Preparation of a socio-environmental management plan.

Place of study

The Tunshi Experimental Station in the livestock area is part of the Polytechnic School of Chimborazo with an area of 145.5 ha, according to the undersecretary of land and the department of physical development of the ESPOCH, of which 65 ha are used by the Faculty of Natural Resources, with the following areas: livestock and natural resources; its objective is the production and exploitation of livestock, as well as the industrialization of products for animal consumption, generating support units for the production and reproduction of livestock [16] (Figure 1).

Figure 1. *Tunshi Experimental Station.*

Data Collection

Information Was Collected Through A Bibliographic Review That Met The Following Criteria: Development Plan And Land Use Planning Of The Licto Parish, Scientific Articles In English Or Spanish From 2017 To 2022, Undergraduate And Graduate Theses And Digital Books On Environmental Impacts In Search Of Information That Meets The Objective Of This Research And Determine The Socio-Environmental Status Of The Eet-Frn.

The Information Collected From Secondary Sources Was Used To Develop A Survey Directed To Students And A Semi-Structured Interview Directed To Teachers In Charge Of The Faculty Of Natural Resources Research Projects At Eet-Frn. These Two Research Instruments Were Used To Gather Information On The Socio-Environmental Impact Caused By The Agricultural Activities Carried Out At The Experimental Station.

Population And Sample

To Determine The Sample For The Survey Application, The Non-Probabilistic Method Of Convenience Was Used [17], Complying With The Following Inclusion Criteria: Students In Their Fifth To Eighth Semester Of The Renewable Natural Resources Engineering Program Of The School Of Natural Resources.

In The Case Of The Semi-Structured Interview, This Was Applied To Four Key Informants; Teachers In Charge Of Research And Liaison Projects Of The Faculty Of Natural Resources, Who Are Directly Involved In Research On Agricultural Production Techniques, Mainly Production With Organic Methods.

Methodological Development

For Data Collection, A Survey Questionnaire Was Used To Collect Information On The Project's Socio-Environmental Impact. 104 Students From The Faculty Of Natural Resources, Who Were Studying From The Fifth To The Eighth Year Of Their Degree, Were Surveyed With Closed Questions Comprised Of Two Phases: Information About The Students And Knowledge Of The Activities Carried Out At The Experimental Station, Evaluated With The Criteria Of Knowledge: A Lot, More Or Less, A Little And Not At All.

With All The Information Gathered From The Surveys Conducted, The Frequency And Percentage Of Each Question Asked In The Survey Were Determined.

Subsequently, Field Visits Were Made, And A Checklist Comprised Six Components: Air, Water, Soil, Flora And Fauna, Landscape And Socioeconomic. As A Result, Eight Agricultural Activities Were Identified In The Study Area, And The Matrix Proposed By Lázaro Lagos, Which Is A Modification Of The Leopold And Batelle-Columbus Matrices [18, 19], Was Prepared, Culminating In A Socio-Environmental Management Plan.

Statistical Analysis

Based On The Data Collected Through The Survey, A Descriptive And Inferential Statistical Analysis Was Carried Out To Determine The Level Of Knowledge About Agricultural Activities And The Perception Of The Socio-Environmental Impacts Caused By These Activities. Panel 1 Shows The Results Of The Statistical Analysis.

Results

Socio-Environmental Baseline

The Results Of The Socio-Environmental Baseline Of The Eet-Frn Are Presented, Where The Type Of Diagnosis With its variables and characteristics are evaluated.

Table 1. *Socio-environmental baseline of the Tunshi Experimental Station (EET-FRN).*

Type of diagnosis	Variable	Feature
Spatial physical diagnosis	Weather	The temperature at certain times of the year is less than 8ºC; however, the average temperature ranges between 12 - 16ºC. The average annual rainfall is 400 - 500 mm [20].
	Soil	The soil presents macronutrients such as Calcium (Ca) and Magnesium (Mg) values were high, Phosphorus (P) and Potassium (K) presented values between medium and low and Sulfur (S) had a low value, micronutrients such as Zinc (Zn), Manganese (Mn) and Boron (B) had low values, Iron (Fe) presented values between high and medium and Copper (Cu) obtained high values, with a neutral pH of these soils, suitable for crops. Source: Soil tests by Juan León Ruiz (2019).
	Ground cover	The area consists of 80% of the soil covered by crops; the remaining areas are areas with buildings and green spaces with ornamental plants.
	Hydrology	The station consists of a reservoir, RAS infiltration minus 1 and a pH of 7.12 normal range, which makes it excellent for irrigation water use and in reservoir 2, RAS infiltration of 1.54 and a pH of 7.93 in the normal range, which makes it suitable for irrigation. Water quality tests were carried out by Juan León Ruiz (2019).
	Relief	Slopes greater than 25% in the communities of; Tunshi San Javier, Tzetzeñag, Cecel Grande, Llulshibug, Santa Ana, Tunshi Grande, Tunshi San Nicolás, Guaruñag, Aso Pungulpala, Cabecera Parroquial, Lucero Loma, Cecel San Antonio, Gueseche [20].

	Geology	In the parish territory, the low threat to mass movements is detected in Pompeya, Chumug San Francisco, Tzimbuto, Lucero Loma, Cabecera Parroquial communities Gueseche, Cecel San Antonio. Medium threat to mass movements; Tunshi San Nicolás, Tunshi Grande, Tunshi San Javier, Sul, Chalán, Santa Ana de Guagñag, Molobog, Tulabug Escaleras, Chimbacalle, Aso. Pungulpala, Cecel Alto, Guanlur, Cuello Loma, Guaruñag, San Antonio de Guagñag, Pungalbug, Nueva, Esperanza, Llulshibug, Cecel Grande. Low threat to mass movements; Tunshi San Nicolas, Tunshi Grande, Tunshi San Javier, Sul, Chalán, Santa Ana de Guagñag, Molobog, Tulabug Escaleras, San Antonio de Guagñag, Resgualay, Pompeya, Chumug San Francisco, Cabecera Parroquial, Gueseche, Cecel San Antonio, Aso. Pungulpala, Cecel Alto, Guanlur, Cuello Loma Guruñag, Pungalbug, Nueva Esperanza, Llulshibug, Lucero Loma, Cecel Grande, with risks of collapse of the main buildings in populated areas [20].
	Flora	Approximately 50% of the species are food plants primarily found in production areas, 14% are fruit plants, an equal percentage is the species used in construction, 4% are medicinal plants, and 3% are forestry plants.
	Fauna	It is composed of 80% of bird and mammal species, followed by 20% of amphibians and reptiles, and it is concluded that there are no fish species in this area [20].
Socio-cultural diagnosis	Population	In the academic period from April to August 2022, the station regularly housed 250 students, 25 faculty and 8 administration staff. Source: Secretariat of the Career of Engineering in Renewable Natural Resources (2022).
	Education	Of the 250 students in the Renewable Natural Resources and Agronomy programs at the Chimborazo Polytechnic School (ESPOCH), 60% are from other provinces, while 40% are from the province of Chimborazo. Source: Secretariat of the Renewable Natural Resources Engineering Career (2022).
	Health	In the parish where the EET-FRN is located, they can access the Tunshi San Ignacio branch health post, with the basic supplies they need in an emergency.
	Basic services	The EET-FRN has basic services such as piped water used for the station’s restrooms and bar, energy service connected to the state’s public network, sewage system, garbage collection and internet access.

Political and administrative diagnosis	Organization	The Escuela Superior Politécnica de Chimborazo's government comprises teachers, students, employees and workers. The institutional polytechnic government is exercised hierarchically by: **a. General level** **Management Level** • Polytechnic Council • Academic Council • Research and Development Council **Executive Level** • Rector • Academic Vice Rector • Vice Rector for Research and Development • Administrative Vice Rector **Advisor Level** • Commissions • Units **Levels of Support** • Departments • Units **Operational Level** • Powers • Research Centers • Production Units • Academic Centers **b. The Faculties** **Management Level** • Board of Directors **Executive Level** • Dean • Vice Dean • School Principals **Levels of Support** • Commissions • Service units **Operational Level** • Academic Areas • Service units • Technology Transfer Centers • Research and production centers [21]
Productive diagnosis	Socioeconomic characteristics	The production of the EET-FRN, within the projects of linkage or research, a production, however, are not for sale due to the policies of the institution, but they are presented in academic activities or consumption of students; on the other hand, thesis students who perform their work of curricular integration can take their final product to sell.

Territorial ecological diagnosis	Presence of projects	Within the EET-FRN, nine projects were found, seven of which are research projects and two of which are related to the cultivation of blackberry, strawberry, tree tomato, prickly pear, peach, horticultural plants, and leguminous plants, which benefit the education of the students of the Faculty of Natural Resources and ESPOCH, other institutions and communities surrounding the station.
	Environmental problems	Negative environmental impacts on soil resources include using chemical fertilizers and pesticides for agricultural production. Environmental impacts on water resources include using chemical fertilizers for agricultural production and chemical pesticides in its water tributaries.
	Agriculture with slight limitations	It is a zone of agricultural production, with slight limitations, for commercialization, self-consumption and soil management practices, such as monocultures and erosion in certain areas.
	Water zone	It is important for conserving springs, rivers, streams and basins due to technified irrigation, which preserves the water tributaries from which water is obtained for irrigation.
	Concentrated housing, social infrastructure and basic services	This area has a social infrastructure with essential services for the institution's community.

Table 2 shows the results of the structured interview with 4 teachers, where they were asked about general aspects of the activities they perform in the study area.

Table 2: *Teacher interviews*

What is the activity that you carry out at the Tunshi Experimental Station in the area of the Faculty of Natural Resources?	
Actor 1: Coordinator of the Natural Renewable Resources career, researched water resources using a lysimeter, looking for production alternatives in semi-hydroponic and hydroponic crops, and harvesting water and determining fertility levels in several crops.	Actor 2: Administrator of the Tunshi Experimental Station, area of the Faculty of Natural Resources, in charge of production and liaison with teachers, technical teachers and students.
Actor 3: Coordinator of the Bioknowledge Center, where agroecological practices were carried out.	Actor 4: Participated in the water resources research and technology transfer group where research on water use was conducted, in charge of the irrigation laboratory, teaching technician in irrigation and drainage and fruit growing.
What agricultural activities are carried out in the Tunshi Experimental Station area of the Faculty of Natural Resources?	

Actor 1: Within the Natural Renewable Resources career, there were three projects: a linkage project and two research projects. One of the activities was the determination of 8 prioritized crops using a lysimeter, another was determining the water requirements of prickly pear and its industrialization, and another was raising production and productivity levels based on the management of irrigation water and fertility oriented to the organic part.	Actor 2: The project was divided into three parts: academic, productive and outreach. In the productive area, crops were planted to produce seeds to obtain green fertilizers and protect against erosion; in the outreach area, people from inside and outside the university were received; in the academic area, agreements were reached with different institutions to carry out research.
Actor 3: The activities were based on three axes: water, soil and biodiversity. The soil activities included polycultures, contour lines, agroforestry, organic fertilizers such as humus, compost and biol, and agrobiodiversity; the water activities included water harvesting and the use of sprinkler and drip irrigation to prevent soil erosion, as well as training for the communities.	Actor 4: The KC crop coefficient adjustment research project was carried out in addition to two strawberry greenhouses under a hydroponic system where four strawberry varieties were evaluated.
What are the crops?	
Actor 1: Potato, corn, peas, beans, lettuce, broccoli, strawberry, blackberry, tree tomato, prickly pear and peach crops.	Actor 2: In general, strawberries, barley, wheat, various vegetables, chocho, garlic, prickly pear, tree tomatoes, peaches, blueberries, beans, peas and vetch were harvested.
Actor 3: There were 8 species of horticultural plants, 4 species of fruit trees, 10 medicinal species, two species of green manure, 15 species of forestry component, and an estimated 62 species of cultivated and spontaneous species.	Actor 4: There were crops of potatoes, corn, peas, beans, lettuce, broccoli, garlic, onions, peaches, prickly pear, prickly pear and strawberries.
What type of fertilizers do you use?	
Actor 1: Organic fertilizer was used, but chemical fertilizers were used to a lesser extent.	Actor 2: The vast majority were used as organic fertilizers such as humus and compost; only in tree tomatoes and peaches were granulated chemical fertilizers used.
Actor 3: Basically, humus, compost and biol were used, which were produced at the bioinputs center.	Actor 4: If chemical fertilizers are used in the lysimeter project.
Do you use any pesticides or pesticides?	
Actor 1: Yes, they were used in most crops.	Actor 2: If they were used due to the characteristics of the climate since they presented collateral problems.
Actor 3: Not used; in agroecology, other alternatives are implemented.	Actor 4: If they were used in the lysimeter project.
What type of pesticides or pesticides do they use?	
Actor 1: Chemical pesticides were used.	Actor 2: Insecticides were applied to the most sensitive crops such as chocho, garlic, strawberry, grapefruit and tree tomato.

Actor 3: Biodiversity and agrobiodiversity of crops to avoid pests.	Actor 4: Pesticides were used for pest and disease control in the lysimeter project.
What are the types of irrigation used?	
Actor 1: Two types of irrigation were used: drip irrigation and sprinkler irrigation.	Actor 2: Irrigation is fully technified; 80% is a sprinkler, drip irrigation, and 10% is gravity irrigation.
Actor 3: It was used with two types of irrigation, drip and sprinkler.	Actor 4: Three types of irrigation are implemented: gravity, sprinkler and drip.
Do you occupy any agricultural machinery?	
Actor 1: Mixed activities were carried out, using harrowing, plowing and leveling tractors and manual labor.	Actor 2: If the tractor was used with a disc plow and harrow plow, motor cultivator and motor hoes for weeding.
Actor 3: The power tiller was used to prevent soil erosion in addition to the harrow tractor to prevent soil overturning.	Actor 4: If the tractor and power tiller were used.
Who benefits from the different agricultural activities?	
Actor 1: The benefit was directly for students of Agronomy and Renewable Natural Resources, farmers who visit the projects at the Tunshi Experimental Station, and students, professors, and national and international scientists.	Actor 2: In general, the beneficiaries were each of the members of the Faculty of Natural Resources and ESPOCH.
Actor 3: More than 100 students per semester and the communities surrounding the Tunshi Experimental Station were trained.	Actor 4: Beneficiaries are students, neighboring communities, and the province’s visitor population.
What is the main agricultural activity that predominates at the Tunshi Experimental Station?	
Actor 1: The agricultural activity of prickly pear was predominant.	Actor 2: The strawberry crop predominated in the research topic and, by extension, the prickly pear crop because it had 1.8 hectares.
Actor 3: There was not only one single activity since it rotates. However, green manure was highlighted.	Actor 4: Mostly small fruit trees and strawberry and blackberry crops.
Are you aware of the socio-environmental impacts?	
Actor 1: If there was knowledge of the socio-environmental impacts caused by the intervention of the projects within the Tunshi Experimental Station.	Actor 2: If known, different practices benefit or affect the environment.
Actor 3: If known, any positive or negative action or activity is either to the environment or the environmental component.	Actor 4: If he knew what is referred to.
What are the socio-environmental impacts caused by different agricultural activities?	

Actor 1: The three projects caused socio-environmental impacts; among them is the direct link with the community due to the ideological transformation from farmers and students with a saving of irrigation water, and an environmental impact is the use of hoses for irrigation as it is eliminated after each crop change and is stored without use cannot be recycled.	Actor 2: A negative socio-environmental impact was the contamination of soil, water and air by chemicals despite using only when necessary, as well as flora and fauna. A positive socio-environmental impact was the recovery of spaces avoiding soil degradation and erosion, and incorporation of organic matter.
Actor 3: These are positive impacts because soil structure and organic matter content were improving, biodiversity increased with the polycultures, ecological functions were being restored, and socially, students, farmers and local people were trained and learned about sustainable natural resource management.	Actor 4: In the KC project, impacts were obtained because the project sought to impact the state of the soil; irrigation technologies are a responsible use of water resources in addition to energy dependencies, but the use of plastics is a problem.
What activities can be carried out to mitigate the negative impacts and enhance the positive impacts of agricultural activities in the Tunshi Experimental Station area of the faculty of natural resources?	
Actor 1: To mitigate the negative impacts, it was not easy to manage because it is not recyclable. An ideological transformation was carried out in farmers and students to enhance the positive impacts of optimal irrigation water consumption.	Actor 2: To mitigate negative impacts, techniques, technologies, and practices such as crop rotation, crop association, diverse crops and promoting projects with good agricultural practices should be used.
Actor 3: Agrobiodiversity should be promoted to have more ecosystem services, including environmental regulation, restore the ecological functions of soil resources, efficient irrigation of water resources in addition to not eroding the soil, having soils covered with vegetation, and agroforestry systems are positive impacts that can be enhanced.	Actor 4: The Tunshi Experimental Station could be transformed into an agroecological station.

Analysis of the information obtained from the semi-structured surveys

Each actor who participated in the semi-structured interview is a Faculty of Natural Resources teacher and has research projects or linkage in the EET-FRN. These projects are based on natural resources such as water, soil, and biodiversity; there is a variety of crops among the most relevant are the cultivation of strawberry, prickly pear, barley, green manure, tree tomato, peach, blackberry and horticultural plants for these crops, different agricultural activities were carried out such as soil preparation with the passing of the tractor, implementation of three types of irrigation such as drip irrigation, sprinkler irrigation, gravity irrigation, organic fertilizers were used, and in specific crops in the rainy season the use of insecticides, the various agricultural activities carried out benefited teachers, students, neighboring communities and even visitors from different parts of the country and abroad. The teachers in charge of the different projects suggested that to mitigate negative impacts and enhance positive impacts; the EET-FRN should become a 100% agroecological station, encouraging society to have a sustainable use of the natural resources provided by nature and to be able to conserve them.

Survey results

Table 3 shows the survey results applied to the Renewable Natural Resources Engineering program students who were studying from the fifth to the eighth level of the program. The questionnaire was applied to 104 students during the regular study period March-August 2022.

Table 3. *Frequencies and percentages of the survey conducted with students*

Ask	Frequency	Percentage
	Genre	
Male	40	38
Female	65	62
Total	105	100
	Academic period	
Fifth	42	40
Sixth	25	24
Seventh	21	20
Eighth	17	16
Total	105	100
	Knowledge social impact	
Much	10	10
More or less	74	70
Little	17	16
Nothing	4	4
Total	105	100
	Knowledge of the environmental impact	
Much	29	28
More or less	67	64
Little	9	8
Nothing	0	0
Total	105	100
	Knowledge on socio-environmental impact	
Much	12	12
More or less	76	72
Little	15	14
Nothing	2	2
Total	105	100
	Knowledge about agricultural activities carried out at the experimental station.	
Much	11	10
More or less	69	66
Little	22	21
Nothing	3	3
Total	105	100
	Knowledge of projects developed at the experimental station	
Much	6	6
More or less	49	47
Little	38	36
Nothing	12	11
Total	105	100
	Knowledge of how pest control is carried out at the experimental station.	
Much	2	2

More or less	22	21
Little	31	29
Nothing	50	48
Total	105	100
Knowledge of types of irrigation performed at the experimental station.		
Much	7	7
More or less	54	51
Little	36	34
Nothing	8	8
Total	105	100
Knowledge of types of fertilizers used in the experimental station.		
Yes	91	87
No	14	13
Total	105	100
Do you consider a socio-environmental impact to be:		
Positive	16	15
Negative	28	27
Both	61	58
Total	105	100

Table 3 shows the frequency and percentages obtained from the survey of 104 students. Concerning gender, refers to what each person feels they are in a psychological sense; therefore, in the Natural Renewable Resources career, 51% of the respondents are female while 49% are male. Furthermore, the academic period resulted in 16% of the respondents belonging to the eighth semester, 20% to the seventh semester, 24% to the sixth semester, and 40% belonging to the fifth semester of the Natural Renewable Resources career.

Social impact refers to the change made in society due to the product of research and technological progress, so 4% of the respondents know nothing about social impact, 10% know little, and 16% know more or less; however, 70% of the respondents know a lot about social impact. Environmental impacts are an alteration or modifications caused by human actions on the environment, which can unbalance the environment. Therefore, it was determined that 8% know little about environmental impacts, 28% know more or less, and 64% of the respondents know a lot about environmental impacts. Socio-environmental impacts are the effect produced by a certain human activities on the environment in its different aspects, or are effects of a catastrophic natural phenomenon, therefore 2% of the respondents know nothing about socio-environmental impacts, 12% know little, 14% know more or less, and 72% of the respondents know a lot about socio-environmental impacts. Within the EET-FRN there are all types of agricultural activities, from cultivation, care and production, so 3% of the respondents know nothing about the agricultural activities carried out in the study area, 10% know little, 21% know more or less, while 66% know a lot about agricultural activities.

Nine research and linkage projects were found in the EET-FRN. Of the 104 participants, 6% know nothing about the projects in the area, 11% know little, 36% know more or less and 47% know a lot about the projects maintained in the EET-FRN. Within the EET-FRN, pest control is not done excessively, only and only when necessary. In this regard, 2% of respondents know nothing about pest control, 21% know little, 29% know more or less, and 48% know a lot about how pest control is done. Technified irrigation is used in the EET-FRN, 90% is by sprinkling and drip irrigation, and the other 10% is by gravity irrigation.

On the other hand, 7% of the respondents do not know about the types of irrigation, 8% have little knowledge, 34% know more or less, and 51% know a lot about the types of irrigation used. Finally, in the EET-FRN most of the work is done with organic fertilizers; only in the tree, tomato and peach crops are done with chemical fertilizers. Of the 104 respondents, 13% do not know what fertilizers are used, and 87% know the fertilizers used on the crops grown at EET-FRN.

A socio-environmental impact is a positive or negative action produced by a particular human action on the environment in its different aspects, so 15% of the respondents consider them positive, 27% consider them negative, and 58% consider them to be positive or negative.

Inferential statistical analysis

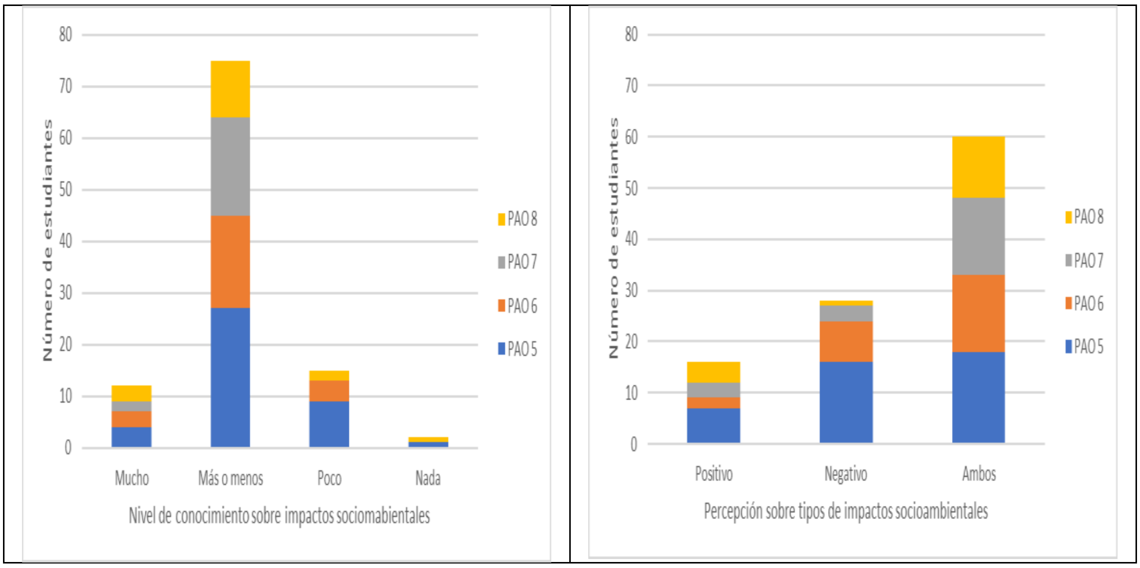
Knowledge about socio-environmental impacts, agricultural activities, types of irrigation, pest control methods and fertilizers used on crops found in the EET is statistically independent of the students' ODP (Table 4).

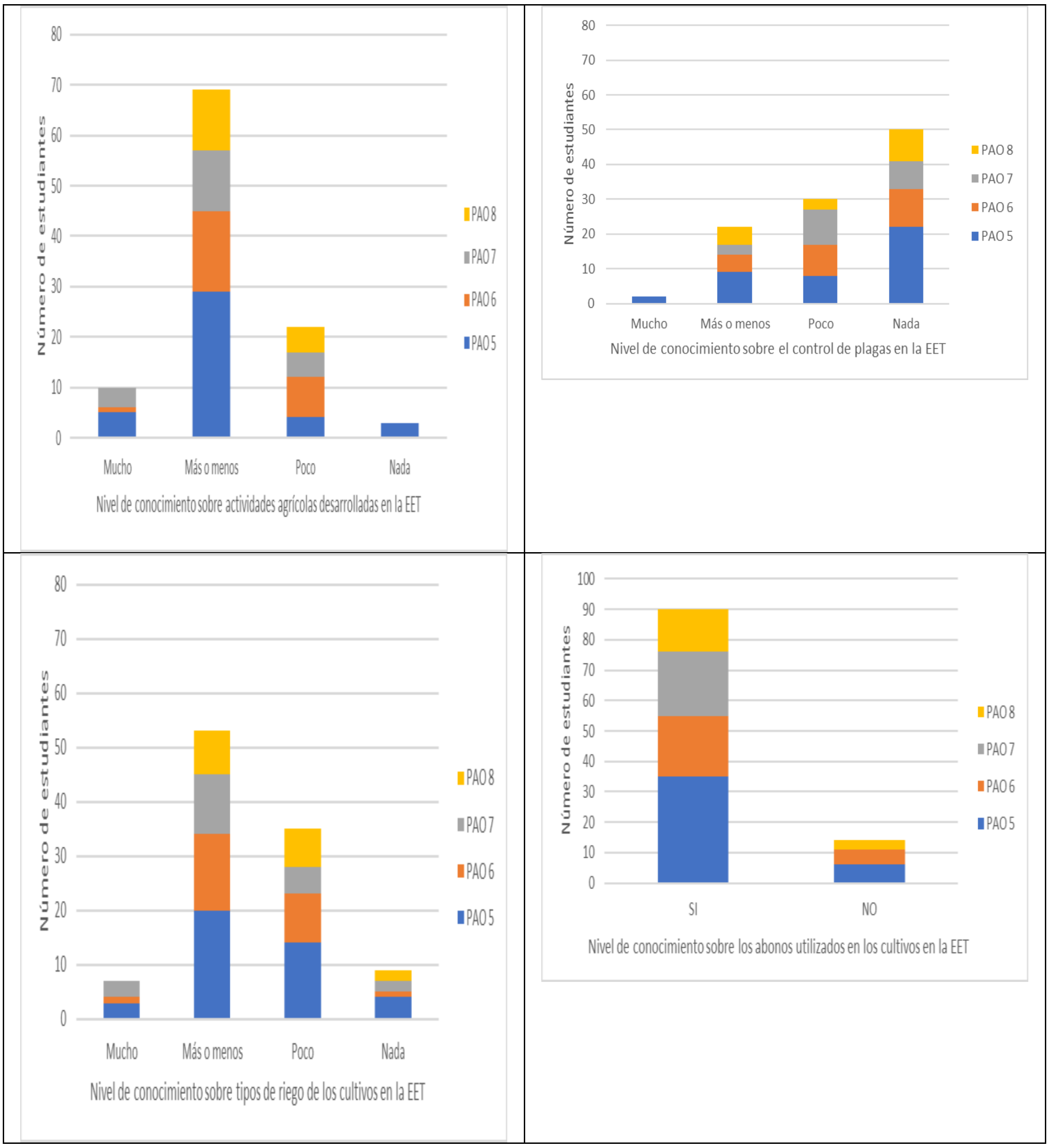
Table 4. *Chi-square test of independence*

Related variables		gl	chi-sq	p-value
PAO	Knowledge of socio-environmental impacts	9	9,169	0,422
	Perception of types of socio-environmental impacts	6	10,774	*0,096
	Knowledge about agricultural activities in the TSE.	9	14,271	0,113
	Knowledge of pest control in the TSE.	9	9,975	0,353
	Knowledge about the types of irrigation in TSE.	9	5,271	0,810
	Knowledge about the types of fertilizers used on TSE crops.	3	4,488	0,213

* significant at 90% confidence

According to the diagrams in panel 1, only 16% have little or no knowledge about socio-environmental impacts; 58% consider that socio-environmental impacts can be both positive and negative, 27% think that they are only negative and 15% only positive. In addition, 66% of students state that they are more or less knowledgeable about the agricultural activities developed in the TSE. However, more than 75% are not knowledgeable about the methods used for pest control. There are also 87% who know about the fertilizers used on crops, and 92% of students know about the types of irrigation.





Panel 1. *Analysis of related variables*

The students consider that the socio-environmental impacts generated by agricultural activities at the Tunshi Experimental Station are primarily positive because the projects and the subjects studied promote good soil resource use, generating awareness of the importance of its care for adequate use of the resources. However, there are negative impacts that must be mitigated or compensated for. To this end, the environmental management plan will include talks with the community to prevent monoculture and erosion, soil recovery, and care of the environment.

Identification and evaluation of socio-environmental impacts

Once the secondary and primary data collection was completed, the socio-environmental impacts identified were evaluated using the Lazaro Lagos method. This method has two different matrices. The first matrix records all the impacts identified and their weighting. The second matrix is used for the total quantification of the impact assessment. This method considers nine criteria to evaluate the impacts: four quantitative and five qualitative. Table 4 shows the results of the evaluation.

Table 4. *Lazaro Lagos Matrix*

Components	Activities								Impacts	Evaluation Criteria									
	1. Soil preparation (plowing, furrows,	**2. Sowing**	**3. Fertilizer application**	**4. Irrigation application (sprinkler,**	**5. Crop maintenance**	**6. Pest Control**	**7. Harvest**	**8. Marketing**		**Nature**	**Magnitude**	**Importance**	**Certainty**	**Type**	**Reversibility**	**Duration**	**Time to appear**	**Consideration in the project**	**Weighting**
A. Air				x	x		x	x	Contamination due to crop decomposition.	(-)	1	1	C	Pr	1	2	C	S	4
						X			Contamination from the use of pesticides.	(-)	1	1	D	Sc	1	1	C	S	3
	x								Noise from agricultural machinery.	(-)	1	1	C	Pr	2	1	C	S	4
		x	x		x	X			Odors generated by pesticides or chemical fertilizers.	(-)	1	1	D	Pr	2	1	C	S	4
B. Water		x		x	x	X	x	x	Decrease of volumes in water bodies.	(-)	1	2	C	Pr	1	3	M	S	6
		x		x	x		x		Increase in water consumption.	(-)	2	3	D	Pr	1	1	M	S	8
	x			x	x		x		Water harvesting.	(+)	1	2	D	Pr	1	2	C	S	5
			x	x					Implementation of technified irrigation types.	(+)	2	3	C	Pr	2	3	C	S	10
		x		x	x	X			Conservation of water sources.	(+)	3	3	C	Pr	2	3	C	S	11
C. Soil	x	x							Reforestation.	(+)	1	1	D	Pr	1	3	C	S	5
	x								Loss of texture due to the use	(-)	2	2	C	Pr	2	3	C	S	9

									of plows and rakes.											
	x					X			Nutritional and microbiological imbalances	(-)	1	2	I	Sc	1	2	M	N	5
				x					Nutrient leaching	(-)	1	1	D	Sc	1	1	C	N	3
	x		x	x		X			Soil conservation	(+)	2	3	C	Pr	2	3	C	S	10
			x		x		x		Implementation of organic matter (soil improvement)	(+)	2	2	D	Pr	2	2	M	N	8
	x								Loss of biodiversity	(-)	1	2	D	Pr	1	2	C	N	5
D. Flora and fauna	x								Affectation of vegetation cover	(-)	1	1	D	Pr	1	1	M	N	3
		x							Crop rotation	(+)	2	2	C	Pr	1	3	C	S	8
	x	x			x	X			Care of flora and fauna	(+)	2	3	C	Pr	1	2	M	N	8
E. Landscape		x							Restoration in affected areas	(+)	2	2	C	Pr	1	2	M	S	7
	x	x							Loss of natural landscape	(-)	1	2	C	Pr	2	1	C	N	5
	x	x	x	x	x	X	x	x	Community training	(+)	3	3	C	Pr	2	3	C	S	11
	x								Implementation of good agricultural practices	(+)	2	2	C	Pr	2	3	M	S	9
F. Socioeconomic	x	x		x				x	Technology transfer	(+)	2	2	C	Pr	2	2	M	S	8
		x	x	x					Generation of economic income	(+)	2	3	C	Pr	1	2	M	S	8
	x	x	x	x	x	X	x	x	Adequate use of natural resources	(+)	3	3	C	Pr	2	3	M	S	11

The weighted values of each of the impacts identified and recorded in the Lazaro Lagos Matrix are transferred to the quantification matrix to obtain the total value of the evaluation obtained from the aggregation of the subtotals of the evaluation of the negative and positive impacts (Table 5).

Table 5. *Lazaro Lagos Quantification Matrix*

Componentes ambientales	Actividades								Total		
	1	2	3	4	5	6	7	8	Total (+)	Total (-)	Total
A. Aire	-4	-4	-4	-4	-4, -4	-3, -4	-4	-4		39	39
B. Agua	+5	-6, -8, +11	+10	-6, -8, +5, 10, +11	-6, -8, +5,+11	-6,+11	-6, -8, +5	-6	84	68	152
C. Suelo	+5, -9, -5, +10	+5	+10, +8	-3, +10	+8	+10	+8		74	17	91
D. Flora y Fauna	-5, -3, +8	+8, +8			+8,	+8			40	8	48
E. Paisaje	-5	+7							7	5	12
F. Socio económico	+11, 9, +8, 11	+11, 8, +8, 11	+11, 8, +11	+11, 8, +8, 11	+11, +11	+11, +11	+11, +11	+11, 8, +11	241		241
Total (+)	**67**	**77**	**58**	**74**	**54**	**51**	**35**	**30**	**446**		
Total (-)	**31**	**18**	**4**	**21**	**22**	**13**	**18**	**10**		**137**	
Total	**98**	**95**	**62**	**95**	**76**	**64**	**53**	**40**			**583**

Once the evaluation using the Lazaro Lagos method was completed, it was found that 26 socio-environmental impacts were identified and evaluated. Therefore, the total value of the evaluation was 583, where 446 (76.5%) corresponded to positive impacts, and 137 (23.5%) corresponded to negative impacts.

Socio-environmental management plan

Once all the results are obtained, a socio-environmental management plan is proposed to mitigate the negative impacts and enhance the positive impacts resulting from agricultural activities in the EET-FRN as shown in Table 5, where the environmental factors are determined, the impact that agricultural activities can generate on each environmental factor and the measures and expected effects are proposed. The management plan also establishes who will be responsible for implementing and monitoring the measures established in the plan and the timing and frequency of actions to monitor compliance with the plan.

Socio-environmental management plan

Environmental factors	Socio-environmental impact	Proposed action	Expected effect	Responsible		Execution	
				Execution	**Control**	**Moment**	**Frequency**
Air	Contamination due to crop decomposition.	Collection of crop residues for the production of bioinputs.	Contamination Control of the entire crop.	Authorities of the Faculty of Natural Resources, teachers with research projects and students.	Teachers with research projects and students.	Sowing-crop maintenance.	Semiannual evaluation.

	Contamination from the use of pesticides.	Implementation of pest control crops.	Decrease in the use of pesticides.	Authorities of the Faculty of Natural Resources, Teachers with research projects.	Administrator of the Tunshi Experimental Station, Faculty of Natural Resources area.	Crop maintenance.	Quarterly evaluation
	Noise from agricultural machinery.	Implementation of soundproof machinery.	Noise reduction due to the use of machinery.	Rector of ESPOCH.	Administrator of the Tunshi Experimental Station.	Land preparation.	Quarterly evaluation
	Odors generated by pesticides or chemical fertilizers.	Use of pesticides and organic fertilizers.	Reduce odors generated by chemical pesticides and fertilizers.	Administrators and teachers with research projects.	Teachers with research projects.	Crop maintenance.	Quarterly evaluation
Water	Decrease of volumes in water bodies.	Implementation of laws for the conservation of water bodies.	Increase in the volume of water bodies.	MAATE, ESPOCH, GAD Parroquial de Licto.	Technicians, ESPOCH authorities.	Planning of agricultural activities.	Semiannual evaluation.
	Increase in water consumption.	Efficient use of water resources in crops.	Regulation of water consumption for irrigation.	MAATE.GAD Parroquial de Licto, ESPOCH.	Technicians, ESPOCH authorities.	Sowing, crop maintenance.	Semiannual evaluation.
	Water harvesting.	Implementation of rainwater collection tanks for irrigation.	Obtaining water for irrigation in greenhouses.	Teachers in charge of research projects,	Teachers.	Crop implementation.	Semiannual evaluation.
	Implementation of technified irrigation types.	Reduce high water consumption for crop irrigation.	Reduced water consumption and efficient irrigation.	Teachers.	Administrator, teachers and students.	Crop implementation.	Quarterly evaluation

	Conservation of water sources.	Conserve water resources through adequate consumption.	Conservation and sustainable use of water resources.	ESPOCH authorities.	Administrator, teachers and students.	Planning of agricultural activities.	Semiannual evaluation.
	Reforestation.	Compensation by planting native forest species endemic to the area.	Reforestation of deforested areas.	Teachers and students.	Students.	Sowing.	Annual evaluation
	Loss of soil texture due to the use of plows and rakes.	Perform minimum tillage for punctual augering.	Minimal loss of soil texture.	Administrator, teachers.	Administrator, teachers and students.	Soil preparation.	Semiannual evaluation.
	Nutritional and microbiological imbalances.	Polyculture association to maintain nutrients and soil microorganisms.	Nutritional and microbiological balance of soils.	Administrator, teachers and presidents of each community.	Teachers, students and each community.	Soil preparation and planting.	Semiannual evaluation.
Soil	Nutrient leaching.	Conserve or implement protection strips of natural watercourses with native cover. Implementation of drip irrigation.	Conservation of soil nutrients.	Administrator, teachers.	Administrator, teachers and students.	Soil preparation, crop irrigation.	Quarterly evaluation
	Soil conservation.	Drawing contour lines.	Soil conservation in the area.	Teachers.	Teachers and students.	Soil preparation, sowing.	Quarterly evaluation
	Implementation of organic matter (soil improvement).	Growing green manure crops that can be applied to the soil.	Soil improvement.	Teachers, students, president of each community.	Teachers, students and each community.	Sowing and harvesting.	Quarterly evaluation

Flora and fauna	Loss of biodiversity.	Training for the population for the care and protection of fauna.	Conservation of the area's biodiversity.	Administrator and teachers.	Teachers and students.	Soil preparation, sowing.	Semiannual evaluation.
	Affectation of vegetation cover.	Revegetation with soil-friendly species.	Revegetation of vegetation cover	Administrator and teachers.	Teachers and students.	Soil preparation, sowing.	Semiannual evaluation.
	Crop rotation.	Maintenance of soil nutrients.	Fertile soils.	Administrator and teachers.	Teachers and students.	Sowing.	Semiannual evaluation.
	Care of flora and fauna.	Training for the population	Conservation of the flora and fauna of the area.	Administrator and teachers.	Administrator, teachers and students.	Soil preparation, planting, maintenance and harvesting.	Semiannual evaluation.
Landscape	Restoration in affected areas.	Implementation of crops in deforested areas.	Reforestation with native or endemic flora of the area.	Administrator and teachers.	Teachers and students.	Planning of agricultural activities.	Semiannual evaluation.
	Loss of natural landscape.	Recovery of natural landscape through reforestation.	Restoration of lost natural landscapes.	Administrator and teachers.	Teachers and students.	Planning of agricultural activities.	Semiannual evaluation.
Economic partner	Community training.	Implementation of good agricultural practices.	Conservation of natural resources.	Teachers.	Teachers and students.	Planning of agricultural activities.	Semiannual evaluation.
	Implementation of good agricultural practices.	Educational workshops for the community.	Adequate use of natural resources.	Teachers.	Teachers and students.	Planning of agricultural activities.	Semiannual evaluation.
	Technology transfer.	Field trips and technical visits.	Interlearning between the community and students.	Teachers and communities.	Teachers, students and communities.	Planning of agricultural activities.	Semiannual evaluation.

Improved economic income for the communities surrounding the station.	Improvement in crop production systems.	Help to the community.	Teachers and communities.	Teachers, students and communities.	Planning of agricultural activities.	Semiannual evaluation.
Adequate use of natural resources	Community training.	Community environmental education.	Teachers and communities.	Teachers, students and communities.	Planning of agricultural activities.	Semiannual evaluation.

Conclusions

At the Tunshi Experimental Station in the School of Natural Resources area, agricultural activities caused mostly positive socio-environmental impacts because each of the teachers who have research projects at the station is working on the search for alternatives for the sustainable use of natural resources.

The results show that agricultural activities in the Tunshi Experimental Station, an area of the Faculty of Natural Resources, do not generate negative impacts; on the contrary, they contribute to the improvement, management and sustainable use of natural resources since the implementation of projects improving the quality of the soil, which was abandoned and had a certain degree of erosion and contamination.

The agricultural activities at the Tunshi Experimental Station, an area of the Faculty of Natural Resources, contributed to new agricultural production systems for society, generating economic income and savings in each agricultural activity.

The level of knowledge about socio-environmental impacts does not depend on the student's level of studies, and they consider that the agricultural activities developed in the EET are mostly positive because of the awareness generated in the care and sustainable use of environmental resources.

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