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The Production of Biodiesel from Jatropha Curca and Its Social Impact

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Abstract

The social impact of planting and harvesting the jatropha curca for the production of biodiesel in the province of Manabí is shown, where there are several municipalities involved in this process, mainly the populations that live in rural areas where the conditions are created for their improvement of quality and good living from the income they receive for performing these tasks. A social relationship model was designed that links the social development of rural areas in the province of Manabí with the sowing, harvesting and industrialization of jatropha curca in social development, demonstrating the benefit of using indigenous natural resources for the in the improvement of the quality of life of the populations directed to the economic, energetic, social and environmental sustainable development.

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1. Introduction

Environmental problems are caused by human, economic, social, cultural and political processes or behaviors, among others, that transform the environment and cause negative impacts on the environment, economy, and society. In Ecuador there are four major environmental problems that began to manifest on a large scale from the modernization of the country, approximately since the 1950s, where the energy sector began to take off quickly (Alcivar, 2015):

1) The destruction and fragmentation of habitats;
2) The introduction of exotic species;

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3) Overexploitation of natural resources and;
4) Pollution.

To these phenomena, we must add global climate change, whose medium- and long-term effects endanger biodiversity and the quality of life on earth. The Galápagos archipelago is located on both sides of the equinoctial line, approximately 970 km west of the province of Manabí in the continental Ecuador. It consists of thirteen major islands, six smaller islands, 42 islets and many rocks that cover a total area of 7,850 km² (Armando Rucoba García, 2013). 97% of the total area of the islands is part of the Galapagos National Park, the rest corresponds to the inhabited and cultivated areas of the islands Santa Cruz, San Cristóbal, Isabela, Floreana, and Baltra.

The Galapagos Islands make up the most diverse and complex archipelago in the world, where conditions remain relatively intact. Because of its distance from the continent and the fact that it was never connected to it, the existing flora and fauna evolved remarkably to what they are now and remained unchanged until the man first came to them. On July 4, 1959, the Government of Ecuador declares National Park to all areas of Galapagos that are not colonized, establishing its limits. On 23 July of the same year, the Charles Darwin Foundation was created and the scientific station of the same name was inaugurated in 1964. In 1978, UNESCO declared the Galápagos "Natural Heritage of Humanity" (Armando Rucoba García, 2013).

The "Special Regime for the Conservation and Sustainable Development of the Province of Galapagos" Law is currently in force and it hopes to regulate the environmental threats facing the territory; nevertheless the demand and generation of energy constitutes an element of risk that must be analyzed with special consideration, that is why strategic plans have been drawn up and an energy program with different renewable sources of energy has now been undertaken, one of them being bioenergy from the use of biodiesel.

The Ministry of Electricity and Renewable Energy of Ecuador, through the National Directorate of Biofuels, is carrying out the pilot project "Piñón-Galápagos", which was presented jointly by the Ministry of Agriculture, Livestock, Aquaculture and Fisheries, counting with the support of the German Federal Ministry of Environment, Nature Protection and Reactor Safety through the German GIZ Cooperation. The project arose as a result of the feasibility study for the replacement of fossil fuels by biofuels for the generation of electric power in Floreana Island, contracted in 2007 by the United Nations Development Program and executed by the German Service, in which was recommended the use of pure vegetable oil of pinion, as the best option for the diesel replacement (CONELEC, 2015).

The generation of electricity from pure vegetable oil on Floreana Island is aimed at replicating at an insular level, in such a way as to integrate electricity generation from non-conventional renewable sources, such as wind and photovoltaic, with thermal from pure vegetable oil of pinion and in this way to comply with the initiative Zero Fossil Fuels in the Galapagos Archipelago. But for Floreana Island and for the Galapagos Archipelago, it may be a problem to consider the non-availability of sufficient arable land to ensure the cultivation and harvesting of the necessary Jatropha Curca for the production of biodiesel that is needed to cover energy needs with zero oil.

For its part, the province of Manabí is located in the center-northwest of continental Ecuador, whose legal unit is located in the geographical region of the coast, which in turn is divided by the cross of the equinoctial line. It limits the west with the Pacific Ocean, the north with the province of Esmeraldas, the east with the province of Santo Domingo de los Tsáchilas and Los Ríos, the south with the province of Santa Elena and the south and the east with the province of Guayas. In front of its coasts to about 970 km is the Galápagos Archipelago.

The province of Manabí is an eminently agricultural land with sufficient land to extend and boost the cultivation and harvesting of Jatropha Curca seed on a large scale. This is why it is intended to contribute to the agroindustrial development of the pinion, which historically exists as a part structural in the province's living fences, thereby increasing the social impact of the collection and industrialization of products derived from the plant, especially the production of biodiesel and its use as an energy source. The scientific problem consists of: How to design a model of sustainable development that integrates the cultivation, harvesting, harvesting and commercialization of Jatropha Curca seeds, as well as the industrial process for the extraction of biodiesel and other derived products and their use as source of energy, in a way that contributes to the sustainability of the territory of the province of Manabí.

The objective is to design and propose the implementation of the "Integrated Territorial Model of Sustainable Agroindustrial Relations Associated with Jatropha Curca", demonstrating its importance in terms of contributing to crop development, harvesting, seed harvesting, biodiesel extraction and harvesting energetic. The work is based on the excellently environmental character of the political constitution of the Republic of Ecuador (Duffey, 2010), as expressed in the seventh chapter of the Rights of Nature, as well as the Master Plan of Ecuador until 2020 (El Diario Manabita, 2010), where the policy to be followed regarding the production and use of biodiesel.

2. Materials and Methods

The work combines the traditional theoretical methods of scientific research, such as The method of analysis-synthesis in the study of available bibliographic material; The historical-logic for the provision of precise considerations regarding the logic of the development of biofuels, especially biodiesel since its evolution in previous years; The method of induction and deduction, which led to the existence of the content of the object of study, to obtain their own conclusions, thus allowing deduction of the essence, causes and why of the final proposals and recommendations. All of the above was applied in order to unveil the essence of the scientific problem, in the processing of information and the definition of the system of central and operative categories. In addition to achieving a concrete result and reaching conclusions and recommendations, which may be useful in the use of experiences to implement the proposed model in the territory of the province of Manabí.

3. Results and Discussions

It is known as biofuels to the set of liquid fuels from different transformations of vegetable or animal matter. They can be used in vehicle engines, and for the generation of electricity as a substitute for conventional fossil fuel derivatives. Under this heading two totally different product lines are collected, bioethanol and biodiesel (Gomez Juan, 2015). Bioethanol is obtained from traditional crops such as cereal, corn or beet, through the process of raw material adaptation, fermentation, and distillation. Their applications are directed to the mixture with gasoline or to the manufacture of an oxygenated additive for lead-free gasoline (ETBE) (Gomez Juan, 2015). The production of biodiesel is carried out by means of transesterification and refining of vegetable oils, either pure (sunflower or rapeseed, for example), well used. The product thus obtained is used in diesel engines as a substitute for gas oil, either in mixtures with it or as a single fuel (Gomez Juan, 2015).

Biodiesel, in particular, is a clean, renewable, quality and economically viable source of energy, which also contributes to the conservation of the environment, thus representing an alternative to fossil fuels, its future can be guaranteed whenever administrations collaborate with legislation in favor of biofuels, with compulsory consumption laws, with the maintenance of fiscal aid, with aid to transform some current crops for oilseeds, such as soybean, rapeseed and sunflower (Gomez Juan, 2015), provided they do not contradict the availability of food should be sought for other plants not considered in the group used in food, such as Jatropha Curca. At the end of the 19th century, Rudolf Diesel (1858-1913) invents the combustion engine that uses fuel oil for its operation and from there implemented early versions of a machine that used peanut oil as energy (CONELEC, 2015); but it was not until 1970 that biodiesel developed significantly in the wake of the energy crisis and the high cost of oil. Years later in 1982 in Austria and Germany, the first technical tests with this vegetal fuel were carried out and in 1985 in Silberberg (Austria) the first pilot plant was produced biodiesel from the seeds of rape or canola.

Currently, Germany, Austria, Canada, the United States, France, Italy, Malaysia, and Sweden are pioneers in the production, testing, and use of biodiesel in cars. Latin America is not far behind in these studies and progress has been made in many countries in the area, the Economic Commission for Latin America and the Caribbean (ECLAC) has developed a study that includes important aspects of biodiesel production, mainly in aspects such as environmental issues, their energy content, greenhouse gas emissions, local emissions, water use and pollution, land use and soil contamination, among the most important (González, 2011). In this region, biodiesel is being obtained mainly with the seeds of Jatropha Curca, a plant that is used as a live fence to demarcate land and does not represent an immediate competition for food production.

The cultivation of Jatropha Curca over several years has proven to be an important source of bioenergy, proving to be a crop that allows to improve the conditions of deteriorated soils and with arid characteristics. For the development of the crop requires people who are linked to agriculture in their sowing and harvest, generating jobs in the territories where it is cultivated and achieving an impact not only energetic but social in its production. According to the technical guide for the cultivation of curcas (pinyon) published in Guatemala (Organo Legislativo del Estado Ecuatoriano, 2008), the products obtained from the Jatropha Curca are shown in figure 1 and it can be observed that it presents a wide range of derivatives from the harvest of the whole plant (fruits, leaves, branches, flowers among others).

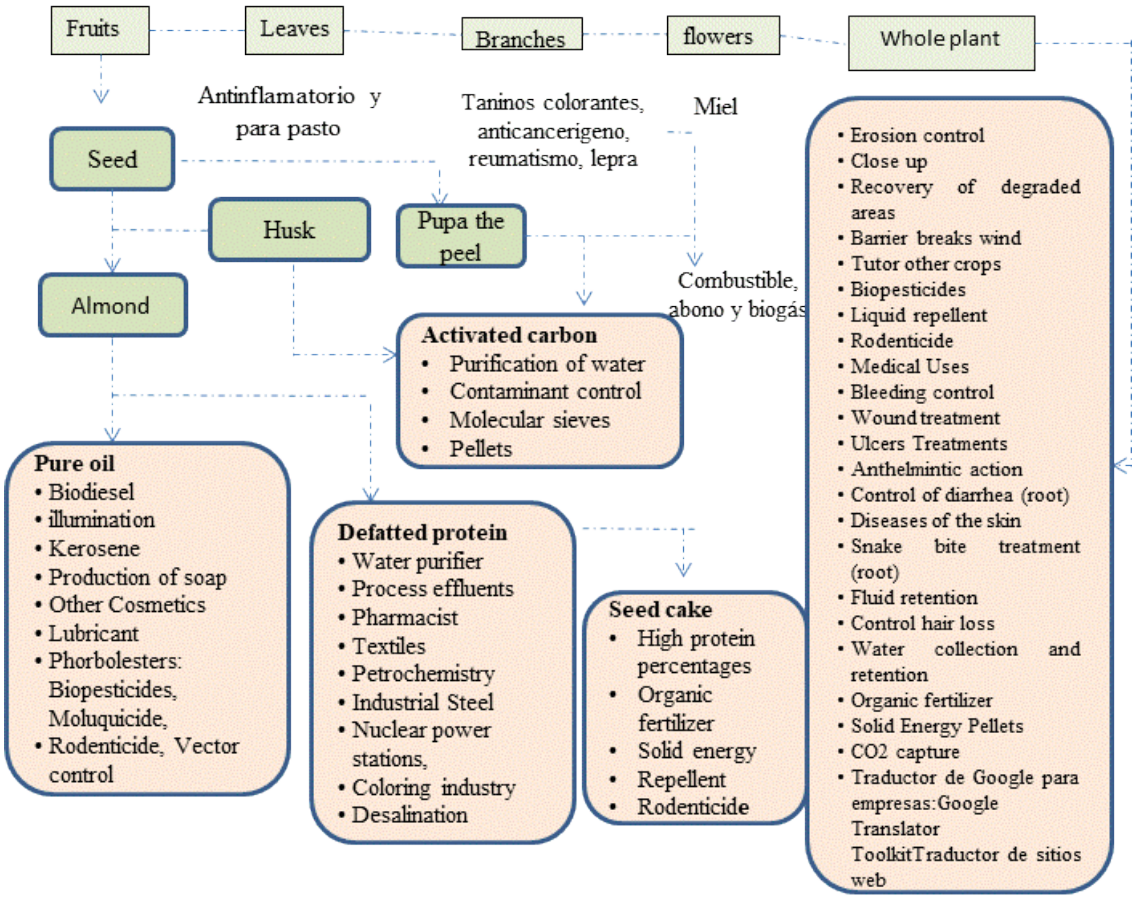

Figure 1. Products obtained from the curve
Fuente: (Organo Legislativo del Estado Ecuatoriano, 2008)

In some countries, research has been carried out on aspects of crop adaptability, its easy adaptation to poor soils, low water requirements and the high oil content of its seed, attributes that are its best presentation. The Jatropha Curca species can be implemented as a productively fast plant in adverse situations, degraded lands, dry climate, marginal lands and at the same time be part of an agroforestry system. It can be planted on fallow lands and along pasture boundaries, because it does not grow too tall, as it has proven to be appropriate on unused land, along railroads, roads and irrigation canals.

Nowadays in the world plans are being developed for the cultivation of the Pinot Noir or Jatropha Curca, for example, China, India and Africa total 5 million hectares and several countries are investigating different types of varieties. Specifically, in Ecuador, there is a biofuels formulation program led by the Ministry of Electricity and Renewable Energy, mainly aimed at the mixture of diesel and biodiesel at 5%, for which they need an amount of 1,456 bls/day of biodiesel (Rodríguez Gámez María, *et al.*, 2016).

In the province of Manabí, there is a project for the extensive development of Jatropha Curca cultivation for energy purposes, including cultic, harvesting, harvesting and commercialization of the seed, with the essential objective of satisfying the demand of this product for the plants of bioenergy of the Galápagos Islands, that today carries out a program of sustainable development with zero oil. At present, the seeds collected and half-processed in the province of Manabí are transferred to the Galapagos Islands, where the process of extracting the oil and its transformation into biodiesel is carried out, generating a source of clean and safe energy for the island, which can be used in industries and trades to substitute a portion of the demand for conventional fuels, the results obtained bring benefits not to mention those obtained by the use of its derivatives (Rodríguez Gámez María *et al.*, 2017).

In the province of Manabí, the plant is used as a live fence and a pepa is harvested, which results in the fruit of the pinion, and is where the oil is concentrated and when it is treated the biodiesel is obtained. The collection of the seeds and their transfer to the archipelago make possible the uninterrupted production of biodiesel, which allows the

operation of the electricity generation plant that provides services on Floreana Island. In the agricultural area as of 2009, a research and training program has been developed, with the Portoviejo Experimental Station of the National Autonomous Institute of Agricultural Research (INIAP) and the participation of local private investigators, who have shown high interest in the project. The research carried out by INIAP presented interesting results regarding the state of the art and novelties of bioenergy in Ecuador.

In 2010, with the support of the Ministry of Agriculture, we worked on about 15 peasant organizations, among which we can highlight the cantons: Chone, Sucre, San Vicente, Tosagua, Rocafuerte, Junín, Calceta, Portoviejo, Santa Ana and Jipijapa, where training was given on pruning and appropriate management closely. A purchase and stockpiling plan for the pinion has been carried out and it has been made aware of the possibility of obtaining an additional income from the sale of a product that to date had no representative economic value. In 2011, the number of communities that worked for the collection and collection amounted to 40, benefiting more than 240 families in the province. Figure 2 shows the map of the province of Manabí, where the sites with people trained in the pruning and proper management of the Jatropha Curca, elaborated using the Geographical Information System for Sustainable Energy Development (SIGDES) (Sandino *et al.*, 2012).

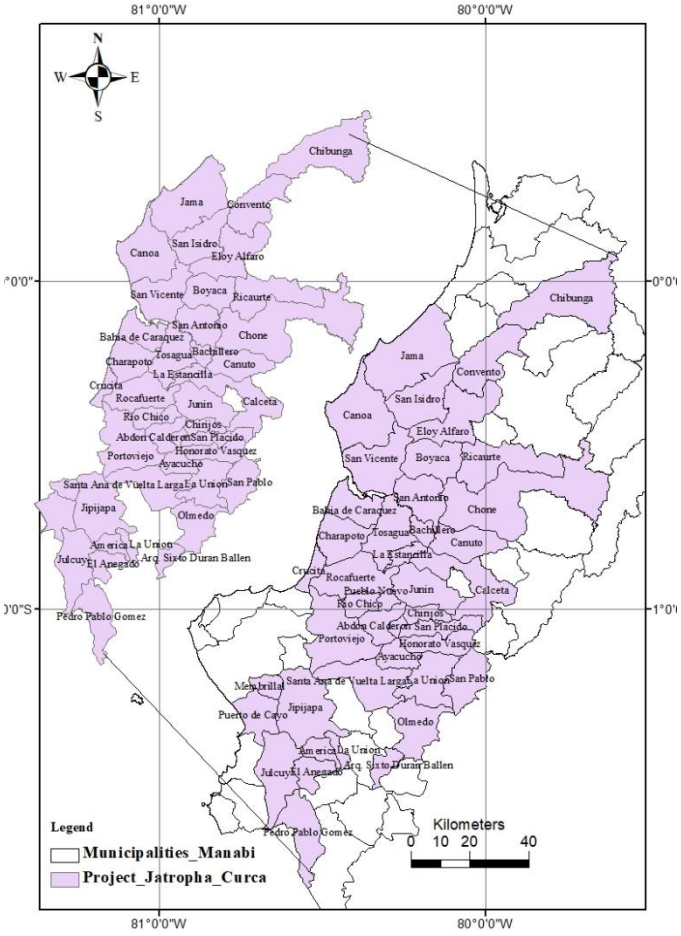

Figure 2. Map of sites with people trained in pruning and appropriate management of Jatropha Curca

The great oil content of the seed ranges from 30% to 55% solvent fraction, with varieties that are developed in Mexico and Guatemala that present up to 67% of oil, something promising for the future development of bioenergy. Of the harvests achieved in the province of Manabí, the yield indicator corresponds to 86.9 gallons of biodiesel per ton of Jatropha Curca seeds. Harvests are currently averaging about 109 tonnes collected and delivered to the industry annually, with which some 9,473 gallons of biodiesel can be produced, enough to generate about 148 MWh, roughly representing demand for electric power on Floreana Island for 8 months. So far the extracted oil is processed

in Floreana Island itself and training are given to demonstrate the social and energetic importance of the project; but we are working on the implementation of an extraction plant in a community of Manabí, with the possibility of expanding production lines, bringing social benefits to the territory.

The engines that are used for generation in the Galapagos are dual, so that they can operate with diesel or biodiesel depending on the availability without need of any technological or operational change; and this conception was based on the possibility of not having 100% of the production of pinion oil due to climatic causes and the time it takes for the development of new agricultural plantations, where constant work is required for at least 3 years (Sandino *et al.*, 2012). The Ecuador Master Plan until 2020 (El Diario Manabita, 2010) sets out the policy to follow regarding the production and use of biodiesel since electricity generation in the country has basically two sources: hydro and thermal.

To eliminate the use of diesel, it is first necessary to expand hydraulic generation and not to discard the option of using other energy sources and alternative fuels such as biomass, biodiesel, ethanol, natural gas, etc., which are environmentally friendly; but which are currently under development. At present, a hundred farmers have joined the cultivation, harvesting, harvesting, and commercialization of the Jatropha Curca seed, which has traditionally been planted as live fences on their farms, providing a new source of income that helps them to support themselves.

According to reports the director of the experimental station pointed out, they have 120 collections of pinion (curcas) that are investigated (Sandino *et al.*, 2012). It seeks to generate two years of crop management technologies and identify early and productive varieties with high oil yields, on this front are involved different social entities, whereas important element is the population sector of the province, which is benefited by the payment of the service of the collection of the product. It also works in the extraction of oils in other plants such as the hillock and soybeans among others. The Jatropha Curca has a high energy potential for the production of biofuel through the pinion, it is necessary to look for the areas that should be used to make its production profitable, not only economically but also socially and sustainability long-term.

To achieve the development of industries and technologies, training must be generated to obtain skilled labor, better jobs, and quality of life. In Manabí, a market study is carried out for export. Today, strategies are being developed to enable the small industry to develop, where peasants can carry out the process of different products such as the production of homemade soap, or as a purgative of horses to eliminate parasites. According to data from the Provincial Council, an entity has signed an agreement with the Ecological Corridor Corporation to operate in Montecristi, Jipijapa, and Paján, where 18 hectares are already planted and there are two nurseries with two millions of seedlings ready to be transplanted. It aims to plant 23,000 hectares and in 60 months it is projected to have 50,000 hectares planted. One hectare of this crop generates between 2,100 and 2,800 liters of oil, where people who improve their social status are imbricated, with the emergence of new jobs and higher incomes (Sun Wind Travel, 2015).

The energetic use of the derived oil in the industrial process of the Jatropha Curca seed can help mitigate the serious environmental problems that society faces. Energy processes take a good share of responsibility in the impacts that have led to the environmental deterioration of the planet, since the extractive processes of fossil fuels, their transfer, and industrialization, are related proportionally to the various effects of pollution, affecting measured in the flora, the fauna and the biotic spaces of the earth, affections that seem irremediable because they do not recover in the period of life of a man.

The discovery of different energy products obtained from biological processes, whether natural or artificial, has made a shift in the use of the primary energy immanent in the processes they generate. Plants with the process of photosynthesis are a natural energy generator and biomass production is growing daily. The industrial use of this natural biomass nourishes the man of a potential energy source practically inexhaustible. In the case of oil extracted from the Jatropha Curca seed and from where biodiesel is obtained, it has a positive impact on energy generation and the preservation of natural resources, constituting one of the most important aspects of the measures.

In general fossil fuels have emission factors of more than 100 g CO2e / MJ, while biofuels reach a maximum of about 70 g CO_2 / MJ for ethanol and 80 g CO2e / MJ for biodiesel (Rodríguez Gámez María, *et al.*, 2016; Sun Wind Travel, 2015). Biofuel corporations and associations have promoted scientific studies that show that the substitution of ethanol and biodiesel with gasoline and diesel oil, respectively, reduces CO2 emissions by 50-75% according to studies. It must be taken into account that carbon is neither created nor destroyed, which is emitted in the burning of the biofuel, was absorbed and stored before by a plant in its growth process. The use of idle dry soils gives Jatropha Curca exceptional properties to contribute to a healthy environment for the production of biodiesel by recovering abandoned unproductive areas not suitable for other crops, this directs its development to the sustainability in the production of the seeds that provide the natural energy oil, which does not compete with man's basic needs such as

water and food. As a result of the research, the Integrated Territorial Model of Sustainable Agro-industrial Relations associated to Jatropha Curca is proposed, with the aim of promoting sustainability in the energy use of this plant:

a) In the Jatropha Curca plantation, the hedge of live fences must continue to be utilized and, in parallel, to carry out their combined cultivation with other plantations, especially in dry and arid lands, thus achieving a greater use of the land, as well as overtime to recover lands in disuse because they were not very productive. All this guarantees the possibilities of expansion of the crop, increasing the possibilities of CO2 capture by natural methods.
b) Harvesting, harvesting, and marketing of seeds should be organized under the principles of Agribusiness, aimed at diversifying the supply of products and increasing sources of family income.
c) Technological processing for the extraction of biodiesel can generate other derivative products with the potential to expand the tradable items in the territory: black soap; ant parasitic for animal use; concentrated solid fuel; among others. In parallel, the final product is a marketable item with a high impact on the territorial economy, avoiding having to depend on the purchase of fuel abroad.
d) Clean energy generation involves the use of extracted biodiesel to ensure the operation of various activities of high social impact: the operation of transport; the generation of electrical energy and; the cooking of foods are among the main. It's guaranteeing an important contribution to the territorial economy and conservative environmental protection of natural resources.

In all cases the model is shaping towards the generation of new jobs and incomes, which ensures the equitable development of the agro-economic function in the territory, fostering social community sustainability (Sun Wind Travel, 2015). The model is geared towards achieving territorial energy independence. Figure 3 shows the Integrated Territorial Model of Sustainable Agricultural industry Relationships associated with Jatropha Curca.

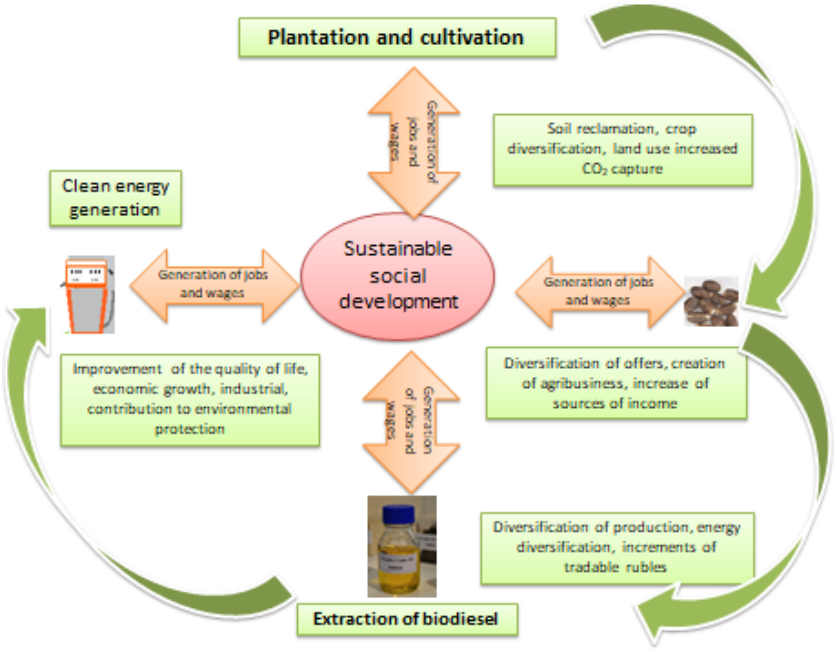

Figure 3. Integrated Territorial Model of Sustainable Agricultural industry Relationships Associated with Jatropha Curca

The model developed shows that from all the actions carried out (planting, harvesting, extraction of biodiesel and the commercialization of the product), there will always be social, economic and environmental improvements that can in this way achieve sustainable development in many territories their productions.

4. Conclusion

The research allowed us to define that the sowing, cultivation, harvesting and harvesting of Jatropha Curca in the territory of the province of Manabí can constitute a productive activity framed in agribusinesses, with the potential to generate new jobs and wages, to recover unproductive lands, to diversify crops, increase the possibilities of CO2 capture by natural methods, diversify marketable offers and have a new source of energy of its own, which can promote the energy independence of the territory. As a result of the work, we propose the "Integrated Territorial Model of Sustainable Agroindustrial Relations Associated with Jatropha Curca", focused on achieving socially sustainable energy in the territory of the province of Manabí.

Conflict of interest statement and funding sources
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Statement of authorship
The author(s) have a responsibility for the conception and design of the study. The author(s) have approved the final article.

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