Huyro Smart Ecological Farm in Peru, an Approach to Sustainability

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Abstract

The present work shows the results of the Huyro Ecological Farm project during its first 6 years of operation in Cusco, Peru. In an attempt to make it 100% sustainable and self-sufficient, many efforts were made to supply energy, water, communications and even food security within the 3 hectares of tropical wetland land.

This paper presents the evaluation of the sustainability of the project that includes the operation of renewable energy equipment and its validation in the field, in order to create a policy that allows the transfer and commercialization of the technologies used on farm to the community. With the use of the Star of Sustainability method we are able to see, visually and efficiently, the process of sustainability of technological projects.

Keywords: Sustainability, ecological farm, smart farm, evaluation, qualitative methods, solar energy

1. Introduction

The Rural Sector Support Group GRUPO PUCP is an operating unit of the Department of Engineering at the Pontificia Universidad Católica del Perú (PUCP) and has developed several designs and implemented equipment in various areas of Peru. This study considers the results of Huyro Ecological Farm conducted by GRUPO PUCP in Peruvian territory during the last six years.

The Huyro Ecological Farm is a training center dedicated to the development and diffusion of research and application of the appropriate eco technologies or appropriate technologies, complemented by rural tourism focused mainly on agro tourism that generates ecological awareness, change of habits and that drive the self-sufficiency of the population, as well as the preservation of the natural resources of the area. See Fig.1

The ecological farm offers the following benefits to the Peruvian community: It is an educational place to teach students of universities, institutes, schools and general public; a place for research in science and engineering; a reserve of Peruvian biodiversity as guardians of seeds; an example of a self-sufficient and sustainable project with ecological agro industry; Peru's first smart farm with state-of-the-art technology; a model for gastronomy, hotel and tourism projects and finally a model of Scientific Park of Appropriate Technologies that makes it the leader among Innovation Centers in provinces in Peru.

Fig. 1. Photos of the main house and hostel in Huyro Ecological Farm in Cusco.

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2. Methodology

Hypothesis

There is a place in the tropical zone of Cusco where you can live using only the kindness of nature, obtaining energy, water, communications with equipment that use renewable energy as a source of energy. Food security is obtained from the processing of fruits and products of the area based on solar energy, achieving a technological, economic, political, social and environmental sustainability of its operation.

Methodology used

The proposed method, Sustainability Star (Hadzich 2014, Ref 1), allows us to analyze the sustainability process of the technology projects that were implemented on the farm during the last 6 years of operation and provides us with a clear view to either decide the continuity of the projects or their cancelation. The Star has 5 tips that analyze the Technological (T), Economic (E), Political (P), Social (S) and Environmental (A) factors which from now own we will refer to as TEPSA (in Spanish). See Fig. 2

Each of these factors includes several aspects within themselves. In TECHNOLOGY we consider aspects such as utility, sustainability, operation, reliability and maintenance; in ECONOMY we consider the income, employment, savings, affordability and innovation; in POLITICS we consider the political interest, the acceptance, legal aspects, promotion and distribution; in SOCIAL we consider the compatibility, motivation, life improvement, participation and capacity; and in ENVIRONMENT we consider the friendliness, climate, pollution, awareness, and health.

We believe it is a good tool to be used in all projects with a technological and political base in their development processes. This method could also be used in other situations where projects have been completed technological base and gives us a good insight to decide the continuation or closure thereof.

SUSTAINABILITY DEVELOPMENT: TEPSA oR 5 E´s

T	Tecnología - Technology	**E**	Engineering
E	Economía - Economics	**E**	Economics
P	Politica - Political	**E**	Ethical
S	Social - Social	**E**	Equity
A	Ambiental - Environmental	**E**	Environment

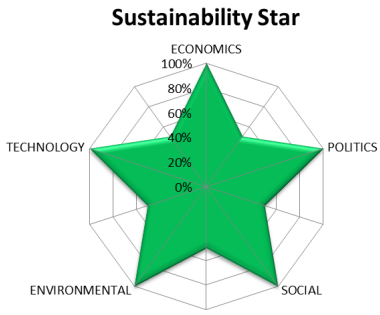

Fig. 2: Factors of sustainable development in the Sustainability Star

To analyze the index that corresponds to each tip of the Star, a 25 question survey is made, defining the break percentage of the shape. These surveys refer to TECHNOLOGY (utility, sustainability, operation, reliability, maintenance), ECONOMY (income, employment, savings, affordability, innovation), POLITICS (political interest, acceptance, legal, promotion, and distribution), SOCIAL (compatibility, motivation, life improvement, participation and capacity) and ENVIRONMENTAL (friendly, climate, pollution, awareness, and health).

If all surveys questions have positive answers then the star will be perfect without any break, as shown in Fig. 2 and the project will be considered as 100% SUSTAINABLE .

In order to decide the percentage corresponding to each point of the star we use a survey of 25 questions which defines the percentage of the Star Broken. See Fig. 3. Negative responses from the survey will fall inside the star percentage values that indicate the failure of the project in each of TEPSA factors.

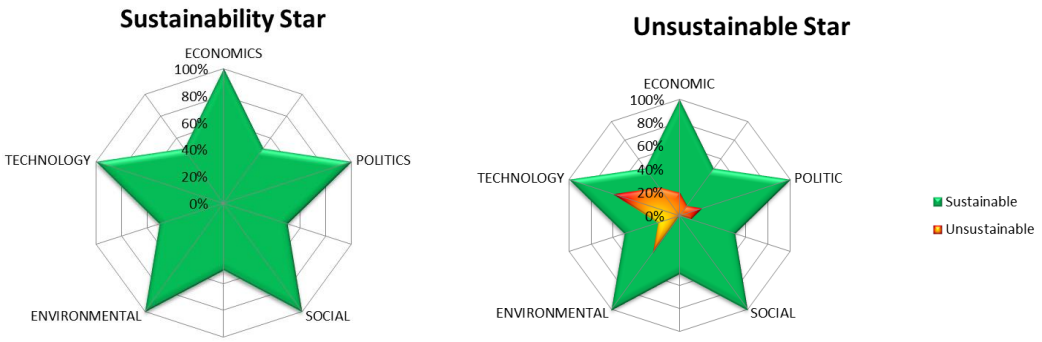

Fig 3: Example of Sustainability Stars – Perfect (left) and Broken (right).

3. Case Studied

The Huyro Ecological Farm is a training center dedicated to the development and diffusion of research and application of appropriate technologies or technologies that use renewable energies, complemented by rural scientific tourism focused mainly on agro tourism.The goal is to generate ecological awareness and change of habits that promote self-sufficiency and self-development of the population of the region, as well as the well care of natural resources.

This centre is a place that has the adequate infrastructure and equipment to be self-sufficient, provides its own electricity and the mechanical forces are obtained from the water, wind and sun sources. It provides its own food with eco farms. To avoid environmental pollution, water and solid waste are recycled and treated in treatment plants. It is a privileged place for demonstrating the operation of GRUPO PUCP technologies and to spread the achievements of the projects that have been developed.

The Huyro Ecological Farm has as its mission: To educate, train and promote awareness and to carry out actions that contribute to the development of sustainable communities. It provides on-site and distance classes, courses, workshops, internships and seminars on the subject of appropriate technologies, renewable energies and organic crops and provides national and international students with an opportunity to study and work voluntarily and learn about techniques for sustainable development.

It has an adequate infrastructure to provide the services required with architecture adapted and respectful to its surroundings; the design includes planned areas, flexible and dynamic spaces to meet educational needs, tourism and recreation in order to assure positive interaction with the environment and effective prevention of the ecological deterioration of the site.

Huyro Ecological Farm is located in Huayopata district, province of La Convención, department of Cusco, Perú, and 3 hours away from the historic Sanctuary of Machu Picchu. See Figs. 4 and 5.

Fig. 4: Photos of Machu Picchu and Thermal Baths in Santa Teresa.

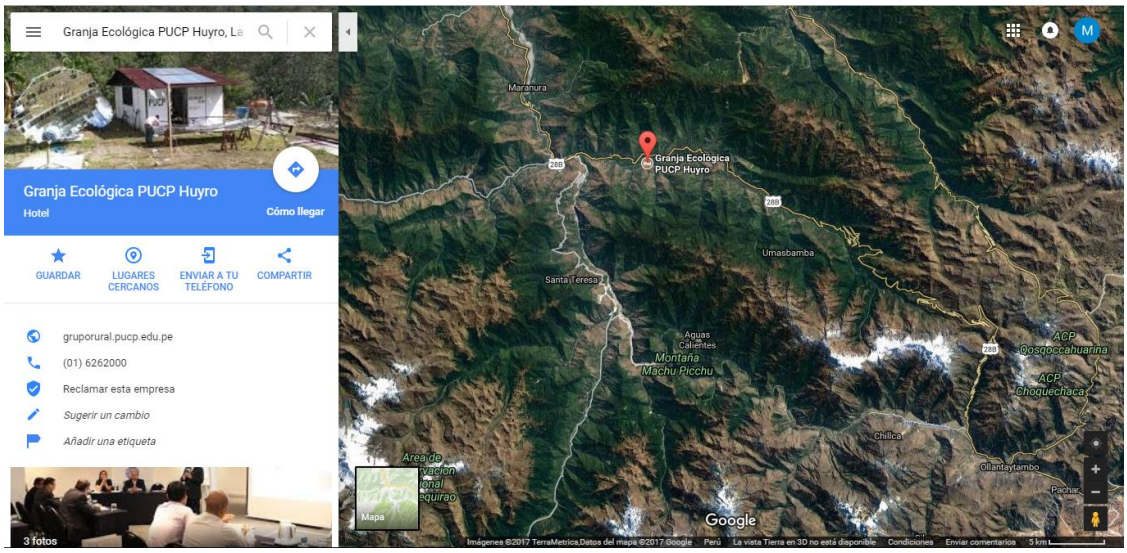

Fig.5: Satellite location of the project regarding Aguas Calientes - Machu Picchu. Google Map or Google Earth.

The technologies used on the farm are being disseminated to the community and the academic world of schools, technological institutes and universities that visit it continuously. See Fig. 6. This interaction of the farm with the visitors enables the products and technologies shown to reach the real world of the communities in need through their free distribution and marketing. GRUPO PUCP carries out the sale and demonstration of the technologies to visitors of the farm making it, both, an educational and commercial place.

Fig. 6: Catalog and Spanish Project of the Huyro Ecological Farm

See Catalog and Complete Project in Spanish in http://miguelhadzich.com/granja-ecologica-huyro/

4. Analysis of the farm's sustainability

The Huyro Ecological Farm obtains profits through training, research, development and transfer of appropriate technologies, volunteering and sustainable tourism. These activities generate economic benefits that can be reinvested to seek maximum profitability and generate the least negative impact. See Fig. 7

		T	E	P	S	A
		Technology	Economy	Politic	Social	Environmental
Energy	ELECTRICITY	Photovoltaic panels		Advice to settlers	Training	Solar energy
		Hydraulic Wheels		Advice to settlers	Educational site	Hydraulic energy
		Interconnected network	Services pay	PUCP Subsidy		Hydraulic energy
	HEAT	Solar thermal		Advice to settlers	Educational site	Solar energy
		Solar Dryers		Advice to settlers	Educational site	Solar energy
		Solar concentrators		Advice to settlers	Educational site	Solar energy
		Wood fired ovens		Advice to settlers	Educational site	Reforested biomass
		Improved kitchens		Advice to settlers	Educational site	Reforested biomass
	TRANSPORT	Van	Fuel purchase	PUCP Subsidy		Contamination
		Tractor		PUCP Subsidy		Contamination
	COMMUNICATIONS	Phone		PUCP Subsidy		
		Internet		PUCP Subsidy	Free Wifi for schools	
Water	Potable	Interconnected network	Monthly payment	PUCP Subsidy		Hydraulic energy
		Rainwater harvesting		Advice to settlers	Educational site	Hydraulic energy
	Irrigation	Sprinkler irrigation		Association of irrigat	Educational site	Hydraulic energy
		Flood irrigation				Hydraulic energy
Food	Orchard Crops		Consumption of Vegetables		Educational site	Biomass
			Consumption of corn, beans		Educational site	Biomass
	Fruits	Drying citrus, banana, mango			Gift coffee seedlings, fruits	Biomass
	Agroindustry	Solar Chocolate Factory	Sale of products	Advice to settlers	Educational site	Biomass
		Solar Coffee Factory	Sale of products	Advice to settlers	Educational site	Biomass
		Solar Tea Factory	Sale of products	Advice to settlers	Educational site	Biomass
	Miscellaneous supplies		Purchase of oil, rice, noodles	PUCP Subsidy		
	Trash	Recycling System			Educational site	
		Biodigesters			Educational site	Biomass
	Foresta and Flowers	Nursery	Sale of seedlings and seeds	Advice to settlers	Educational site	Biodiversity
	Lodging	Chainsaws	Sale of firewood			Biomass
		Rooms for 16 people	Sale of food and lodging rental			

Fig. 7: General scheme of the Sustainability and Self-sufficiency of the Huyro Ecological Farm

4.1 TECHNOLOGICAL SUSTAINABILITY

The Farm generates its own energy thanks to the natural resources of the area; it provides its own electricity and its own mechanical forces of the sources of water, wind, sun and biomass using technologies already developed by the GRUPO PUCP in its 25 years of life. All agro-industrial technologies are operating within the farm as a model for visitors and finished products are available for sale.
Each technology is available to interested people through workshop courses that are taught throughout the year. See survey on Technology Sustainability in Fig. 8.

			TECHNOLOGY SUSTAINABILITY	
			Survey about machines or project operation	
	YES	NO		
1.-	x		**Do you tkink that the machine is going to be useful?**	
2.-		x	**Technology (or machine) is constantly being used during the last year?**	
3.-	x		**Do you think the machine can easily operate?**	
4.-		x	**Do you think is a reliable technology?**	
5.-	x		**Do you think that local technicians can repair, copy or modify -all or part- of this machine?**	

Fig. 8: Survey on the Technological Sustainability of the Huyro Ecological Farm

The supply of electric energy is through a hybrid system of photovoltaic panels, hydraulic wheel and connection to the grid. There are 6 photovoltaic panels of 300 Wp each, as well as a hydraulic wheel of 4m in diameter. Water consumption is supplied by 5 different sources: drinking water from the nearby town, water for technical irrigation, water from the springs or rainwater collection and water pumping from the Lucumayo River. Mobile and internet services were installed through a private company. All the waste is recycled and the organic matter is converted into compost and processed in biodigesters.

To generate electricity there are 6 photovoltaic panels of 300 Wp each, with atotal 1.8 kWp, which generate electrical energy with an average solar irradiation of 5.54 kWh / m2 day. There is also a (1) 2.4 m diameter hydraulic wheel that provides 2 kW of electric power at 12 V with an inverter at 220 V AC. In addition, there is (1) Pelton hydraulic turbine of 500 W to 220 V AC. For emergencies, there is an interconnected electrical grid which unfortunately has many fluctuations in voltage (180-230) and causes the machines to fail continuously.

To produce HEAT we have installed: Solar heat pipes and traditional hot water heaters. Hot boxes also provide hot water from firewood improved stoves. The wood used comes from controlled forest and only the surpluses of the largest trees are burned. There are two (2) Scheffler concentrators used for roasting products and cooking food. There are solar dryers both tunnel type (1) and domes (2) for the drying of products.

There are 5 WATER sources: Freshwater that comes from the city located 5 km away through the public network. This service costs US$ 3.00 a month to the board of irrigators. Technical irrigation supplies the farm with water through a 4-inch pipe from Huyro River specifically for sprinkler irrigation. In a future project, water from the Lucumayo River will be pumped to the house located 300 m away from it and at an altitude of 10 meters.. The farm can access water from the springs for flood irrigation. Finally, there is a traditional rainwater harvesting system using filters. For health reasons all water for human consumption has to be boiled.

Due to the good location of the land in relation to the transmission towers, there is a good telephone line service for cell phones and internet connection for which you pay $ 80 per month.

4.2 ECONOMICAL SUSTAINABILITY

Food security is achieved with the products of fruit trees and first need products to supply a family of 5 members. On the farm the following first need products produced are: Corn, sweet potato, cassava, beans, uncucha, potato, etc. Fruits such as oranges, mandarins, lemons, pineapples, avocados, bananas, medlars, raspberries, lucuma, cherimoya, passion fruit, cocoa and wild plants are produced. For controlled firewood trees we have pacae, walnut, tóroc, among others. There are medicinal and aromatic plants such as fennel, lavender, matic, chamomile, coca, tea, coffee, anise, etc. See Fig. 9 annual agricultural calendar of the farm.

The heat for cookers and ovens is obtained from wood from ecologically managed forest. To dry and roast products, solar thermal energy is used through Scheffler concentrators and linear parabolic plants that process coffee and cocoa in an agro-industrial and ecological way to produce solar coffee and chocolate.

Farm products are sold to villagers, such as tea, coffee, chocolate, sugar cane, jams, honey, etc .; souvenirs, books and videos regarding each of the technologies shown are also sold. The sale process is similar to that of the "Tiendecita Verde" of the GRUPO PUCP in Lima.

Internship programs are carried out for students from other countries; this project is carried out through the Field School program of PUCP. Refer to http://fieldschool.pucp.edu.pe/courses/engineering-ecological-technologies-cusco/general-information/#.U441K_l5OSp

Fig. 9: Annual agricultural calendar of the Huyro Ecological Farm

Ecotourism and educational tourism are promoted for colleges, institutes and universities where GRUPO PUCP technologies installed on the farm are displayed and explained as well as the balanced coexistence between the natural environment and the dwellers. See Fig. 10. Rural ecotourism is promoted through guided tours, birdwatching activities and research projects designed for this type of climatic zones.

Fig. 10: Ecotourism and Training in the Huyro Ecological Farm

				ECONOMIC SUSTAINABILITY	
				Survey about machines and project cost	
	YES		NO		
6.-	x				**Do you see an economic improvement in your life or business when using this technology?**
7.-	x				**It has generated work for someone with the use of this technology in the community?**
8.-	x				**You think that you have saved on fuel or electricity when using this renewable technology?**
9.-			x		**Do you (or your neighbors) purchase or install a similar machine?**
10.-	x				**Do you think that this technology can be produced and sold in your community in the future?**

Fig. 11: Survey on the Economic Sustainability of Huyro Ecological Farm

In order for the farm to start generating more economic incomes that will make it profitable it is necessary to implement a tea factory that complements the existing coffee and chocolate factories. It is also necessary to increase the production of dried local fruits, especially citrus fruits such as orange, lime, grapefruit, mandarin as well as pineapple, mango and banana. See survey on Economical Sustainability in Fig. 11.

In addition, it is necessary to finish the preliminary research on the wild and native plants and implement the current nursery in a more modern and ecological way, using solar energy for thermal effects and laminar flow germinators for in vitro propagation of some endangered species.

For AGROINDUSTRY, there is a solar and coffee chocolate processing plant operating with 1.8 kWp photovoltaic panels that supply roasting machines (0.5 kW motor), a small 300 W refrigerator, (3) small electric motors for grinding - 0.25 kW each- as well as an electric motor of 0.5 kW for the de-pulping of coffee during production times. See Fig.12.

Fig. 12: Photo of the solar coffee and chocolate processing plant

The following figure 13 shows the financial evaluation of the farm project. The recovery time of the investment is calculated in around 9 years, but the farm can start generating incomes since its third year of operation.

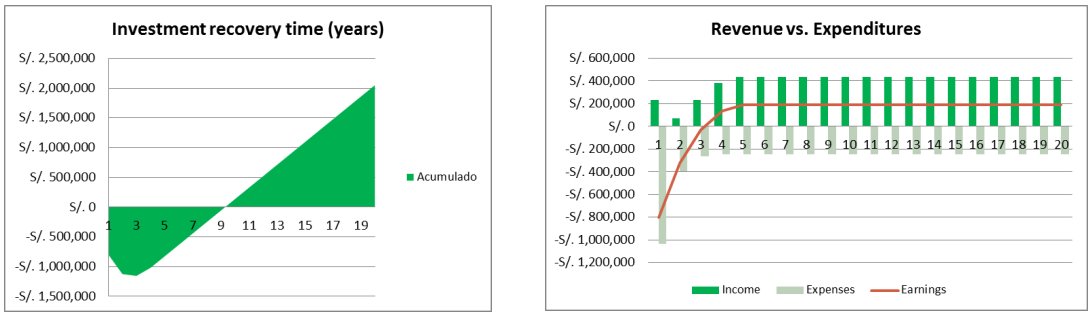

Fig. 13: Financial evaluation of the project

4.3 POLITICAL SUSTAINABILITY

We have a good social relationship with neighbours, as well as with the local and regional authorities. It has the recognition of the Huyro District Municipality and the Huayopata Governorship. See survey on Political Sustainability in Fig. 14.
It fosters an environment of solidary work amongst community residents and project staff.
Work is being carried out with the NGO “Projects Abroad” and with the “Colibrí Association” which also have offices in Huyro to encourage volunteering activities.

			SUSTAINABILITY POLICY	
			Survey on political and organizational project management	
	YES	NO		
11.-		x		**There has been interest in the project or the machine by any political authority?**
12.-	x			**The authorities of the community accept the project? There are requests from the community to some authority?**
13.-	x			**The project complies with the laws and regulations of the community and technical institutions ?**
14.-	x			**Do you believe that the government, person, or institution should promote this technology to other Peruvians?**
15.-	x			**The people of the town know the project?**

Fig. 14: Survey on the Political Sustainability of Huyro Ecological Farm

4.4 SOCIAL SUSTAINABILITY

The technologies developed are easily inserted into the sociocultural environment of the community, promoting development and revaluing local creativity. See survey on Social Sustainability in Fig. 15.

Community participation is sought through projects and activities that are carried out, especially with local schools and colleges. See Fig. 16. We have several projects with students from our own university supported by the Social Responsibility Direction focused on the construction of improved stoves in schools in the area.
We work with local people especially with builders, carpenters and metal mechanics.

			SOCIAL SUSTAINABILITY	
			Survey on the perception of the community about the project	
	YES	NO		
16.-	x			**The project is accepted "normal way" for the community?**
17.-	x			**There is interest in the community or their neighbors for the proposed technology?**
18.-		x		**The project has improved the standard of living of someone in the community ?.**
19.-	x			**The people have participated in some part of the project or activity?**
20.-	x			**There are people in your community with the necessary capabilities for operation and maintenance?**

Fig. 15: Survey on the Social Sustainability of Huyro Ecological Farm

Fig. 16: Visit of universities and colleges of the sector.

4.5 ENVIRONMENTAL SUSTAINABILITY

All systems, whether they are machines or processes, operate with technologies designed to maintain the ecological balance of the place. The use of renewable energy sources is mandatory and essential in all projects. Primarily local resources are responsibly used preserving the flora and fauna of the place making sure it is kept as a pleasant place where you can interact with nature.

All facilities have an environmentally friendly architecture to avoid negative influence in the management of its natural resources. See survey on Environmental Sustainability in Fig. 17.

				ENVIRONMENTAL SUSTAINABILITY	
				Survey on the impact of the project or the machine on the environment	
	YES		NO		
21.-	x				**The project is seen as a friendly environment technology ?**
22.-	x				**You do you think this machine is good for our Earth planet?**
23.-			x		**The project has created some kind of contamination in the environment?**
24.-	x				**Mind that this technology is clean rather than other similar package?**
25.-			x		**The use of this technology affects your health?**

Fig. 17: Survey on the Environmental Sustainability of the Huyro Ecological Farm

5. Conclusions

The Farm Sustainability Assessment shows us a great development in the fields of social, political and environmental components and the weaknesses in the economic and technological factors in which we are in the continuous process of improvement. In the case of the Huyro Ecological Farm, we are on the way to achieve 100% sustainability, but we still need to put a lot more effort to achieve this, especially in the field of food security.

We are aiming at attracting more tourists and environmental researchers so that their stay on the farm is pleasant and instructive. Thus, we plan to install more technologies such as a solar pool, a solar Jacuzzi, a solar tea factory, among others, that will become a model for the introduction of these technologies in the ecological hotels and rural communities of the surrounding areas and eventually be able to spread them throughout the world.

The Huyro Ecological Farm will be fully sustainable from the 9th year of operation. All constructions and technologies installed on the farm will be built by training/teaching local people, volunteers and participating students. We are trying to achieve sustainability through hard work and constancy.

Finally, the following Fig. 18 shows the evolution of sustainability in the Huyro Ecological Farm in the 5 years of existence and the positive advances in the different TEPSA aspects to try to achieve the necessary self-sufficiency and sustainability can be noticed.

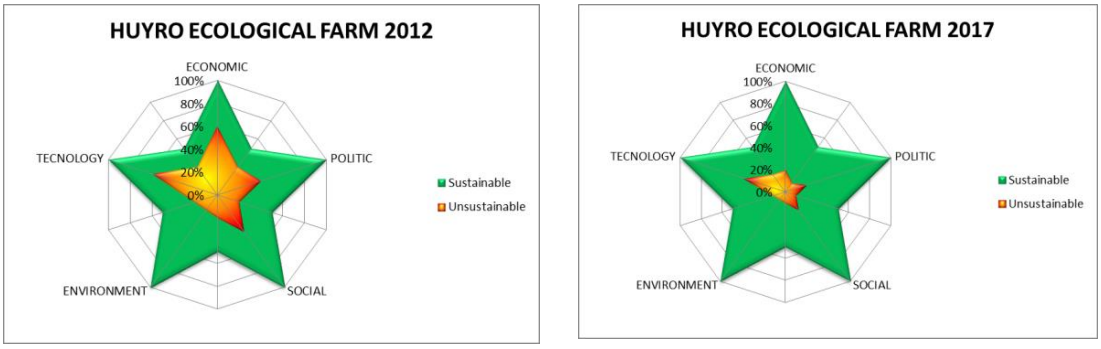

Fig. 18: Evolution of the Sustainability of the Huyro Ecological Farm from 2012 to 2017

The proposed methodology for the evaluation of technological projects has proven to be a good tool for decision making, since it allows us to evaluate the results of a project by analyzing it's sustainability.

The evaluation of the sustainability of projects depends not only on technological and economic conditions of the equipment that works with renewable energy but also depends heavily on the social and political situations of the places where these projects are to be implemented.

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