Hochschule Anhalt
Anhalt University of Applied Sciences

Implementation of Renewable Energies in the Master Plan of Pifo-Ecuador

A plan to help a small region accomplish sustainable development

Master Thesis

Submitted in partial fulfillment of the requirements for the degree of Master of Landscape Architecture

Anhalt University of Applied Sciences

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To my grandfather, Nicolás Guillén, who taught me to always see the bright side of life.

ABSTRACT

Pifo is a Parish in the surroundings of Quito, the capital of Ecuador. Because of this proximity, is target to industrial zoning and assisting services for the city.

These changes create pressure on Pifo, which currently is losing much of its natural environment to industry and therefore much of its identity. To guide this growth the local government's plan has various sustainability objectives which this project can help fulfill. With a Strategic Environmental Assessment (SEA) this thesis creates a possibility of changing the current patterns of development by proposing a combined model where different technologies work together, increasing performance and assisting in the maintenance and enhancement of natural environment and identity.

It is a main subject of this thesis to consider the different "stake holders" when planning; not only finding the optimal areas for implementation of Renewable Energy (R. E.) technologies, as are strong winds, but taking into account other factors such as historical places, natural landmarks, environment, habitats, amongst others. Including information from a meeting with the local government (GAD Pifo), the Development and Territorial Ordering Plan, the history of Pifo as well as the Constitution of Ecuador and the programs from different Ecuadorian ministries, this thesis is able to examine different aspects that influence the decision making. With this information, the proposal proceeds to identify sensitive issues and analyze the conflicts these areas portray; with further detailed site analysis, a proposal of compensation measures is considered to decrease affectation of the project. Regarding social significance, the opinions of the local citizens should be considered following several steps of the recommended public participation. The proposed compensation measures include enhancement of ecological features as well as restitution for the social effects that the project can have.

The information gathered many times displays different results. For example, when compared to a visual analysis, municipal and development plans display different realities. From both outlooks, potential areas for the implementation of R.E. technologies are selected where compensation options are possible. Priority is given to areas that have already been interfered and that match high production areas of wind and sun. This selection has provided a range of locations where a wide variety of R.E. technologies can be implemented.

By introducing Renewable Energy technologies in the current master plan and making Pifo a self-provider of energy, the proposal also opens access to more jobs and income for the locals. Through this shift, the development patterns can change into a more sustainable and local driven system where Pifo will be able to manage its own growth while being less conditioned to external pressures. All this process has to be carried on with constant educational and participation programs where the local citizens are active participants and therefore responsible for the success of the projects.

II. Acknowledgements

My path this last years has been specially touched by admirable teachers and colleagues, who have been always pushing me to improve myself professionally and, above all, personally.

I want to give special thanks to my supervisor, Prof. Adrian Hoppenstedt from Hochschule Anhalt, this project could not have been possible without his guidance and pragmatic direction when I most needed it.

For the overall structure of this thesis I want to thank Prof. Caroline Lavoie from Utah State University, for her attention to detail, her guidance and support, which help me improve the quality of the project. For always being attentive of my progress, I thank Prof. Alexander Kader from Hochschule Anhalt, for his suggestions and his trust in me.

At the beginning of the project, in December 2018, I met with the representatives of the local government of Pifo, who provided the information needed to accomplish the main analysis for this project and gave me insight into the requirements of the parish, therefore I want to extend special appreciation to the GAD of Pifo (Decentralized Autonomous Government of Pifo).

To my family and friends who, even from the distance, have provided immense support along the way.

I feel blessed to have had so much support, advice and guidance.

III. Declaration of autorship

I certify that the material contained in this Master Thesis is my own work. This document shows individual work and no other person has worked in its production. All consultations and external work have been cited and properly acknowledged.

This master thesis has not been previously published or submitted to any other award, degree or diploma in any other institution.

Signature: _____

Date:

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V. List of abbreviations

- **Arconel:** Agency for Regulation and Control of Electricity of Ecuador(Agencia de Regulacion y Control de Electricidad)
- **Art.:** Article
- **C:** Celsius
- **ca.:** circa
- **Ch.:** Chapter
- **CNEE:** National Committee for Energy Efficiency (Comité Nacional de Eficiencia Energetica)
- **E:** East
- **EIA:** Environmental Impact Assessment
- **et. al.:** and others (Et alii)
- **F:** Fahrenheit
- **GAD:** Decentralized Autonomous Government (Gobierno Autonomo Decentralizado)
- **Gwh:** Gigawatt hour
- **H:** height
- **ha.:** hectares
- **Km:** Kilometer
- **Km/h:** kilometer per hour
- **Kwh:** Kilowatt hour
- **Lat.:** Latitude
- **m:** meter
- **m/s:** meters per second
- **mamsl:** meters above mean sea level
- **mm:** millimeter
- **N:** North
- **NBI:** Unsatisfied Basic Needs (Necesidades Basicas Insatisfechas)
- **OCP:** Heavy Crude Oil Pipeline (Oleoducto de Crudo Pesado)
- **p:** page
- **PDOT:** Territorial Ordering and Development Plan (Plan de Desarrollo y Ordenamiento Territorial)
- **PLANEE:** National Energy Efficiency Plan (Plan Nacional de Eficiencia Energetica)
- **pp:** Pages
- **PV:** Photovoltaic
- **R. E.:** Renewable Energy
- **S:** South
- **SEA:** Strategic Environmental Assessment
- **Senplades:** National Secretary of Planning and Development (Secretaría Nacional de Planificación y Desarrollo)
- **UN:** United Nations
- **UNSDG:** UN sustainability Development Goals
- **W:** West
- **w/m2:** Watts per square meter

VI. Definitions

The following terms are important to understand in the context of this thesis.

- Aesthetic standards: Standards set by the local government in accordance with the local citizens to regularize new development in a way that harmonizes with the history, identity and goals of the parish.
- Development Priorities: Areas that are best suitable for growth in a way that density increases where there is already existing settlement and green areas are safeguarded from new development. (Duany, Speck, & Lydon, 2010)
- Environmental conflicts: The conflict that a project can cause in the environment or in specific habitats in a way that the habitat can no longer perform as intended. In many cases the hindering the service a certain habitat provides, as for example water recollection from air humidity and transferring it to underground water sources which later provide drinking water to the parish.
- Green connections: Connecting existing vegetation in a way that flora and fauna can migrate and reproduce maintaining a healthy life cycle; preventing local extinction.
- Green print: The region's existing natural resources. (Duany, Speck, & Lydon, 2010)
- Identity: The character of the place given by culture and historical events in a way that singles out the area and differentiates it from others by building a sense of belonging in its citizens.
- Natural Landmarks: The higher mountain peaks surrounding the area which create a sense of direction.
- Renewable Energy: Electrical Energy created by a natural source that is constantly restored, such as wind or sun. Also called "clean Energy" (NRDC, 2018)
- Smart Growth: A method of designing communities and controlling sprawl, in a way that the community decides which areas to protect and maintain, which areas to develop and which areas to enhance. As the example of this project shows, industry is going to come and this fact is difficult to avoid, but where and how can be planned and smartly decided by the local government when attaining to the principles of smart growth. (Duany, Speck, & Lydon, 2010)
- Sustainability: Besides the generally accepted definition of sustainability of "meeting the needs of the present without compromising the ability of future generations to meet their needs" (IISD, 2019), this thesis considers sustainability also as a way of inclusion. Sustainability encompasses the goals of the locals as well as the interests of the government and the importance of safeguarding the environment.
- Landscape: According to Emily Smyth, landscape is the process of interaction between humans and our environment (Smyth, 2015). This broadens the view of landscape from a classical concept of "natural surroundings" and includes the human as part of the ecological systems.
- Sustainable development: A way of advancement that includes different types of people and interests while giving priority to the protection of the environment. Can be achieved by following the UNSDG which "address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. (UN, 2018)

1

Introduction

Chapter 1. Introduction

The area of study chosen for this thesis is Pifo, a town in the surroundings of Quito the capital of Ecuador. The main focus of this study is to help this area have a more sustainable development by analyzing the possibility of placing Renewable Energy (R. E.) technologies in its territory. This chapter will focus on looking at the circumstances that influenced the area of study towards its current situation and how its position makes it vulnerable to lose its identity as well as have very sensitive social fabric prone to poverty.

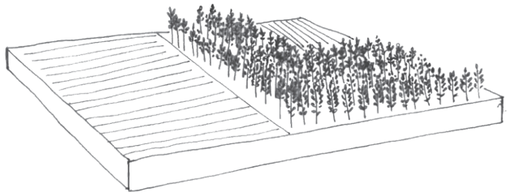
FIGURE 1. PICTURE FEATURING A NATURAL LANDMARK OF PIFO: THE COTOHURCO HILL OR "SLEEPING LION" AS IS KNOW TO THE LOCALS. THE CENTRAL TOWN OF PIFO LIES ON ITS SKIRTS. SOURCE: SELF

1.1. Purpose Statement

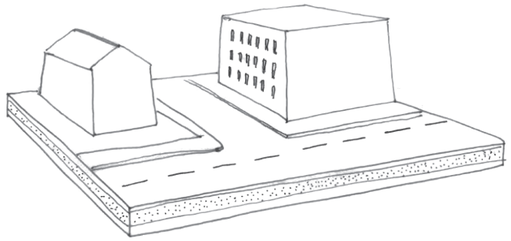
Traditional development patterns are associated with numerous negative ecologically and socio-economic impacts. Sustainable development and technologies are currently used as a path to reduce these impacts. However, the majority of the investment, research and implementation of sustainable technologies and practices has been focused in 1st world countries. This thesis wants to help the community of Pifo, in Quito Ecuador, in the fulfillment of the sustainability objectives detailed in their Development Plan. The proposal will be accomplished by doing a Strategic Environmental Assessment (SEA) for the positioning and implementation of Renewable Energy (R. E.) technologies in the specified area of Pifo; and to elaborate compensation measures in case of being necessary. As a side product, this analysis will provide insight and recommendations of areas to be protected and areas for future development.

The approach of this proposal wishes to implement these technologies without losing the identity of the place, rather suggest a concept that strengthens the local history and sense of belonging and pride for the local citizens.

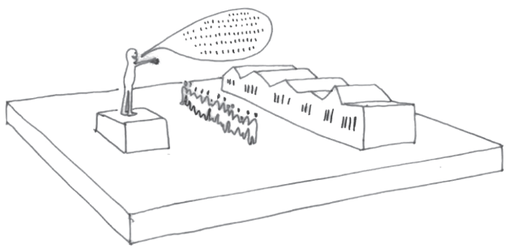
TRADITIONAL DEVELOPMENT EXAMPLES:



Monocultivating: degradating the productive land



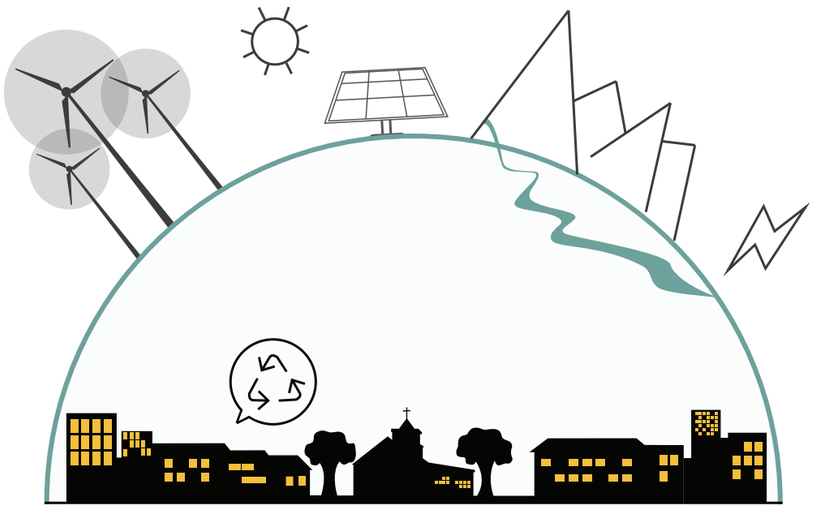
Anthropocentric use of Land: creating extreme sealing and fragmentation of habitats



Top- Down development model: creating non-inclusive communities

FIGURE 2. REPRESENTATION OF TRADITIONAL DEVELOPMENT SOURCE: SELF

1.2. Thesis Argument and Hypothesis



A combined model where different technologies assist in the sustainable performance of the area.

FIGURE 3. MODEL FOR SUSTAINABLE PERFORMANCE. SOURCE: SELF

When using R.E. technologies, one of the big problems that the system faces is the inconsistency in the source of energy; as can be seen with wind changes or cloudy and rainy weather. The hypothesis of this thesis proposes that using a wider variety of R. E. technologies implemented in smaller quantities, instead of a wide-spread area with one sort of technology, the environmental disturbance decreases and the yield of total energy increases. Hence, lowering the impact on the landscape and compensating energy problems; which in many cases limits the possibility of implementation. This is the case of “solar and wind (R.E. technologies), that being dependent on weather conditions, can cause instability in the system” (Pelaez Samaniego & Espinoza Abad, 2015).

1.3. Context of Pifo

1.3.1. Location

South America-Ecuador

Ecuador-Pichincha-Quito

Quito-Pifo

FIGURE 4. LOCATION OF PIFO. SOURCE: SELF

Due to its location, Pifo has a cultural history closely related to important events that have influenced Quito, the capital of Ecuador. Given the geological formations, ridges and ravines, this community has been considered strategic, providing direct access from the capital to the Amazon Rain Forest. From pre-Columbian history of trading routes to oil companies in the 70s with the pipelines and development that followed. This position, between Quito and the Amazon, establishes Pifo as key for major development, as current history shows, allowing this thesis to focus on the development of this area considering that Pifo is now a focal point for the assisting services of the capital, such as Heavy Impact Industrial Zones, the Municipal Waste Landfill and Petroleum Gas Packaging Repository that have been located here. Since 2013 the new Quito International Airport was located in the vicinity, creating in this area a strong focus of investment. In the past 5 years, first class roads and services have been built in near surroundings.

1.3.2. External Influences

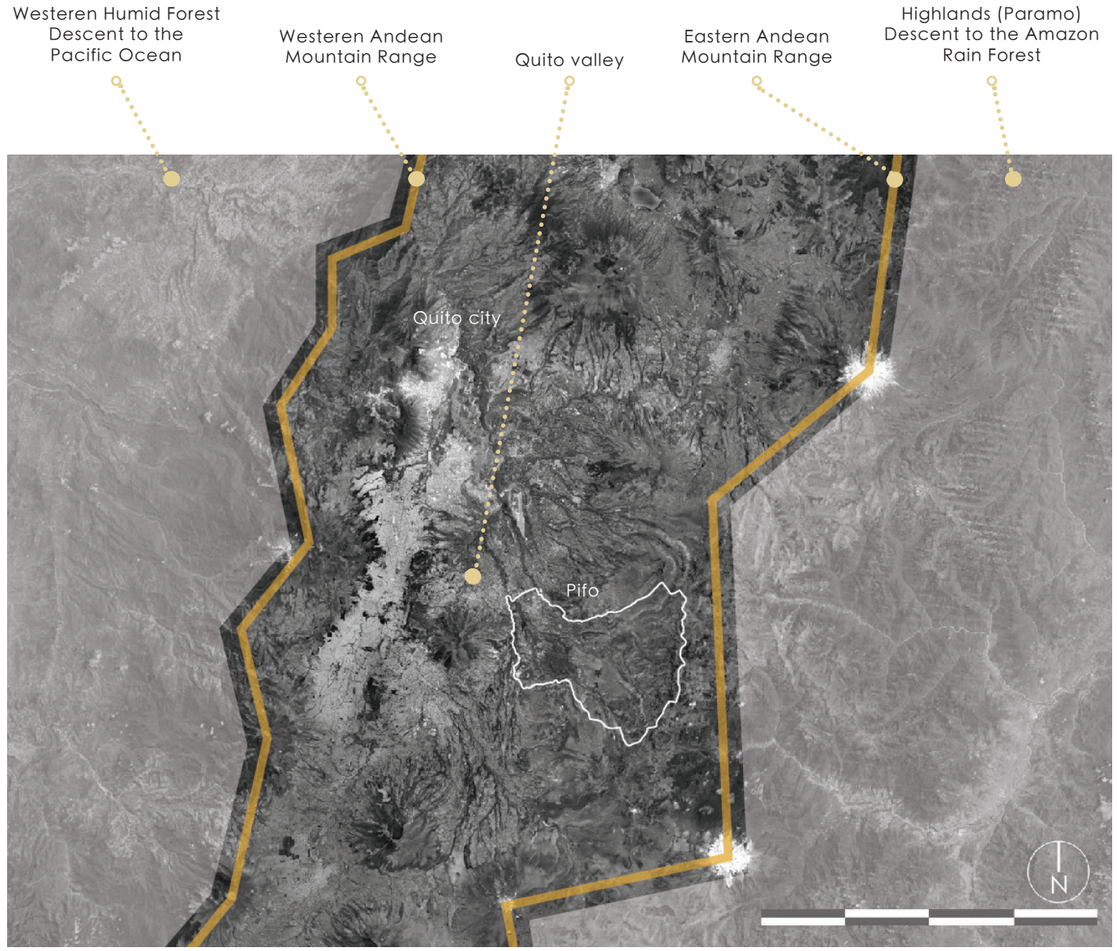


FIGURE 5. EXTERNAL INFLUENCES TOWARDS PIFO. SOURCE: SELF

As seen in the map, Quito lies to the west side of Pifo within a distance of approx. 27km (30 min by car), generating a close relationship of the study area to the city. On the east, Pifo is sided by the Eastern Andean Mountain Range which leads to the Amazon and creates rich ecosystems in between. Hence, these two forces exert pressure in this town making it important that an environmental report is developed, and the future growth plans of the town are based on healthily merging these forces.

1.3. Context of Pifo
1.3.2. External Influences

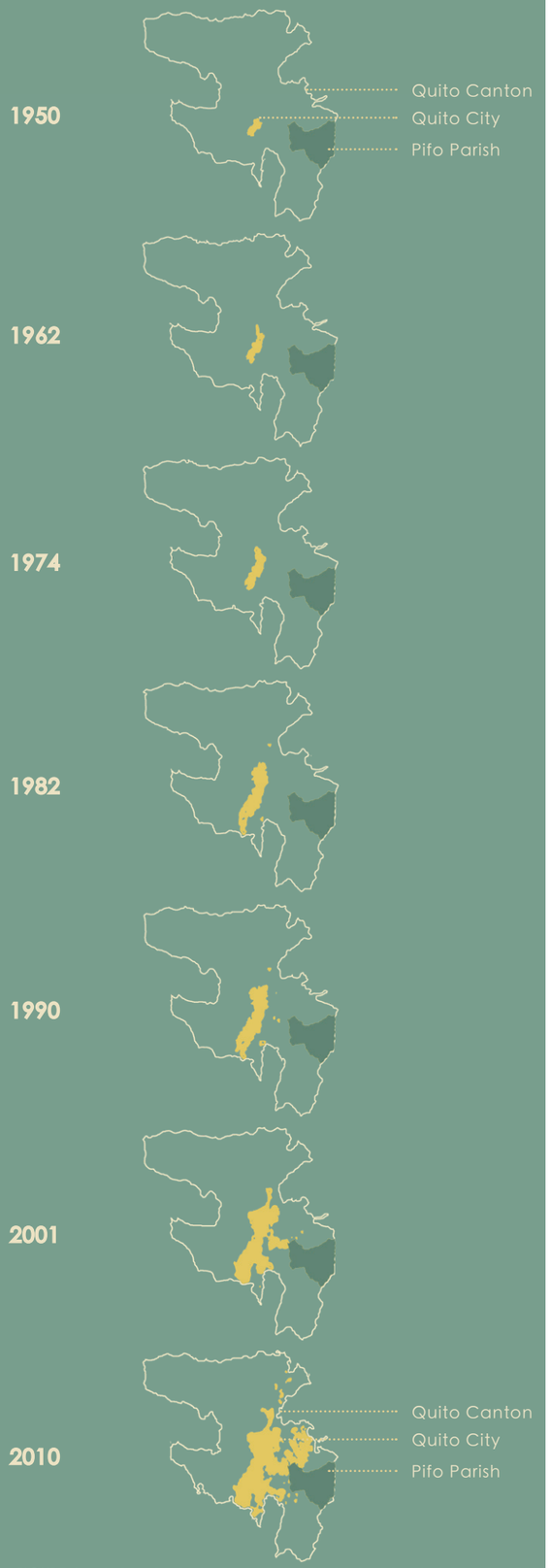


FIGURE 6. HISTORY OF GROWTH OF THE CITY OF QUITO. SOURCE: ADAPTED FROM "POPULATION GROWTH AND URBANIZATION IN QUITO (JONKER, 2017)

In recent years the area has become an important pole of industrial development and establishing a series of important companies focused in various aspects. Likewise, the Industrial Park of Quito has been created in this zone, "which plays an important economic role in the development of the area, along with the Repository for storage and gas packing" (Capservs Medios, 2015, p. 56). The constant growth of the city and the industrial development threaten the identity of the area. Socially and ecologically these pressures represent a challenge for Pifo.

Figure 6 shows the Urban growth of Quito and how, due to topography, Pifo is being approached greatly by the growth of the capital.

FIGURE 7. VIEW OF QUITO TOWARDS THE EASTERN ANDES MOUNTAIN RANGE, WHERE PIFO LIES. SEEN FROM THE PICHINCHA CABLE CAR. SOURCE: HTTPS://WWW.SKYSCRAPERCITY.COM/SHOWTHREAD.PHP?T=1763356&PAGE=51

Quito's growth in recent years has had a rapid development and with little organization. The identity of the parish of Pifo has been changing and has become a more urban area than it used to be, losing its old houses, gardens and agricultural lands.

Understanding the history of the area is important due to the parameters created for future development. This thesis is focused on an environmental analysis, nonetheless, is important to map important historical locations and understand the past. Not only these spaces are part of the environment, but also give identity to the place and signal desired protection sites and could foster Tourism. Therefore, any future growth proposals should be done holistically and comprehend these areas.

1.3.3.1. Cultural History

10,000 to 7080 BC

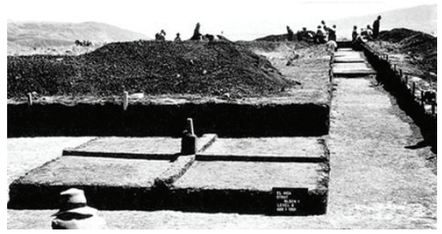


FIGURE 8. ARCHEOLOGICAL SITE "EL INGA". SOURCE: HTTP://WWW.QUITOADVENTURE.COM/ESPANOL/CULTURA-GENTE-ECUADOR/ARQUEOLOGIA-ECUADOR/ANDES-ECUADOR/INGA-PICHINCHA.HTML

Until 750 AD

SOURCE: HTTPS://WWW.CULTURAYPATRIMONIO.GOB.EC/EL-INGA-11-000-4000-A-C/

SOURCE: HTTP://WWW.PIFO.GOB.EC/WEB/INDEX.PHP/CONTENIDO/ITEM/QUE-VISITAR

FIGURE 10. OBSIDIAN ARROW HEAD AND HIGHLAND LAGOONS YUYOS AND BOYEROS

Approx. from 1470 AD

FIGURE 9. ABANDONED LEFTOVERS OF INCA TRAIL. SOURCE: HTTP://DOCENTECONVOZ.BLOGSPOT.COM/2012/02/EL-CAMINO-DEL-INCA-EN-LA-SIERRA-NORTE.HTML

First evidences of settlement are found in the sector of El Inga (Pifo). "According to the Archeologist Ernesto Salazar, little evidence is found given agricultural disturbance. Despite this, arrowheads and knives among other artifacts have been found in this zone. (Larrea Araujo, 2013). In 1847 information was given to the government on bones of "Marmontes and fossils of antidiluvian elephants" which were discovered in La Alcatarilla ravine in Pifo. (Larrea Araujo, 2013)

Settlements in the area are created, it seems, due to rich obsidian deposits and the richness of fresh water sources (the name Pifo etymologically means "Water Corner"), as well as access to food sources and medicinal plants. Due to great obsidian deposits, Pifo becomes a trading hub where the Obsidian Route, according to Inés del Pino, reaches the Ecuadorian coast. This route became such a significant economic center that was not interrupted, not even from the various volcano eruptions, and there is evidence of this route even until 750 AD (Larrea Araujo, 2013, pp. 14-21).

The Incas arrive to the south of Ecuador and in the late of the fifteenth century to the north of the country. Pifo was constituted of several manors, or "Llaktakunas", which got together to form a strong defense against the Inca conquerors. The Inca culture, imposed new management of land and people, as well as trade routes such as the Inca trail "El Camino del Inca". One of the roads of this famous route passes through Pifo and "was declared (…) World Heritage by the Unesco. This is the oldest road network in America, that runs longitudinally along the entire Tahuantinsuyo (Inca Kingdom) along the Andes mountain range, from western Argentina to southern Colombia" (El Comercio, 2014).

Approx. from 1470 AD

FIGURE 14. HERDING COWS IN AGRICULTURAL LAND OF PIFO. SOURCE: SELF TAKEN

In these years the inhabitants focused in agriculture and can be assumed that generated influence on the vicinity due to its richness in water sources. As an ancient water channel found in the area and due to its history of fruit and vegetable farming, it is hypothesized that Pifo even supplied water to other towns with a lower altitude and less water resources. (Larrea Araujo, 2013, pp. 5, 25, 32, 38)

1534 - 1822 AD

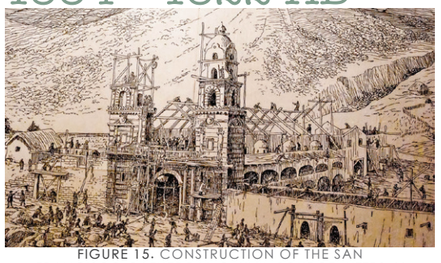


FIGURE 15. CONSTRUCTION OF THE SAN FRANCISCO CATHEDRAL C. XVII. SOURCE: HTTPS://HISTORIADELARTEJUANB.WORDPRESS.COM/2012/08/15/IGLESIA-DE-SAN-FRANCISCO/

Spain stablishes a colony in the area of Ecuador, builds cathedrals and urbanizes main cities. An important purpose of the Spanish crown is to catechize the locals. Monasteries and convents are built for many different religious catholic orders, reaching an approximate of 22 temples in the city center besides monasteries and convents.

1536 AD

FIGURE 11. HACIENDA HOUSE. SOURCE: HTTPS://WWW.CLAVE.COM.EC/2015/11/04/HACIENDA-ITULCACHI-UNA-PAUSA-CERCA-DE-LA-CIUDAD/

The Spanish distribute the land in Pifo and eventually create Haciendas, which constitute often a basis ground for expeditions of historical figures like Von Humboldt and La Condamine as well as for revolutionary groups that fought against the liberalist president Eloy Alfaro (Quito, 1899) (Larrea Araujo, 2013, p. 124).

After 1822 AD

FIGURE 13. HACIENDA HOUSE IN PIFO. SOURCE: HTTPS://FIESTASDEPIFO.WORDPRESS.COM/2019/01/31/RINCONES-DE-PIFO/

The Jesuit order place a Hospital in Pifo, in one of the old Hacienda houses of the area and made it a center to do evangelization missions in the Amazon Rain Forest (Larrea Araujo, 2013, p. 115). Because of its geographical location, Pifo has commonly been used as last stop before going to the Amazon through the mountains, which were normally avoided as an overnight stay because of the freezing conditions.

From 1920 - 1941

FIGURE 12. "EL CHICHE" BRIDGE BUILT AT THE END OF 1960S. SOURCE: HTTPS://NOTIMUNDO.COM.EC/SISMO-EN-QUITO-NO-REQUIRIO-ACTIVAR-EL-COE/

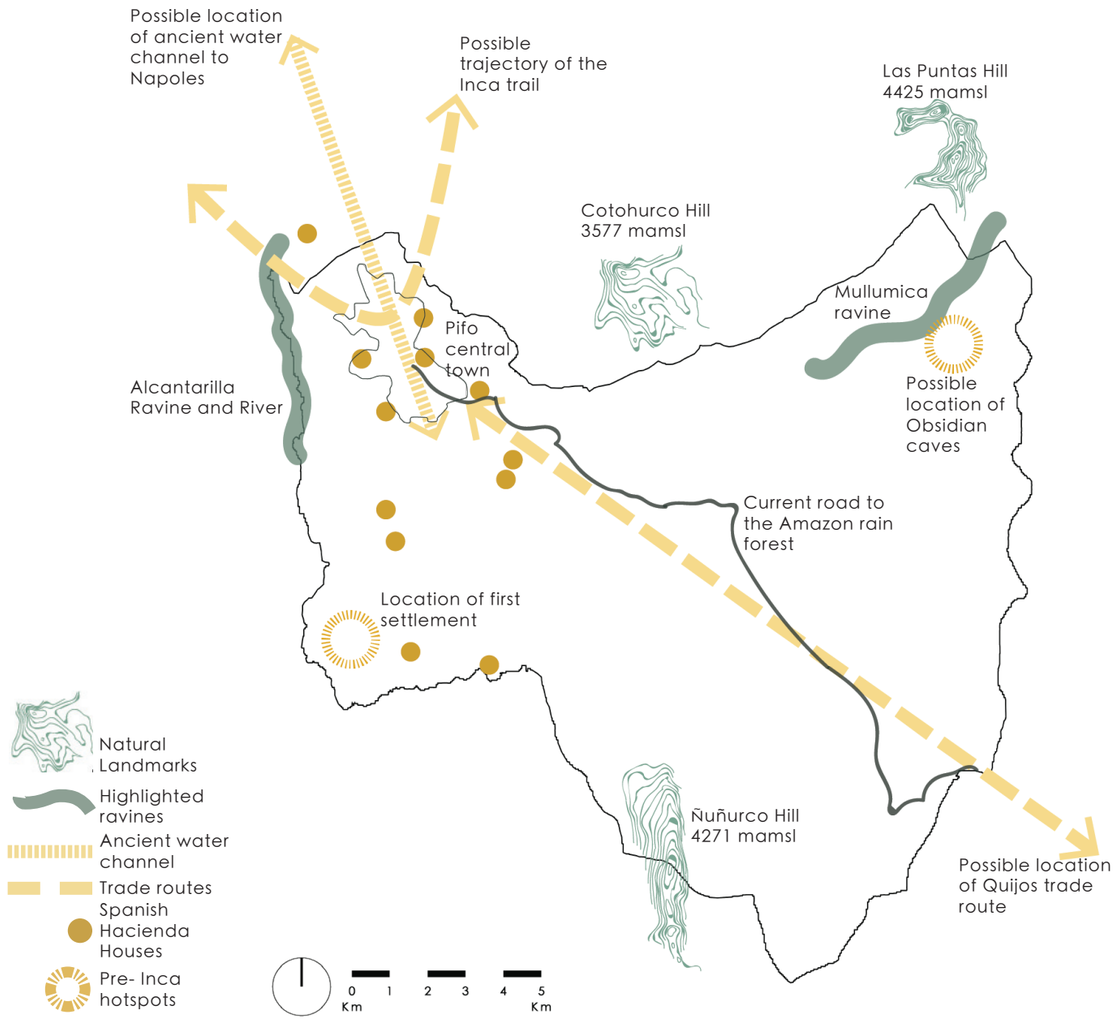
A small road is built by the Ecuadorian military to do explorations in the Amazon and in 1970 "the oil group Texaco-Gulf, as compensation measures for the Amazon exploitation, build and restore parts of the road Quito-Coca, which passes through Pifo, and is associated with the construction of the construction of 318 miles of Trans-Andean oil pipeline" (Arévalo, Andino, & Grijalva, 2008).

From 1970 - Today

FIGURE 16. OIL PIPE FROM THE AMAZON. SOURCE: SELF TAKEN

FIGURE 17. OIL PIPE CROSSES PIFO. SOURCE: HTTPS://FIESTASDEPIFO.WORDPRESS.COM/2019/01/31/RINCONES-DE-PIFO/

The oil pipeline has been enlarged and renovated (OCP Ecuador, 2019) and constitutes a common sight in Pifo. Together with the Hacienda houses, the rivers and ravines, and the road through the mountain Range create a common view from Quito to the east. This characteristic is essential to consider in the location of any R.E. technologies, since it will be seen from many areas of the West Andean mountain range where Quito lies.



MAP 1. MAP OF HISTORICAL PLACES AND NATURAL LANDMARKS. SOURCE; SELF

1.3. Context of Pifo

1.3.3. History of Pifo
1.3.3.2. Natural Landscape conditions

1 Forest on the highland zone of Pifo made of Pumamaqui

FIGURE 18. PUMAMAQUI FOREST. SOURCE: HTTP://WWW.LAGEOGUIA.ORG/RUTA-DEL-AGUA-RESERVA-ECOLOGICA-CAYAMBE-COCA-ECUADOR/#13/-0.2973/-78.2024

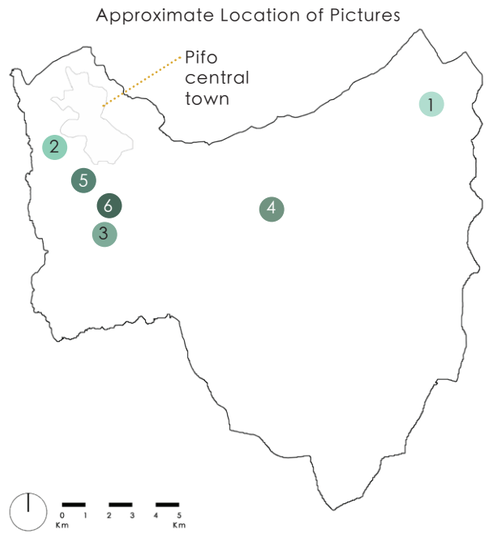
2 Shrub vegetation remaininng on the ravines while Eucalyptus (an invasive neophyte tree) are planted around agricultural land

FIGURE 19. SHRUB AND GRASS VEGETATION ON RAVINESSOURCE: SELF TAKEN

3 Agricultural fields are dry and eroded with little productive soil

FIGURE 20. COMMUNITY AGRICULTURAL FIELDS. SOURCE: SELF TAKEN

Vegetation of the area at early stages of human settlement was characterized by Native Forest mostly of Aliso (Alnus acuminate), Quishuar (Buddleja incana) and Pumamaqui (Oreopanax andreanus) (Larrea Araujo, 2013); native trees which are now endangered and therefore protected and fomented by the current municipality (Burbano & Herdoíza, 2019).



MAP 2. LOCATION OF PICTURES REALTED TO PIFO AREA. SOURCE: SELF

With the development of agriculture, mainly corn seeding, the forests began to decline. Furthermore, with the arrival of the Incas the agricultural area increased, and the cultivation system was propagated with irrigation and terraces.

4 Farming in the highlands is wide spread

FIGURE 21. CATTLE FARMING ON THE HIGHLANDS. SOURCE: HTTP://PARROQUIAPIFO.BLOGSPOT.COM/2018/08/TOUR-LA-LAGUNA-DE-PIFO.HTML

5 A typical hacienda patio built the year 1613 AD

FIGURE 22. SPANISH HACIENDA WITH FLOWER GARDENS. SOURCE: HTTPS://WWW.CLAVE.COM.EC/2015/11/04/HACIENDA-ITULCACHI-UNA-PAUSA-CERCA-DE-LA-CIUDAD/

6 Industry is being built in agricultural fields increasing disturbance on remaining habitats and erosion on the suroundings

FIGURE 23. INDUSTRY GROWTH. SOURCE: SELF TAKEN

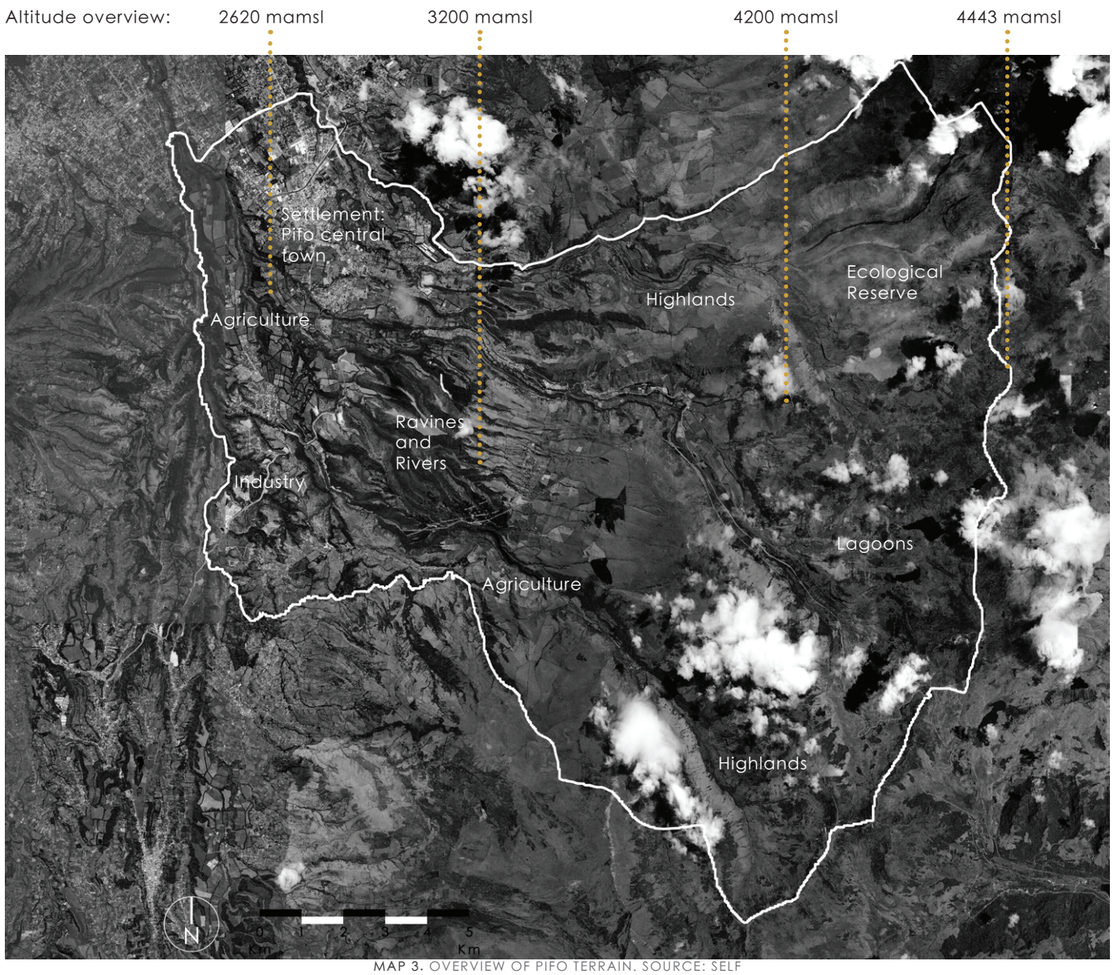
Later, with the arrival of the Spanish and their consolidation in Quito (1529), the lands are distributed to the conquerors and the exploitation for agriculture begins with the development of haciendas. Forest remnants are used to produce wood and charcoal tools by indigenous people in order to acquire an economic income, extinguishing the forest completely. The last remnants where exploited until the mid 20th century. (Larrea Araujo, 2013) With the reduction of the forest, an extreme erosion was generated and continues to increase, for which, nowadays the depth of the productive soil of Pifo is very thin. (Capservs Medios, 2015)

During the Spanish colony, there are registers of the existing orchards and rich vegetable and flower gardens of the area (Larrea Araujo, 2013, pp. 25, 53, 55).

Much of the local fauna of the area has greatly diminished due to the incoming industry, growing settlement and agricultural areas. Nonetheless in many areas the following animals are still to be seen: mountain rabbits (Sylvilagus Brasiliensis), wolves (Psudalopex culpaes), Sacha cuy (cavia tschudii), deer (Odocoileus virginianos), Raposa (Didelphis marsupiales), the Servicabra (Mazama rufina), the spectacled bear (Tapirus pinchaque), Black dante (Tapirus pinchaque), Peregrine falcon (Falcoperegrinus). (Capservs Medios, 2015, p. 27)

1.4. Current Data
1.4.1. Overview

Looking at the current data, provides an overview on the present situation and shows important aspects to be taken into account while planning R.E. installations.



MAP 3. OVERVIEW OF PIFO TERRAIN. SOURCE: SELF

1.4.2. Terrain

According to the PDOT, the total territory has 254 241 km² (25 424 hectare). Natural sceneries as ravines, highland moor (páramos), protected areas, represent about 150 km² (Capservs Medios, 2015, p. 11). Located within the limits of Pifo: a part of the Cayambe Coca Ecological Reserve, the Wetland Complex Ñucanchi Turopamba and the Protected Forest of Sigsipamba. These represent, 31.04% of the territory. (…) The current forestry area is reduced to a 0.04 % and the Wood industry from the area is doing reforestation programs with the citizens as reserve for future exploitation (Capservs Medios, 2015, pp. 22, 26) but the trees used are rarely native.

FIGURE 27. VIEW OF PIFO HIGHLANDS. SOURCE: SELF TAKEN

1.4.3. Altitude

Since the location of Pifo is in the foothills of the eastern mountain range, the Altitude ranges from 2600 to 4250 mamsl with the main settlement around 2790 mamsl (Capservs Medios, 2015, pp. 11, 23)

FIGURE 26. YUYOS AND BOYEROS LAGOONS. SOURCE: HTTP://WWW.PIFO.GOB.EC/WEB/INDEX.PHP/CONTENIDO/ITEM/QUE-VISITAR

1.4.4. Main Water Bodies

The main water bodies are the Yuyos and Boyeros lagoons located to the east, and the rivers Guambi, Cariyacu, Chiche, Alcantarilla, the Sigsal, San Lorenzo, Paluguillo, Sigsichupa, Ayahuayco, Quebrada del Peñón. The northeast of Pifo, where the Eastern mountain range is located, characterized by high rainfall, are important water sources that flow into the Guambi and Ayahuaico rivers.

FIGURE 24. SPECTACLED BEAR. SOURCE: HTTP://PARROQUIAPIFO.BLOGSPOT.COM/2018/07/BARRIO-ITULCACHI-DE-PIFO.HTML

FIGURE 25. CONDORS NESTING IN A RAVINE OF PIFO. SOURCE: HTTPS://WWW.ELCOMERCIO.COM/TENDENCIAS/HALLAZGO-NIDO-CONDORES-QUEBRADA-QUITO.HTML

1.4.5. Remaning Fauna

Much of the local fauna of the area has greatly diminished due to the incoming industry, growing settlement and agricultural practices. Nonetheless in many areas animals such as wolves (Psudalopex culpaes), Black dante (Tapirus pinchaque), Peregrine falcon (Falcoperegrinus), and even endangered species as the spectacled bear (Tapirus pinchaque) are to be seen (Capservs Medios, 2015, p. 27).

A good example is the sighting of a Condor nest in the Itulcachi ravine in Pifo discovered in “June 27, 2017, by a workshop organized by the Secretary of Environment of Quito. “The nesting site must have been there for centuries,” says the ornithologist Juan Manuel Carrión, since the Andean condors are faithful to these spaces. Currently, there are 100 specimens in the country in the wild and 20 under human care.” (Alarcón, 2017)

FIGURE 28. PIFO CENTRAL TOWN. SOURCE: SELF TAKEN

1.4.6. Population

Until the last census done in 2010 the population was 16 645, and according to the demographic analysis of the last PDOT (Development Plan and Territorial Order) it has grown to 18 580 inhabitants in 5 years. (Capservs Medios, 2015, p. 35). With 4469 households in 2015 the approximation made by the PDOT is that in 2020 there will be 5817 households and 7231 households in 2030. (Capservs Medios, 2015, p. 83) If there is an average of 0.07 ha per household (Capservs Medios, 2015, p. 80) then in 2015 the occupied area was of 312 ha.

1.4.7. Growth

YEAR	POPULATION	AREA
2020	20 741	407 hectares
2030	25 574	506 hectares
2050	37 491	742 hectares

TABLE 1. POPULATION GROWTH APPROXIMATION. SOURCE: SELF

The given growth rate is 11.63% between 2010 and 2015, meaning a yearly growth rate of 2.33%. If this rate continues the population will be 37 491 inhabitants for 2050, as shown in the table. This rate is important to note so that future energy requirements can be calculated. Through the years 2020 – 2050, settlement will occupy around 2 - 3% of the total area pf the Parish (This data is a self-developed approximation)

FIGURE 29. PIFO OLD HOUSES BAREALY MANTAINED. SOURCE: SELF TAKEN

1.4.8. Poverty Index

This area is categorized as a critical area regarding Poverty. 58% of the population area classified as poor and 64% cannot satisfy basic needs (NBI index).

1.4.9. Energy requirements

According to the Electrical regulation and control agency of Ecuador (ACONCEL, 2017), the energy consumption of the Pichincha province was 1337.79KWh per inhabitant. Assuming the consumption remains constant Pifo will consume:

2020: 27.74 GWh/year
2030: 34.21 GWh/year
2050: 50.16 GWh/year

1.4.10. Distance from Quito

Depending on the route you choose, the distance to the capital ranges from 27.1 km (google maps) to 35 km (Visita Ecuador, 2019)

1.4.11. Temperature

The main area has a relative regular temperature on an average of 12 C (Capservs Medios, 2015, p. 11) (53.6 F) and 15C (59,54 F) (Climate Data, 2019), with the highest area reaching -3 and -6 C 21.2 F) (Capservs Medios, 2015, p. 23)

1.4.12. Presipitation

The annual average precipitation is of 960 mm per year, with a dry season between May and August and a Rainy season between September to November (Capservs Medios, 2015). Regularly, Pifo has constant precipitation along the rest of the year.

1.4.13. Wind

According to the Eolic Atlas of Ecuador, the main wind direction comes from the east and south-east. The months with more wind are June, July and August with a speed between 7- 10 m/s (25-36 km/s) at a height of 80 m above ground level.

1.5. Methodology

In the book “Strategic Environmental Assessment” the author, Riki Therivel, a partner in Levett-Therivel sustainability consultants and visiting professor at Oxford Brookes University, argues that planning with SEA means taking into account many different aspects that are normally overlooked, giving the plan a “focus on key environmental/sustainability constraints”. Namely, considering options, within the decision-making process, that give priority to environmental issues as could be the maintenance and health of open space, watersheds, forests, biotopes, etc. It is important to identify the best strategy for achieving the objectives while “minimizing the negative impacts, optimizing positive ones, and compensate for the loss of valuable features and benefits” (Therivel, 2010, pp. 10-11).

Therefore, the goals and objectives of the community have to be analyzed and questioned to answer the following: what does the community really want? By questioning and analyzing the objectives of the Pifo PDOT (Territorial Organizing and Development Plan), the opportunity for new environmentally friendly solutions can be opened.

With the new objectives in mind, a strategic action can be chosen, and the legal framework of the country analyzed to recognize all the possible stake holders as well as any policy modifications that need to be done to increase importance to environmentally friendly solutions. The strategic action proposed has to be implemented in the local master plan, including compensation measures in small and large scale, as well as in the proposal of programs that the local government (GAD) can have.

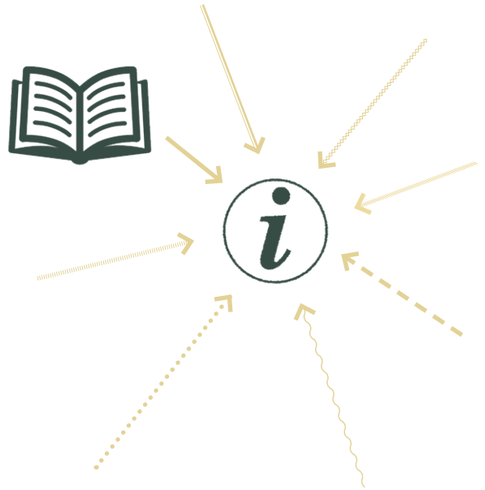


FIGURE 30. GATHERING DIFFERENT INFORMATION FROM AS MANY SOURCES AS POSSIBLE. SOURCE: SELF

After having an interview with GAD officials to find out their point of view and needs, which in this case consists in creating jobs and promoting sustainable tourism, the research proceeds to make a literature review, consisting on evaluating the legal framework of the proposal, stated in the local PDOT (Territorial Organizing and Development Plan), the regional and municipal PDOT, and the Ecuadorian constitution, to find the interests of different levels of government. Regarding this thesis, the review shows that R.E. implementation is a national priority. The literature review must expand subjects as much as possible, regarding history, ecosystem classification, protected areas fauna, flora as well as current data.

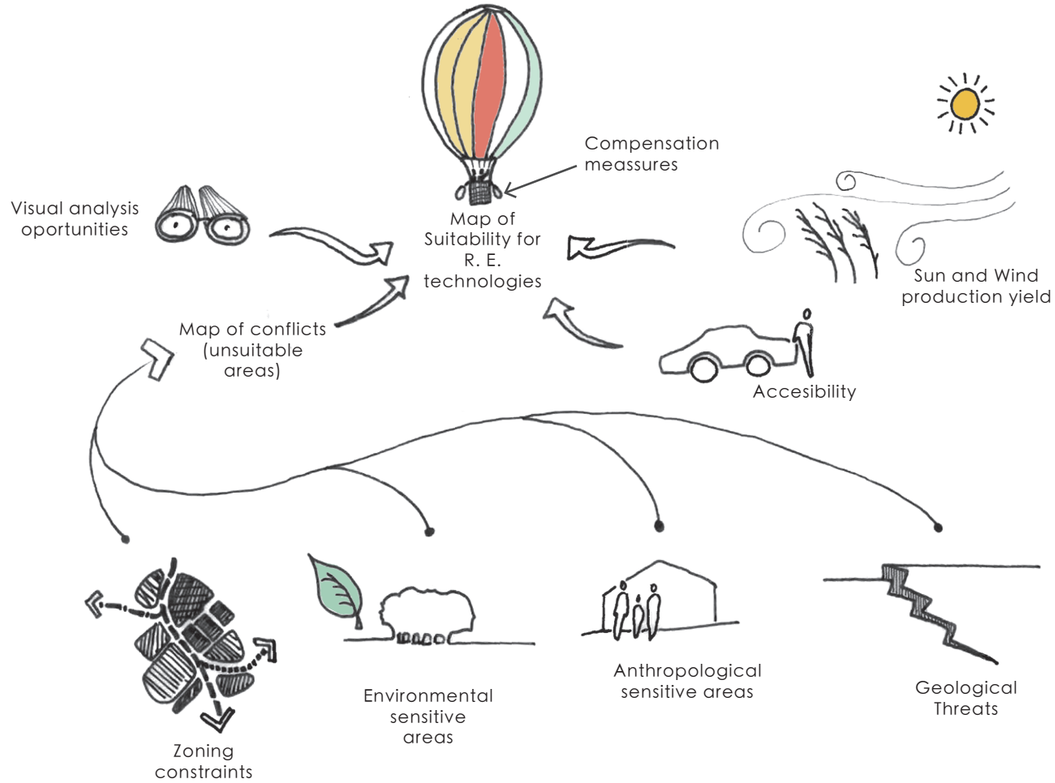


FIGURE 31. REPRESENTATION OF METHODOLOGY FOR MAPPING. SURCE: SELF

Once the context of the area of study has been understood, this thesis will proceed by doing a site analysis and identifying optimal areas for the implementation of R. E.

The mapping method will be done in the following way:

1. Identifying sensitive areas and habitats.

2. Mapping historical points that are important for the identity of the study area.

3. Optimal energy production areas will be selected by overlaying the wind and solar maps.

4. Road Map: priority should be given to those that already have good accessibility.

5. Comparison with a visual analysis of the area so that unseen opportunities can surface.

6. Once the possible areas are chosen for the use of different R. E. technologies, the environmental conflicts of these areas have to be analyzed.

7. Proposal of the most optimal locations for R.E. technologies and compensation options for the areas with environmental conflicts.

2

Legal Framework

Chapter 2. Legal Framework

To create a Renewable Energy project there is the need to comply with the country's planning iprogram and objectives which will allow a lawful completion of such proposals that regards national, regional and local interests. The purpose of this chapter is to understand and analyze how the Ecuadorian law will influence the implementation of a Renewable Energy project in Pifo. For this, it is important to consider the regional and national objectives and to assist the local government (GAD), supporting local objectives by evaluating how these could promote the implementation of R.E. technologies.

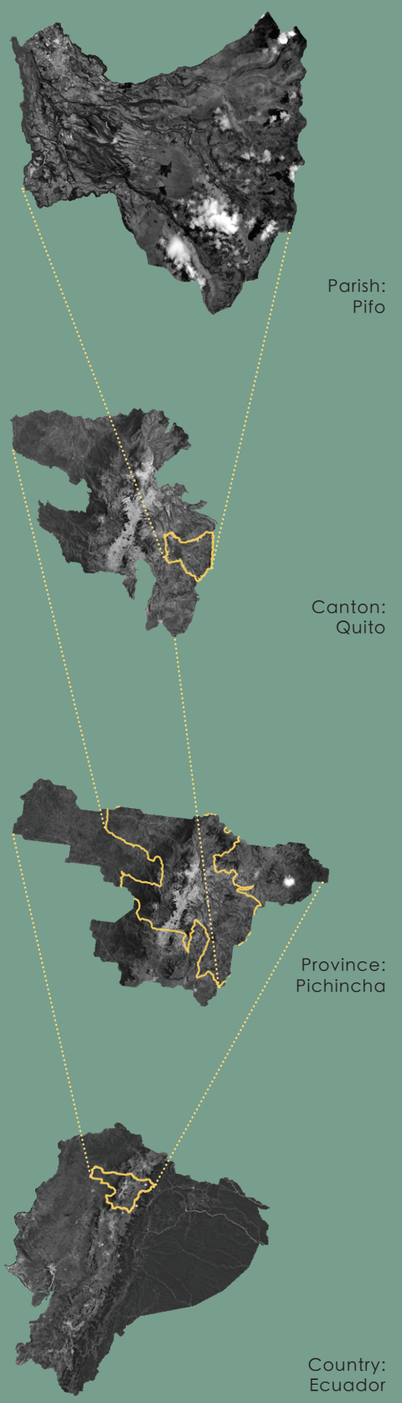


FIGURE 33. POLITICAL STRUCTURE OF ECUADOR. SOURCE: SELF

2.1. Political structure of Ecuador

2.1.1. Administrative organization of Ecuador

For this project it is important to understand the levels of administration in Ecuador. The implementation of such proposals needs to comply to the different levels of government and the objectives set by these other areas.

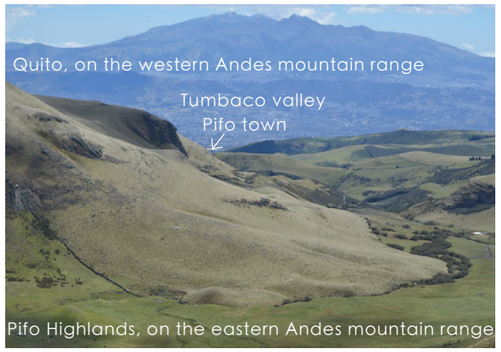


FIGURE 32. VIEW OF QUITO FROM THE PIFO HIGHLANDS. SOURCE: HTTP://PARROQUIAPIFO.BLOGSPOT.COM/2018/07/PARQUE-ECOLOGICO-EN-PIFO.HTML

Country-Provinces-Cantons-Parishes

Pifo is a Parish that belongs to the canton of Quito in the province of Pichincha in Ecuador.

2.1.2. Planning instruments

This section is an overview of the legal planning instruments in Ecuador that can be used for the implementation of R. E. technologies. These planning instruments are then integrated into the spatial planning system of the PDOT.

2.1.2. Planning instruments

2.1.2.1. Influence from higher administrative levels

As seen previously, the Ecuadorian government is divided in 4 different administrative areas, each of which has a specific planning instrument and scope. According to the constitution of Ecuador, in Art. 238 specifies that the GADs (Local governments) will have “political, administrative and financial autonomy” (Asamblea Nacional Constituyente del Ecuador, 2008) although they have to comply with the goals of higher levels of government. Therefore planning levels act simultaneously at 4 levels shown in the following table (adapted from PDOT (Capservs Medios, 2015, pp. 101, 106). Collaboration between the different levels of government and public companies can guarantee the success of large projects and create more social equality. Public entities must use all the communication tools available to encourage transparency and success of projects that benefit a regional or even national scope.

ECUADOR PLANNING INSTRUMENT			
ADMINISTRATIVE AREA	CURRENT PLANNING INSTRUMENT	INTERPRETATION	RELEVANCE FOR THIS THESIS
National Government	Good Living National Plan.	The document presents the nine national objectives, grouped into three axes: Rights for all throughout life; Economy at the service of society; and, More society, better State. Each objective contains the policies and goals to which the National Government aims. It is articulated with the 2030 Agenda for Sustainable Development. (Senplades, 2017)	The placement of R. E. technologies can be a pivoting point for Sustainable Development of the area, in ordinances with the national aims.
	Change of the productive matrix.	It implies productive diversification, generation of added value to promote the substitution of imports and diversify exports, as well as the development of new economical sectors. (Senplades, 2017)	Producing electricity with renewable sources aligns with the change of the productive matrix through the distancing from the main petroleum products.
	Strategy for the reduction of poverty.	Focuses in the transfer of higher funds to the most needy according to the following terms: i) superior goods for the guarantee of rights (health, education, habitat and housing, and water and sanitation), ii) integral protection to the life cycle (protection and social security, care and protection of rights) and iii) work and productive revolution. In addition, the Strategy is based on three conditions: sustainability and sustainability, knowledge management and popular power. (Senplades, 2017)	Not particularly relevant for this thesis, although is important to keep social sustainability always in mind while developing any type of project.
Province Government	Provincial Territorial Ordinance Plan 2012 - 2025 of the Provincial Council of Pichincha.	States the current situation, goals, objectives and strategies of the Province of Pichincha. Focuses on public-private alliances for productive development, connectivity of communities, food jurisdiction, cultural heritage, water management, justice and rights, research and innovation with sustainable focus	Scope is stated on Art. 263 of the constitution, is focused on irrigation and drainage. This project needs constant cooperations with the Quito municipality so its implementation doesn't interfere with water rights, agricultural rights and cultural heritage. For a long term success of R.E. projects and sustainable development, local research on sustainable proactices is encouraged.
Cantonal Government	Territorial Planning Plan of the QMD (Quito Metropolitan District) 2015 - 2025	States the current situation, goals, objectives and strategies of the canton Quito. Works together with the Quito Electrical company, Quito mobility and public works company, among others	Scope is stated on Art. 264 of the constitution, is focused on transportation and security. Constant coordination with the municipality must be fostered so that the implementation of R. E. in Pifo is provided with access roads, has regular security surveilance and reaches as much households as possible.
Parish Government	Development and Territorial Planning (PDOT) Plan 2012 - 2020	States the current situation of this community, with the strategies, goals and objectives of the local government, as analyzed later in this chapter.	Is closely related to the development of this project and is taken into account to shape the project.

TABLE 2. ECUADOR PLANNING INSTRUMENTS AND LEVELS OF GOVERMENT. SOURCE: SELF, ADAPTED FROM THE PIFO PDOT, PP. 101, 106.

2.1. Political structure of Ecuador

2.1.2. Planning instruments

2.1.2.2. Current participation instruments

The Ecuadorian uses participation as a planning instrument as stated in the constitution, Art. 100, saying that every government has to take decisions regarding planning, investment, budgeting, among others, with public participation "made up of elected officials, representatives of the dependent regime and representatives of the society of the territorial area from each level of government" (Asamblea Nacional Constituyente del Ecuador, 2008). According to the Pifo PDOT, this participation is organized in the following way:

- Working Tables: Working groups will be organized among the different levels of local governments in order to analyze projects of cantonal, provincial and parochial impact.

- Planning committee: An Analysis group made up of technicians from local governments will be established. The progress of the subjects presented in the PDOT will be analyzed.

- Citizens' monitoring and oversight committees: Groups made up of representatives of the civil society and delegates of citizen participation from local governments.

The participants to form these groups come from the Provincial, Cantonal and Parish governments.

*ADAPTED FROM TABLE 4. MATRIX FOR DESCRIPTION OF ARTICULATION MECHANISMS ESTABLISHED BY THE CANTONAL LEVEL IN WHICH THE PARISH GOVERNMENT HAS INTERFERENCE (CAPSERVS MEDIOS, 2015)

For this project, alternative public participation methods are proposed by informing the public about the current situation of the region and the parish as well as considering their opinions and local knowledge.

2.1.2.3. Current legal framework

Different stakeholders can be determined by looking at the different levels of government that are above the Parish's local government. Each level has a specific scope that can be important for a different phase of the project of placing R. E. technologies in Pifo.

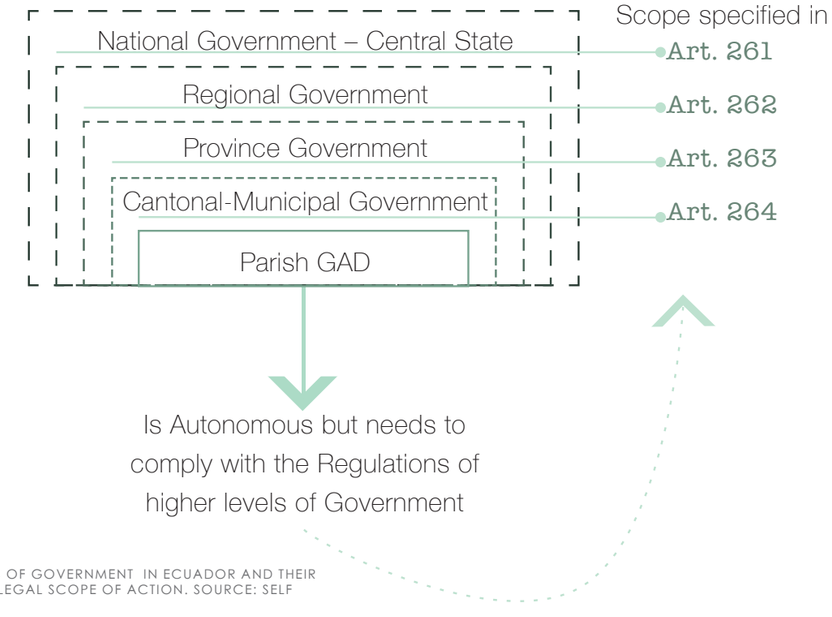


FIGURE 34. LEVELS OF GOVERNMENT IN ECUADOR AND THEIR APPROPRIATE LEGAL SCOPE OF ACTION. SOURCE: SELF

2.1.2.4. Scope of higher levels of government

If R.E. technologies were to be implemented in Pifo, it is important to consider the following scope numerals from each level of government, so that each level of government is taken into account regarding its specific role. This gives an overview of which level of government would be responsible for each action and how different levels can cooperate to help a project succeed.

	Subject	Relevance for this thesis
National Government Art. 261	# 2 International relationships. # 7 Natural protected areas and natural resources. # 11 Energy resources; minerals, hydrocarbons, water, biodiversity and forest resources.	Considering international financing or technological support, for example, from the UN. Selecting possible additional land that could be protected. National government should provide the respective permits.
Regional Government Art. 262	# 1 Plan a PDOT that is articulated with the other levels of government. # 6 Policies of research and innovation of knowledge, development and transfer of technologies, necessary for regional development, within the framework of national planning. # 9 Manage international cooperation for the fulfillment of the competencies.	Creating a collaboration plan with neighboring communities to reach consistent planning as for green and transportation connections. Promoting educational programs where local sustainable solutions for the region can be developed. International financing and guidance can be fomented.
Province Government Art. 263	# 1 Plan a PDOT that is articulated with the other levels of government. # 2 Plan, build and maintain the provincial road system, which does not include urban areas. # 3 The provincial environmental management.	Planning collaborations between the cantons as to maintain water quality as well as organizing new projects that strengthen the public services within the province. Keeping good access and flow of resources between neighboring cantons, could help a project like R.E. technologies succeed.
Province Government Art. 264	# 1 Plan a PDOT that is articulated with the other levels of government. # 7 Plan, build and maintain the physical infrastructure of public use. # 13 Manage prevention, protection, relief and extinction services of fires.	Planning together with neighboring communities creating urban centers such as touristic highlights, nature and sports parks that promote social equality throughout the area. Public maintenance of infrastructure, as are R.E. technologies, can be difficult to tackle for one community alone, but if it benefits and is maintained by a group of communities the project has more opportunity for thriving.

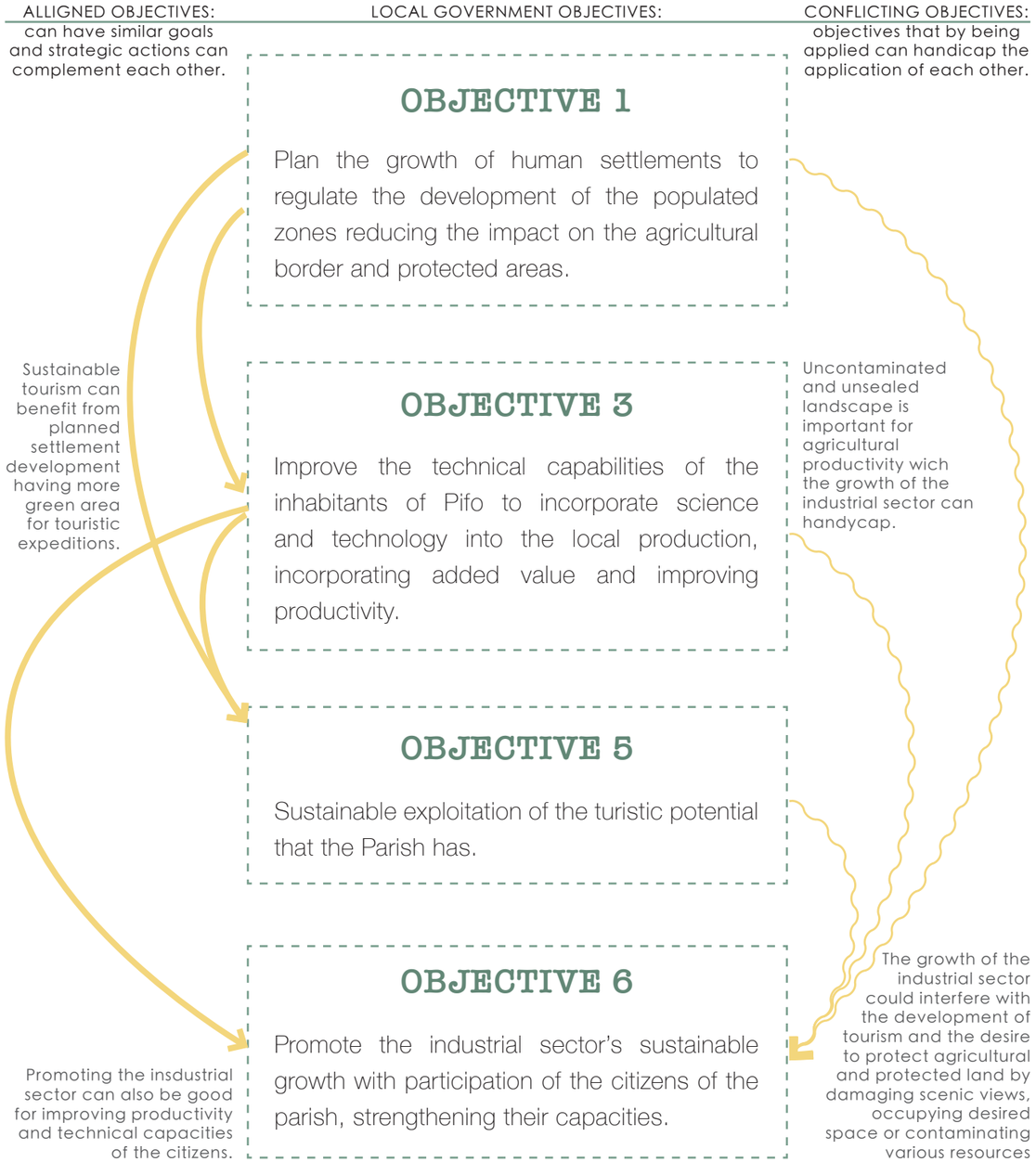
2.1.2.5. Relevant observations

Unclear communication and disregarding local wishes and needs could be the reason of many failed projects. Participation should be more open to the public, by combining different methods that can be used depending on the type of policy, program or strategic action to be discussed. Public participation is simultaneously a learning and sharing instrument for the community itself, proposed later in this thesis, where various actors have input in a variety of scenarios. Currently, small parishes like Pifo and its local citizens play a small role in the decision-making process. Hence, local benefits of the proposed projects are rarely seen, creating social inequality. Since the GAD (local government) has autonomy to make decisions, these inequalities should be regulated, but normally lack of communication and financial problems hinder this independence. Such complications within the government increase bureaucracy and limit positive results.

2.2. PDOT Goals and Objectives

2.2.1. Selection of relevant objectives for this thesis

To be able to propose new solutions, there is the need to extract the main idea from the local government's objectives. With new synchronized objectives, not only the strategic actions to accomplish each goal will have less conflict but they can also support other goals. From the PDOT document, objectives 1, 3, 5 and 6 (Capservs Medios, 2015, p. 120) have been extracted and can be relevant for this thesis; as can be seen in the following figure.



2.2.2. Analysis of current objectives

What does the local government really want? What is behind the PDOT proposed objectives?

FROM OBJECTIVE 1

- Safeguard ecological protected areas
- Control settlement growth

FROM OBJECTIVE 5

- Create jobs and increase income while maintaining the local environment in optimal conditions
- Promote and educate locals in sustainability
- Optimize access and knowledge to natural assets

FROM OBJECTIVE 3

- Improve productivity and therefore income for the parish
- To increase local production
- Foment education of technical knowledge in local citizens.

FROM OBJECTIVE 6

- Create higher quality jobs
- Diversify production
- Coach and educate the local citizens to broaden the capacity of jobs

2.2.3. Proposal of new objective

Having sustainability and ecology in mind as a main subject, this thesis project proposes to join the above information and propose a new objective which aligns the concepts behind the previous 3 objectives and allows space for the creation of new goals. As Therivel points out, is important to create scenarios where options do exist (Therivel, 2010).

NEW OBJECTIVE

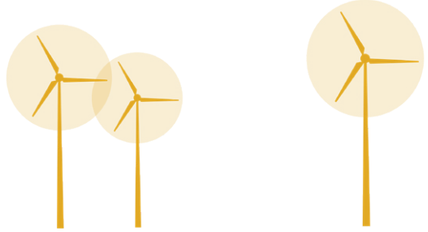
Create new, high quality jobs for locals along with supporting and improving existing local business, while taking care and enhancing the natural assets of the parish.

2.3. Environmental Planning Instruments

The Ecuadorian Environmental Management Law, supports the implementation of R. E. technologies and guides itself by the Sustainable Development Principles stated in the Rio de Janeiro convention of 1992; statement written in article 1 and 2 of the mentioned law. (Ministerio del Ambiente, 2019)

The Ministry of Environment is in charge of determining if a project needs to undergo an environmental approval process. Art. # 9 states that for this task they will gather environmental information and coordinate with the adequate institutions to abide by the system of permits and licenses, as well as the criteria of national plans and technical standards related to land use. The relevant organisms will "verify the compliance with environmental quality standards regarding air, water, soil, noise, waste and pollutants". (Ministerio del Ambiente, 2019).

In Art. #12, external governmental institutions are bound to regulate and promote the conservation of environment and sustainable use of resources with accordance to social interest (Ministerio del Ambiente, 2019). In this case, this obligation is the responsibility of the local government (GAD) of Pifo. The GAD should also ensure the participation of the community in the issue of policies for management and protection of natural resources.



2.3.1. Approval process

The Environment Plan is the technical instrument that promotes "conservation, protection and environmental management; and it will contain the specific objectives, programs, actions to be developed, minimum contents and financing mechanisms as well as the review and audit procedures."

Art.# 19 states that any project that can cause environmental impact will undergo a qualification process done by the independent control organisms previously qualified by the Ministry of Environment before the project is implemented. To begin any activity that could cause environmental damage, the ministry should first issue the corresponding license which, as established in Art. 21, "will include baseline studies; environmental impact evaluation; Risks evaluation; management plans; risk management plans; monitoring systems; contingency and mitigation plans; environmental audits and abandonment plans. Once these requirements have been met and in accordance with the qualification (previously mentioned), the Ministry of Environment may grant or deny the corresponding license." (Ministerio del Ambiente, 2019).

After the license is approved, auditioning can occur at any time by the independent control organisms.

2.3.2. Environmental Assessment

Art. # 23 of the national Environmental Management Law states that:

"The environmental impact assessment (for the aproval of the project) will include:

a) The appraisal of the effects caused to the human population, biodiversity, soil, air, water, landscape as well as on the structure and behavior of the existing ecosystems in the area that will be affected;

b) The conditions of public tranquility, such as: noise, vibrations, odors, light emissions, thermal changes and any other environmental damage resulting from the projects' execution; and,

c) The impact that the project, work or activity will have on the elements that make up the historical, scenic and cultural heritage." (Ministerio del Ambiente, 2019).

According to Art. # 26, all the pre-contract documents will contain the specification of the previously mention studies and will determine if the implementation of the project needs avoidance, mitigation or compensation regarding the environment.

This evaluation will be made before the concerning ministry issues the approval of the project, in this case the Ministry of Energy.

FIGURE 35. ENCOURAGEMENT OF SUSTAINABILITY, ENVIRONMET AND SOCIAL EQUALITY TALK MUST HAPPEN WITHIN THE SOCIAL FABRIC OF THE LOCAL CITIZENS. SOURCE: SELF

2.4. Law of Energy Efficiency

The Ecuadorian constitution, in Art. #15, promotes the use of environmentally clean technologies and alternative non-contaminating, low impact energy. (Asamblea Nacional Constituyente del Ecuador, 2008)

In Art. #84 the constitution states that normative organisms must adequate the laws to comply with the constitution and international treaties subscribed by Ecuador. This includes the UN Objectives of Sustainable development that Ecuador signed in 2015. Since then, the efficient, rational and sustainable use of energy has priority as national interest. (Asamblea Nacional, Republica del Ecuador, 2019)

For this reason, the Nacional Efficiency Plan (PLANEE) has been issued and the National Comity of Energy Efficiency (CNEE) has been formed. The duty includes to "promote the development of local and technical capacities within the society, regarding the responsible and efficient use of energy, for which it must involve the educational system, environmental system, GAD and the community. The CNEE will incorporate in the PLANEE actions and projects through training about energy efficiency" as stated in Art. 8 #g of the Law of Energy Efficiency. (Asamblea Nacional, Republica del Ecuador, 2019)

Since the PLANEE is binding to the public sector and suggestive for the private sector, it would be recommendable that the Pifo PDOT is updated to comply the national goals, as appointed in Art. 9 of the Law of Energy Efficiency. Therefore, the GAD must "issue, socialize and put into operation mechanisms to meet national goals in coordination with the CNEE so that the energy efficiency aims can be reached" (Asamblea Nacional, Republica del Ecuador, 2019)

For the implementation of a project as the one suggested by this thesis, the Pifo GAD has a very limited amount of resources, but "Projects and / or programs for energy efficiency and rational use of energy, are to be financed by the national fund for investment in energy efficiency". Such projects will also have incentives and preferential financing for its implementation. (Asamblea Nacional, Republica del Ecuador, 2019) For this reason, this thesis project is a viable suggestion that the Pifo community can implement in the future.

2.5. UN International Sustainability objectives

The importance of targeting the United Nations Sustainable Development goals is that by doing so, the GAD of Pifo will be able to access international advice, guidance and financing regarding R. E. technology and implementation. (Sustainable Development Solutions Network, 2019) By doing this, the GAD will comply also with the Ecuadorian constitution and with higher levels of Government.

This Thesis project can help the GAD of Pifo follow UNSDG (UN Sustainable development goals) by aiming to goals number 7, 9, 11, 12, 13 and 17 as seen in the table from Annex 1 which describes the mentioned goals. In the following list is the explanation of how each goal is meaningful to this project.

Goal 7- Affordable and Clean Energy

By the placement of Renewable Energy technologies in medium to small scale, in a way that does not dominate the landscape picture, can increase interest, research and knowledge of the local citizens towards R.E. Collaboration and ownership of small projects can also encourage good stewardship and facilitate access to energy, creating more justice and equality.

The local government can also have independent relationships to the international community as well as to the national government and to neighboring local governments.

Goal 9- Industry, innovation and infrastructure

Encourage local research and development of new technologies that use local materials, that can be recycled in the future once infrastructure is dismantled. This type of technological development cares for the environment and even helps improve and enhances the current state of the location. Infrastructure that encourages good stewardship on the locals due to their involvement in the projects as active individuals.

Private industry must also take part on this active role and be part of the community, not only producing technology for themselves but also for the community they are located on. E.g. Photovoltaic panels in the roofs of private houses and of private industry that provides to the public network.

Goal 11- Sustainable cities and communities

A smart growth plan that focuses on the implementation of renewable technology as well as in the quality of open spaces and maintenance of sensible ecological areas. Its important to note that the customs and identity of the place have to be understood and sustained. Imposed external solutions for local problems do not work correctly.

Goal 12- Responsible production and consumption

Local jobs can be created when local technology is developed and collaborative research centers are placed in the locality. With involvement of the citizens there is also an education and conscientization process that helps achieve the goals. Besides, by prioritizing local and seasonal production and strengthening the local economy long term objectives can be achieved.

Goal 13- Climate action

Reducing emissions also happens with the planning of high quality open space, new local jobs and recognizing the price of social and environmental intervention; not only economical assistance and involving the local governments, but also caring for the citizens and educating about the international agreements and goals.

Goal 17- Partnerships for the goals

Besides promoting the development of technologies, is important to provide the knowledge so that new research can be locally made and local solutions can be settled. As well as the National Government, the local governments also must have the independence to make international contributions and partnerships for achieving local goals that must be in accordance to national and international regulations.

Another Important partnership is the collaboration of local private with local public institutions so that local economy is boosted and the systems works to achieve a common goal.

3

Existing Conditions

Chapter 3. Existing Conditions

This chapter aspires to answer the following questions:

Where are the limits and where are the possibilities of this area for implementing R. E. technologies?

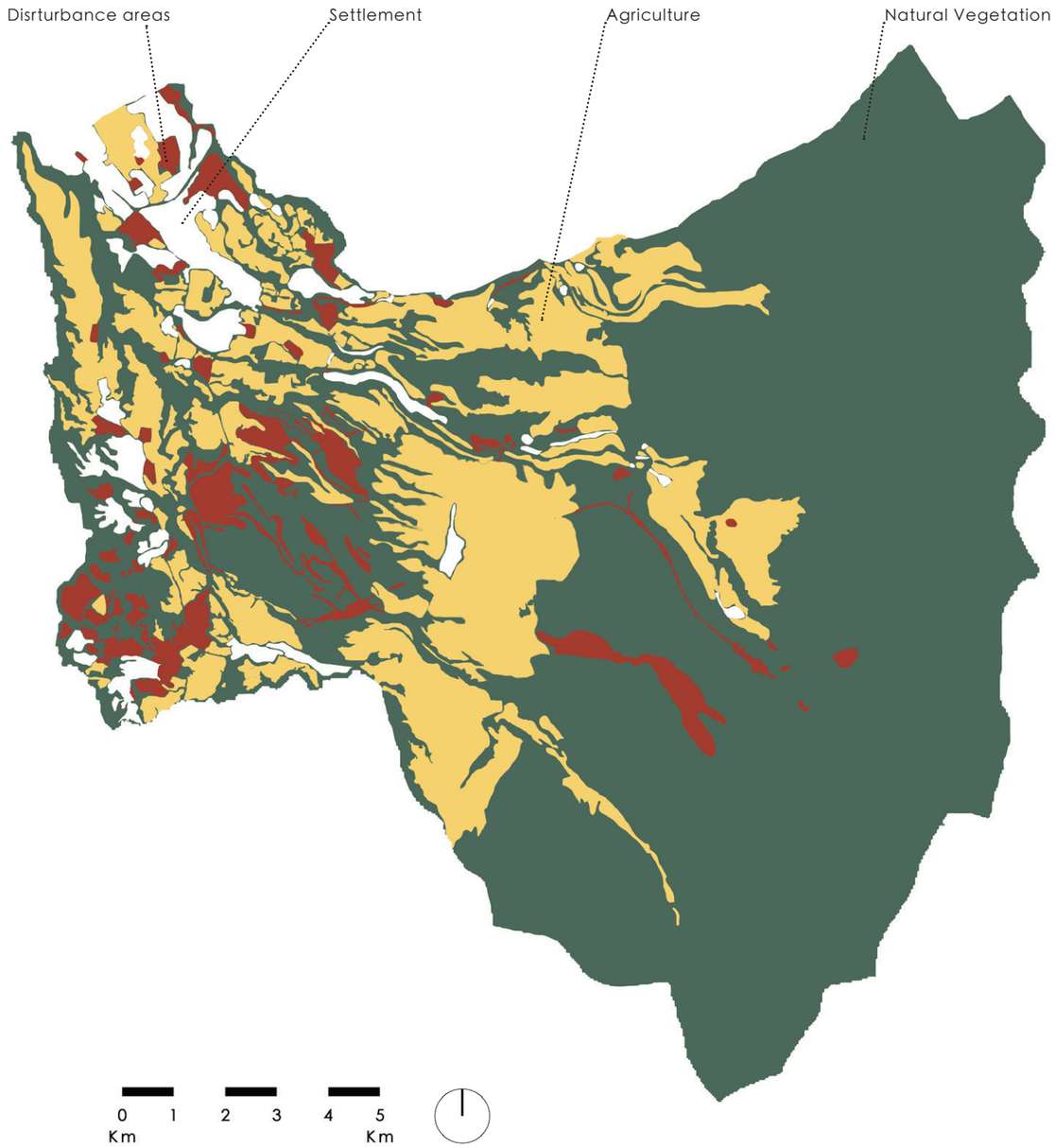
What and how is the current planning situation and how will it develop?

It recollects existing plans on the parish of Pifo and analyzes the current situation. The information is taken from Google maps, ArcGIS online, the Pifo PDOT (Development plan), Ecuador Wind Atlas and Sun Atlas; joined together with self-created maps such as a history and natural landmarks map and watersheds map. From this information, the areas of constraints for R.E. technologies are removed from the analysis area, and a map is created that locates the areas of opportunity for R. E. options. Once the areas are found, individual zoning is analyzed to select the most optimal areas for each technology.

3.1. Visual Analysis
3.1.1. Generalities

As seen in the context description in Ch. 1, this area is a mountainous landscape that ranges from 2600 to 4250 mamsl. Flatter areas are situated at the extreme east as well extreme west of the study area with deep ravines located in a N-S axis. The eastern area is characterized by large water deposits that flow later into numerous rivers that form the ravines where the topography abruptly changes altitude. This area has a high level of ecological protection, not only because of the ecosystem services it provides but also due to it being a habitat of endemic and protected species such as the spectacled bear and different types of bats. The main endemic vegetation is conformed of high montane evergreen forest, wild grassland and evergreen shrubland with species adapted to highland weather and soil type. The importance of the montane forests is that “they attract the mist, capture the water through their branches and leaves and filter it into the soil.” While the wild highland grasslands “act as sponges, store rainwater until the dry season and release it little by little through streams and springs that go towards the valleys.” (Carrera, Bustamante, & Saenz, 2016, p. 16)

Human influence can be seen in the flatter fields between the ravines, with larger settlements located in lower altitudes and larger agricultural regions located in the higher altitudes. The landscape is dominated by agricultural interventions, not only in the higher areas, as mentioned before, but also intertwined between settlements. Many ecological disruptions can be seen as the area turns into a focal point of industrial oriented production.



MAP 4. OVERVIEW OF VISUAL ANALYSIS AREAS: SETTLEMENT, AGRICULTURAL, DISTURBANCE AND NATURAL VEGETATION. SOURCE: SELF

Disruption areas: Areas that have a visual disruption in the landscape such as large industrial establishments, clearly cleared forest areas or industrial agriculture greenhouses.

Settlement: Small or large areas of clear rsidential housing, may incloude gardens or small orchards.

Agriculture: Mostly farms with clearly marked grasslands and paddocks, mostly for cattle.

Natural vegetation: Grasses and shrublands from the highlands that have been mostly untouched by agriculture or construction. Inside the ravines there may be traces of some woody vegetation but not greatly extended.

3.1.2.1. Agricultural Landscape

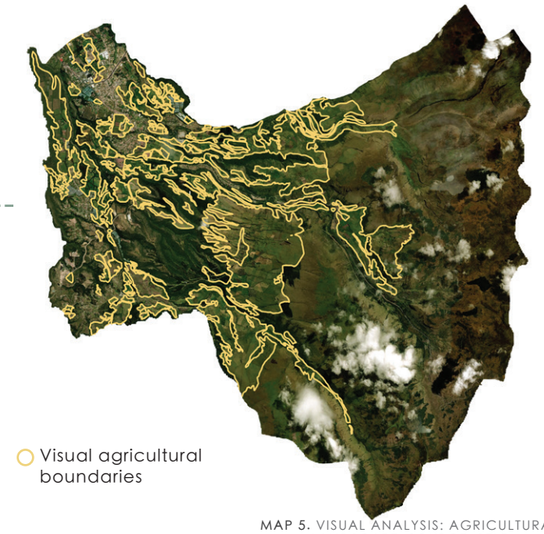
Agricultural development is part of the cultural landscape developed through the history of the study area. This area can be identified by larger patches of subdivided land. The larger patches are prone to more fruitful production but create as well larger disruptions in the landscape. The main production of the area is milk, trout and chickens, in smaller amount, the communities also cultivate chard, alfalfa, onion, corn, cabbage, beans, lettuce, beet, tree tomato, among others (Capservs Medios, 2015, pp. 58-67). Mainly directed to individual consumption, this kind of agriculture mainly happens in individual orchards. The remaining product is destined to commercialization. The subdivisions are characterized by being corridors of thicker vegetation between the grasslands. These areas can act as habitat connectivity for wildlife as well as increase the quality of the soil, protect from erosion and provide visual diversity and enhancement. The shape of the agricultural areas is mainly defined by the topography; with irregular edges and buffers created by the vegetation on the surrounding slopes. These patches show a tendency of growth towards the highland, where there is more water as well as more flatland.

3.1.2.2. Settlement pattern

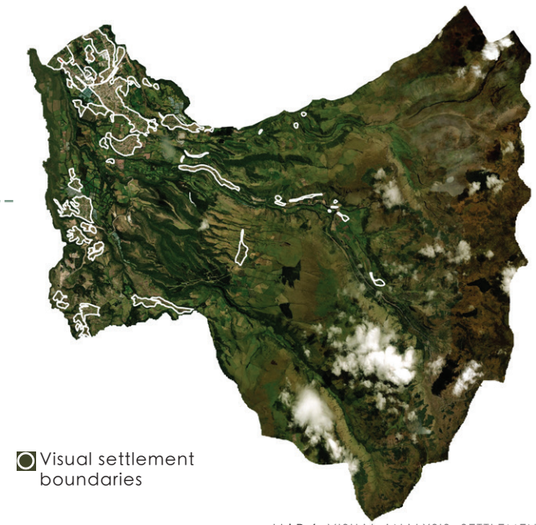
Main settlement areas are located at the edge of the study area, where there is easier accessibility from Quito, the most dominant neighboring city. The pattern of growth of the patches have no distinct organization but seem to grow towards the agricultural areas, where a mix of uses can be seen between smaller agricultural land of individual use and settlement. Relatively low-density settlements are mostly recognizable, with back gardens and small orchards. The edges of this types of settlement can be considered very soft and even invasive, which is difficult to control since is mainly privately-owned land. Houses are located towards the road and the crops are located towards the vegetated area, creating a succession of vegetation but increasing the probability of growth of settlement. The boundaries of these settlements are thin or inexistent, whether towards agricultural, industrial (disrupted) or vegetative patches. This fact can decrease the quality of the settlement greatly.

3.1.2.3. Disturbance areas

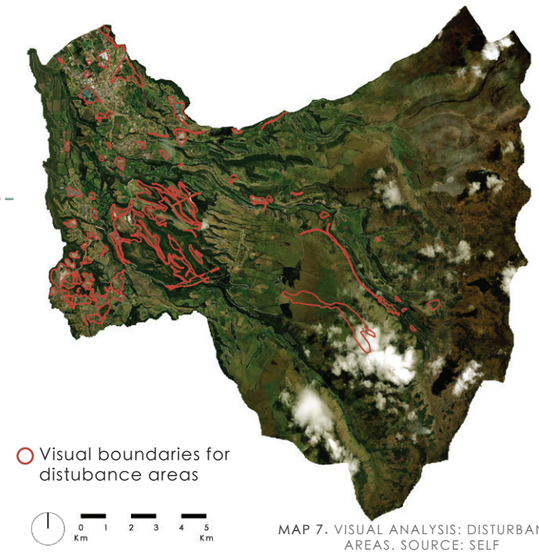
These areas are selected for representing a disruption of the landscape that is not agricultural or settlement. Many are industrial and others recreational as is a motorcycle track; mostly visually difficult to differentiate other than it being a disruption on natural vegetation. These patches are smaller and more abundant on lower and flatter land. Large disruption areas can be seen in the higher altitudes, with straighter edges that can easily act as fragmentation entities. In general, these disruption areas show less convoluted edges and little boundary towards its surroundings, creating degradation in the quality of the habitats and dissection (splitting intact areas). Unfortunately, these spaces can act as sinks, reducing greatly the endemic species and presenting a threat to the existing habitats around them.



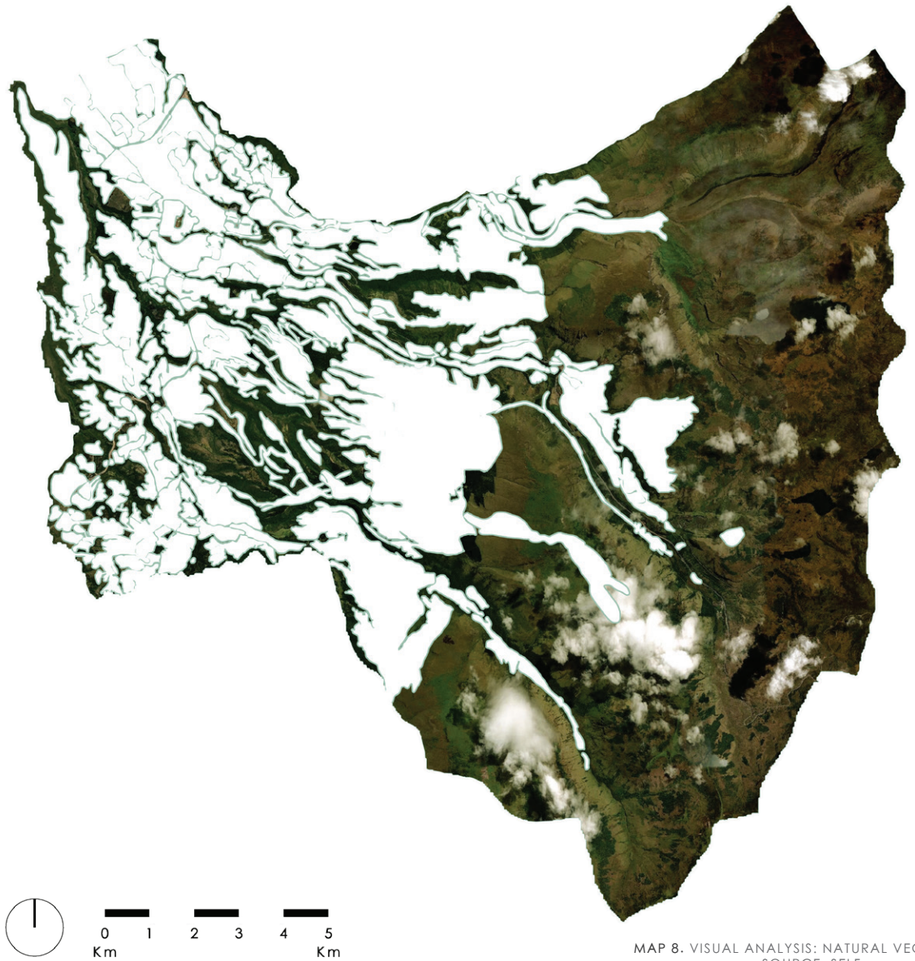
MAP 5. VISUAL ANALYSIS: AGRICULTURAL LANDSCAPE. SOURCE: SELF



MAP 6. VISUAL ANALYSIS: SETTLEMENT. SOURCE: SELF



MAP 7. VISUAL ANALYSIS: DISTURBANCE AREAS. SOURCE: SELF



MAP 8. VISUAL ANALYSIS: NATURAL VEGETATION.
SOURCE: SELF

3.1.2.4. Natural Vegetation

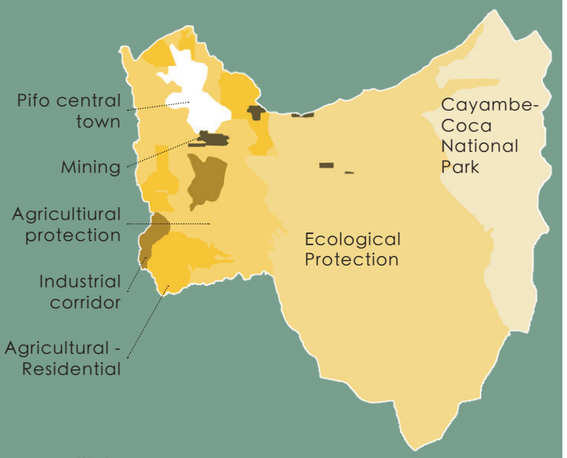
In the highlands, a large undissected patch of natural vegetation, mainly grassland and shrubland (Ministerio del Ambiente del Ecuador, 2013), is evident. This patch presents a good core area, but also many indents done by human intervention that can be threatening to the integrity of the core area. The size of the patches decreases while the landscape lowers in altitude. Towards the agricultural areas the patches become smaller and decrease in quantity while in the proximity of settlement the patches become almost inexistent. The edges of all these patches are intricate and convoluted, increasing interaction with the surrounding areas. This interaction can have negative effects in the quality of ecological sensitive areas such as watersheds, where contamination can easily flow in. Fortunately, the existing ravines provide green corridors that act as connectivity for the smaller and more isolated patches, giving opportunity for the movement of species. This suggests also, that the flatter areas have been used by humans leaving the more drastic topography to the natural vegetation and fauna. Many of the vegetation seen can be confused with natural, due to the timber industry in the region, which plants conifers as an investment for future felling (Capservs Medios, 2015, p. 68). Through this particularity, the probability of loss of species that cannot adapt to the steeper slopes or the new plantations increases greatly. The networks of natural vegetation and corridors for the flow of nutrients and species runs along the water sources inside the ravines. This makes them susceptible to contamination from the flatland and accidental dissections such as landslides. The vegetation on these areas contributes greatly to the quality of air; the air flow runs faster inside the ravines due to the funnel effect and the dirt particles are trapped between the leaves and branches.

3.2. Current Development Plan

3.2.1. Plan proposals based on the Pifo PDOT (Development and Territorial Ordering plan)

3.2.1.1. Current model plan analysis

The existing conditions are mapped showing the current development as a product of historical circumstances seen in the Chapter 1.

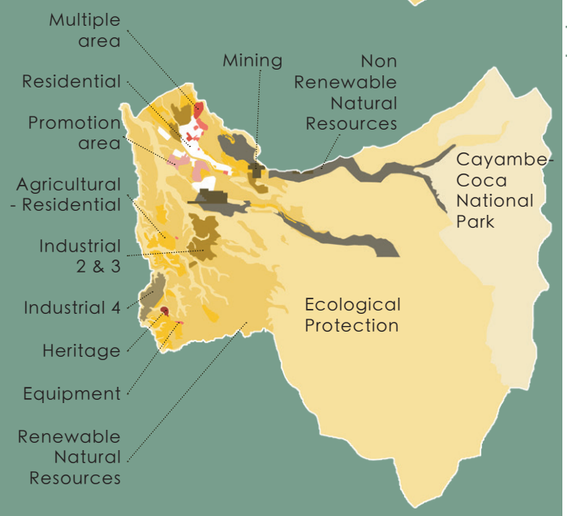


MAP 9. CURRENT DEVELOPMENT PLAN: CURRENT MODEL PLAN. SOURCE: PIFO PDOT

The specification of the areas is not detailed but some conflicts can be already seen. Settlement growth can be seen with no specific order or limitations and it presents various conflicts such as proximity to mining and industry, which can be harmful for the health. In the ecological protection and production areas there are locations for mining and industry. No buffers are to be seen and the edges are mostly regular and straight which does not promote wildlife movement or usage and may promote soil erosion.

3.2.1.2. PUOS plan analysis

PUOS is the zoning plan developed and proposed by the Quito municipality. This plan acts as a guideline for future development and guides the proposals from the GAD of Pifo.

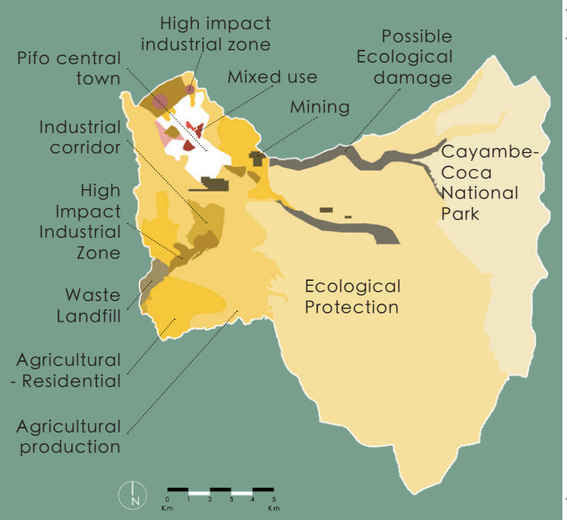


MAP 10. CURRENT DEVELOPMENT PLAN: PUOS (ZONING AND LANDUSE). SOURCE: PIFO PDOT

The PUOS Plan offers an opportunity to keep green connections and has more awareness of the topography of the study area. It distinguishes different types of industrial development as well as settlement development. The edges are complex which allows more wildlife interaction but also more contamination by not providing clear patches with healthy and protected cores. Unfortunately, no buffers have been considered enhancing the problem previously mentioned. A big patch of ecological protection is planned but industrial interventions (mining) are allowed, decreasing the quality of the protected area.

3.2.1.3. Proposed model plan analysis

The proposal made by the GAD of Pifo is seen in this plan. It takes into account future development and the goals established in the PDOT, i.e. the planning of future settlement and agricultural growth.



MAP 11. CURRENT DEVELOPMENT PLAN: PROPOSED MODEL. SOURCE: PIFO PDOT

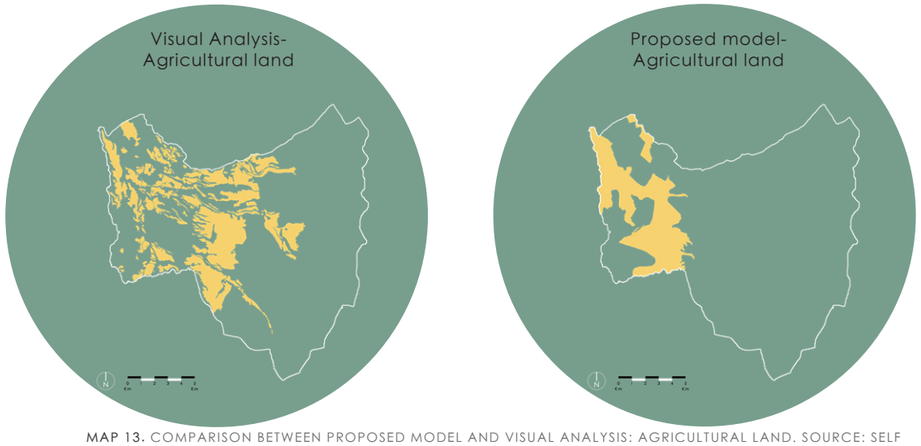
The proposed model does not regard topography removing the green corridors seen in the PUOS model. In accordance to the parish objectives for creating new jobs, gives priority to mining exploitation and industry growth. This can cause large environmental and agricultural production conflicts. It considers small settlement growth and no agricultural growth while maintaining the ecological protection area intact with a big core. In the main settlement centrality different usage is given but it does not consider R.E. production or ecological interventions. As well as the PUOS zoning guideline, it does not offer vegetation buffers for agricultural or ecological protection areas. This puts at risk wildlife interaction and movement while degrading visual enhancement areas.

3.2. Current Development Plan

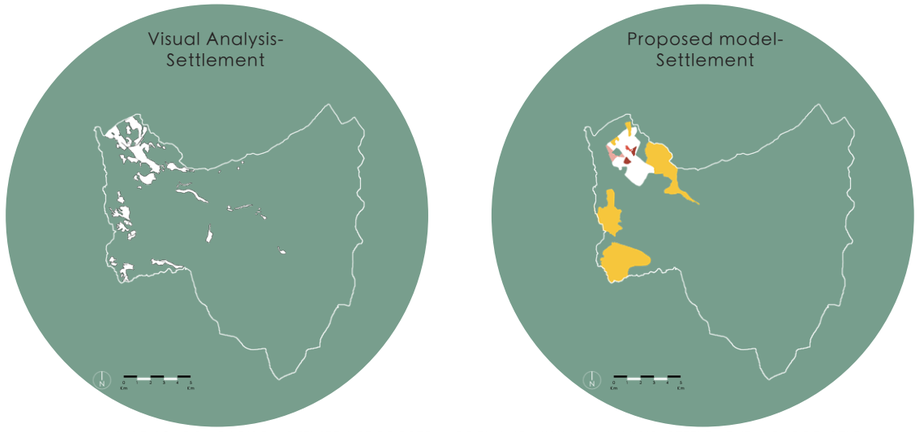
3.2.2. Comparison between proposed model and visual analysis

3.2.2.4. Agricultural land

Whether it is crops or grassland for cattle grassing, the agricultural border is clearly larger and more invasive in the visual analysis as in the proposed plan. This, again, opens an opportunity for implementation of R.E. on degraded areas. Although shows a unfortunate invasion on natural vegetation creating fragmentation, degradation and shrinkage of valuable habitats.



MAP 13. COMPARISON BETWEEN PROPOSED MODEL AND VISUAL ANALYSIS: AGRICULTURAL LAND. SOURCE: SELF



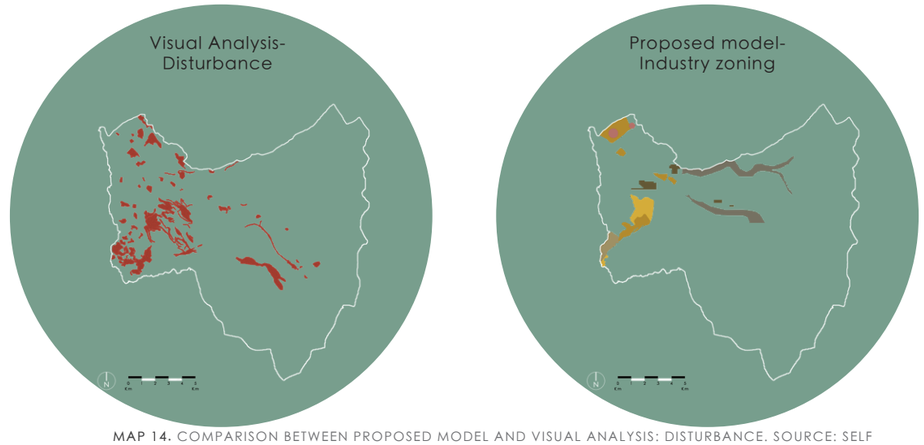
MAP 12. COMPARISON BETWEEN PROPOSED MODEL AND VISUAL ANALYSIS: SETTLEMENT. SOURCE: SELF

3.2.2.1. Settlement

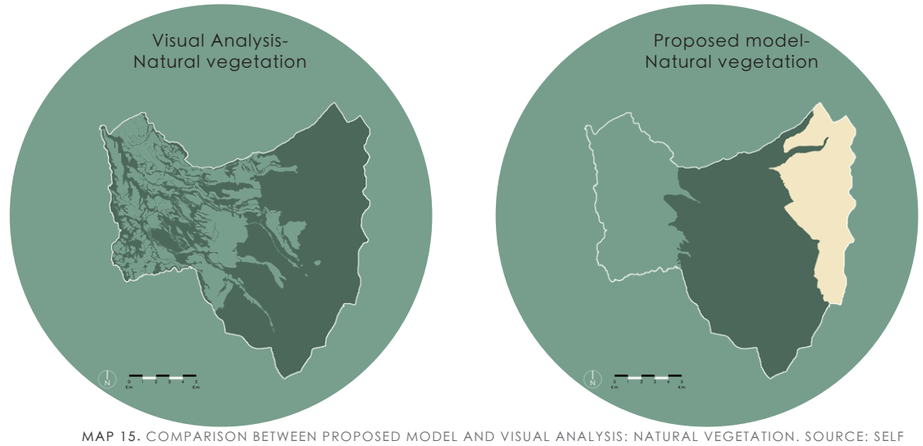
In general, settlement is seen smaller and more scattered than what the municipality has planned. In the western side of Pifo the settlement corresponds correctly in both plans, naturally, the municipality considers future growth. On the contrary, the smaller settlements on the eastern side are not taken into account in the proposed plan, probably in part due to the low density these settlements besides them being so close to agricultural areas. For R.E. implementation is an important consideration, regarding the impact R.E. can cause in these small settlements. (Secondary impact is also important to consider, such as the growth that these settlements have in the vegetation area.)

3.2.2.2. Disturbance of the land

There are many disturbances in the landscape that can be seen in the satellite images, such as industry, tree or shrubland felling and greenhouses, that are not considered in the proposed plan. Such disturbances are larger and much more spread in the visual analysis, which means more degradation on the landscape. These areas offer an opportunity for the placement of R. E. sources on areas that are already intervened, hence causing less impact.



MAP 14. COMPARISON BETWEEN PROPOSED MODEL AND VISUAL ANALYSIS: DISTURBANCE. SOURCE: SELF



MAP 15. COMPARISON BETWEEN PROPOSED MODEL AND VISUAL ANALYSIS: NATURAL VEGETATION. SOURCE: SELF

3.2.2.3. Natural Vegetation

The natural reserve Cayambe-Coca is the only area that fully matches the intact vegetation areas presented by the proposed plan. Mostly the “Ecological Protection” area shows clear degradation due to agricultural treatment. This observation complies with the growth of settlement seen in this analysis and presents an immense constraint for the implementation of R. E. technologies. Due to the evident degradation of the area and high sensitivity, it must be protected from further intervention.

3.2. Current Development Plan

3.2.3. Selection of sensitive areas

From the plans that are given by the PDOT (see Annex 2 and 3) the most sensitive areas have been selected as the least recommendable areas for the placement of R.E. technology. These are regarded as areas in which the impact of R.E. technologies can be high and disturbing; as well as areas that can be dangerous for the installations. These areas range from highly populated zones to very sensitive ecological areas. In the following descriptions are the areas selected as sensitive for each plan.

3.2.3.1. Existing Model

- Pifo central town
- Cayambe Coca Reserve
- Agricultural - Residential

3.2.3.2. PUOS

- Nonrenewable natural resources
- Residential zone
- Cayambe Coca Reserve
- Heritage
- Agricultural – Residential

3.2.3.3. Proposed Model

- Residential and commerce
- Mixed Use
- Urban zone
- Pifo central town
- Agricultural – Residential

3.2.3.4. Historical Places and Natural Landmarks

- Historical buildings
- Ravines where historical elements have been found.
- Historical routes

3.2.3.5. Settlement density

- High density settlement
- Middle density settlement

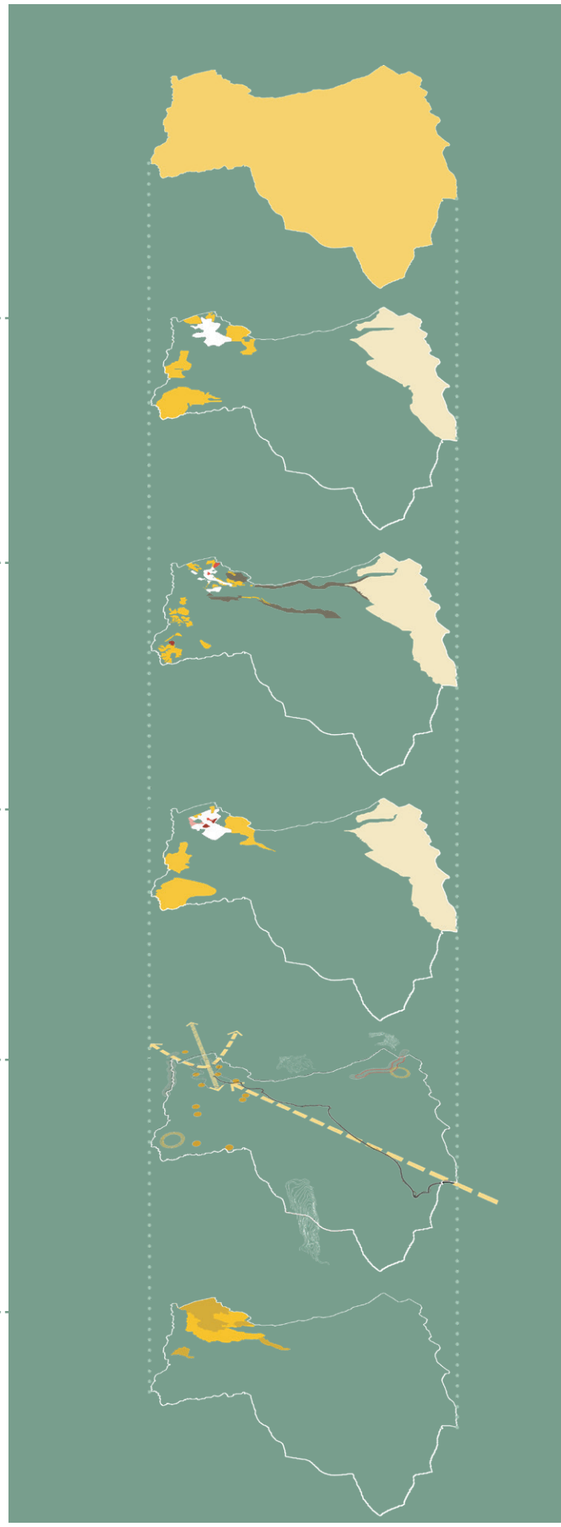


FIGURE 36. OVERLAY OF NON ECOLOGICAL SENSITIVE AREAS. SOURCE: SELF

FIGURE 37. OVERLAY OF ECOLOGICAL SENSITIVE AREAS. SOURCE: SELF

3.2.3.6. Ecosystems

- High montane evergreen forest
- Mountain evergreen shrubland
- Evergreen shrubland and wild grassland
- Evergreen montane shrubland

3.2.3.7. Ecosystem services (soil coverage)

- Settlement
- Forest plantation
- Shrubland vegetation
- Natural heritage

3.2.3.8. Soil classification (this map considers soils regarding its productive yield)

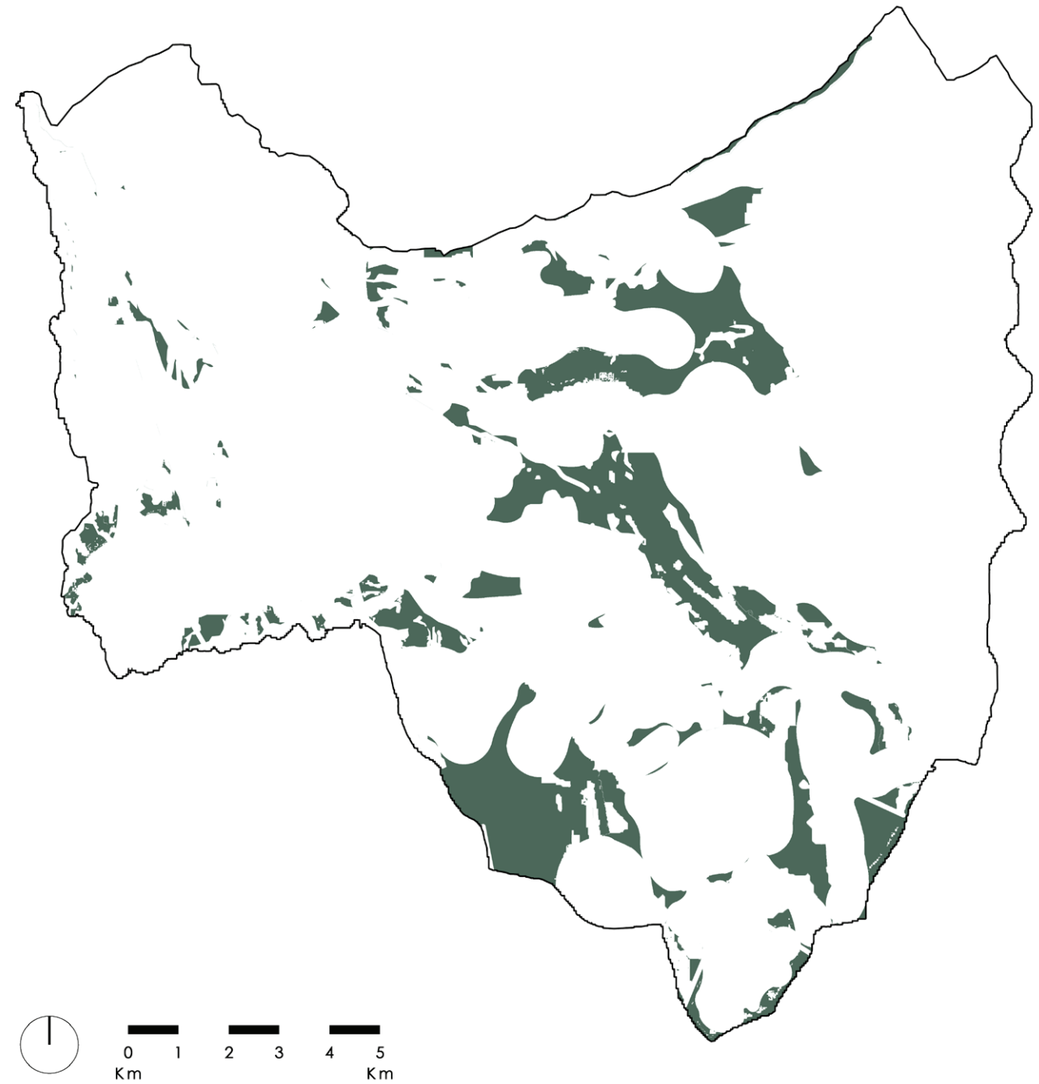
- Class II: Agriculture with low limitations
- Class III: Agriculture with medium limitations
- Class IV: Agriculture with large limitations

3.2.3.9. Rivers and watersheds

- All rivers
- Watersheds considered specially in the higher altitudes where the rivers are born

3.2.3.10. Geological threats

- Geological faults
- High danger of landslides (^ 45° slope)



MAP 16. POSSIBLE AREAS FOR R. E. IMPLEMENTATION: REMAINING AREAS AFTER REMOVAL OF SENSITIVE AREAS

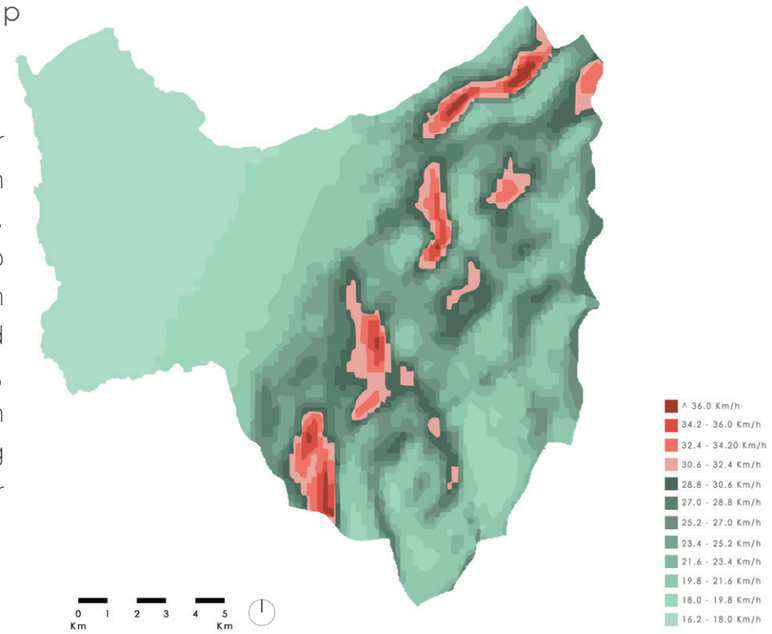
The first overview of possible areas for the implementation of R.E. technologies is seen when the sensitive areas selected previously are removed from the plan. By recognizing the characteristics that provide more value when prevented from such development, such as soils that are better for agriculture or watersheds that provide fresh water to the lower areas; and characteristics that must be preserved, such as habitats and peaceful settlement areas, a first overview of possible areas is given and shown in the plan above. A further selection of areas is done once the different R. E. technologies and individual conflicts are analyzed. Seen in the following chapter (CH. 4) are the following the R.E. technologies considered: Eolic, Biomass, Hydroelectric, Electrolytic Hydrogen and Photovoltaic.

3.3. Wind and solar analysis plans

3.3.1. Overview of optimal areas

3.3.1.1. Wind Speed map

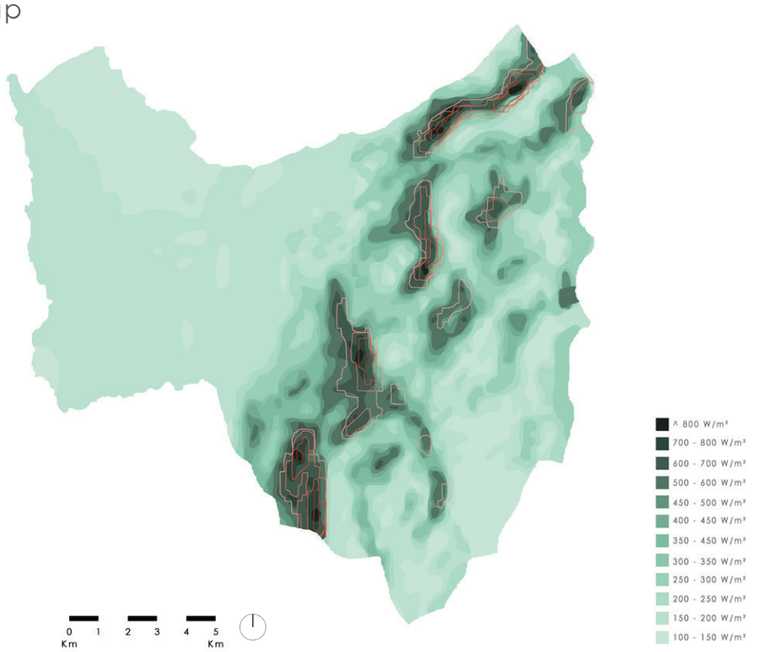
Based on the Wind Atlas for Ecuador, wind speeds in the eastern Andes is high. The wind speeds taken into consideration have been measured at 80m over ground level. As seen in the map, some of these areas match the Pifo highlands making it optimal for wind power production.



MAP 17. WIND SPEED AT 80 M ABOVE GROUND LEVEL. SOURCE: ADAPTED FROM ECUADOR WIND ATLAS (MINISTERIO DE ELECTRICIDAD Y ENERGIA RENOVABLE)

3.3.1.2. Wind density map

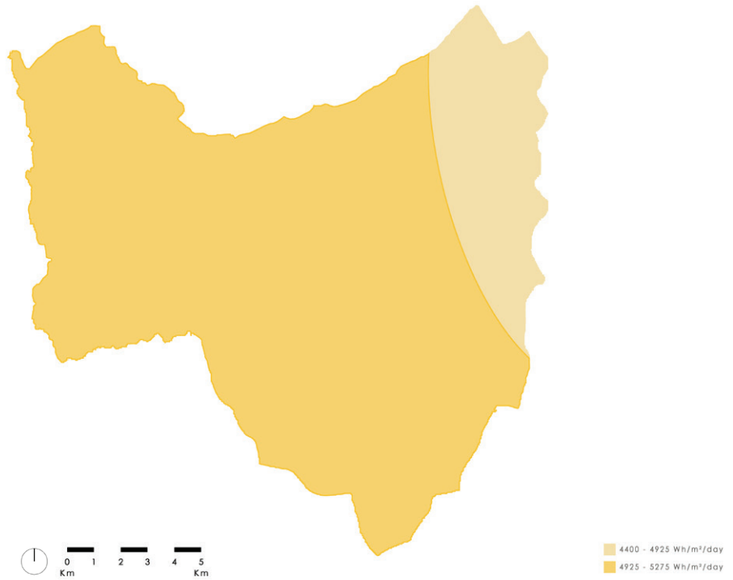
The wind density map is compared to the wind speed map, showing that at 80m above ground level, the greatest speeds also carry the higher density, which determines the potential of energy generation in Windmills.



MAP 18. WIND DENSITY AT 80M ABOVE GROUND LEVEL. SOURCE: ADAPTED FROM ECUADOR WIND ATLAS (MINISTERIO DE ELECTRICIDAD Y ENERGIA RENOVABLE)

3.3.1.3. Solar map

According to the Solar Atlas for Ecuador, solar power in Quito is stronger on the western mountain range. Nevertheless, Pifo has the stronger sun potentiality on its western side, making the flatland on the western side of the parish a possible area to place solar power generation.

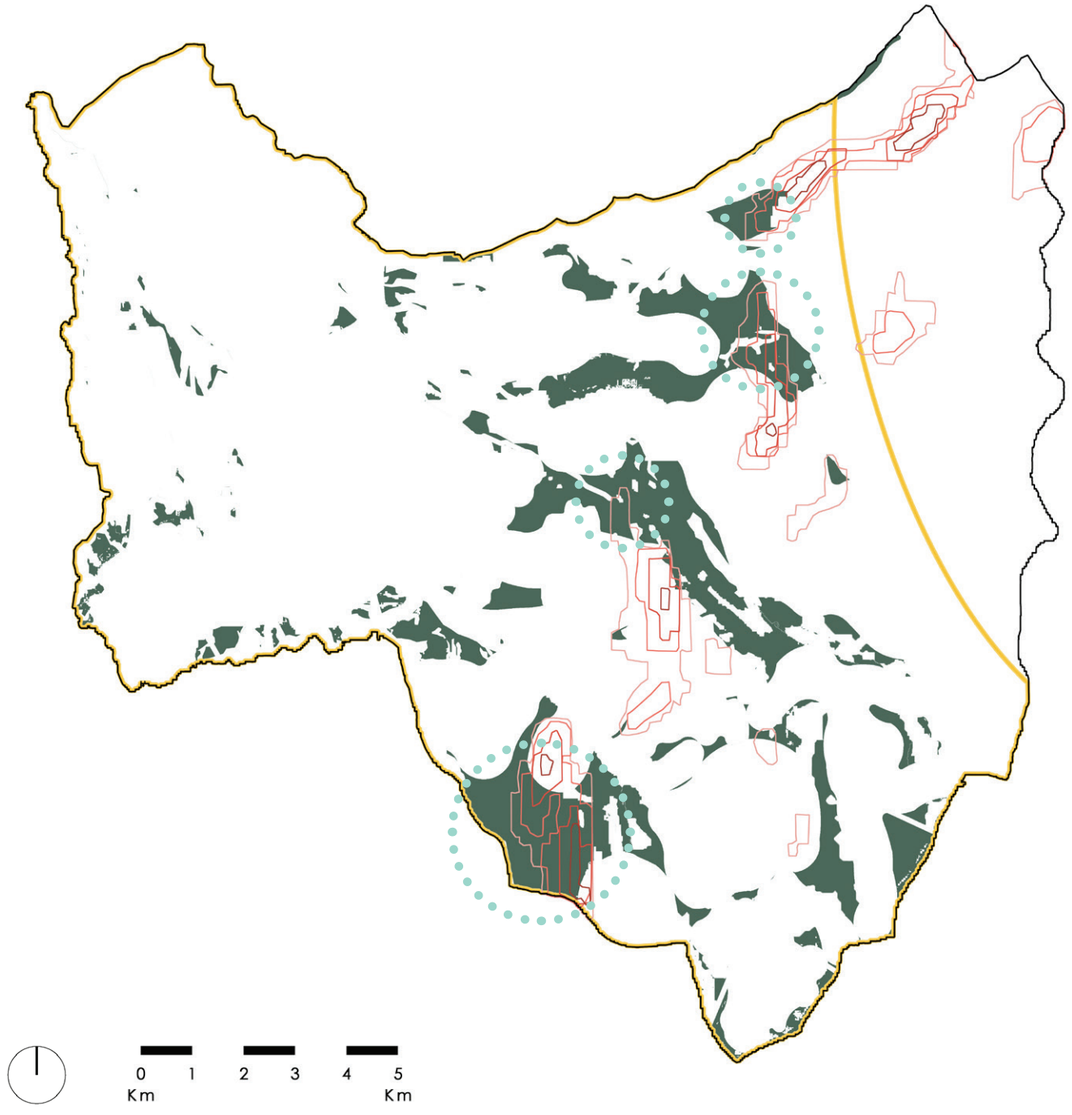


MAP 19. INSOLATION STRENGTH OF THE STUDY AREA. SOURCE: ADAPTED FROM ECUADOR SOLAR ATLAS (CONELEC, 2008)

3.3. Wind and solar analysis plans

3.3.2.Outocome of optimal areas

This plan shows a comparison of the prime wind areas to the possible areas selected according to the zoning plans.

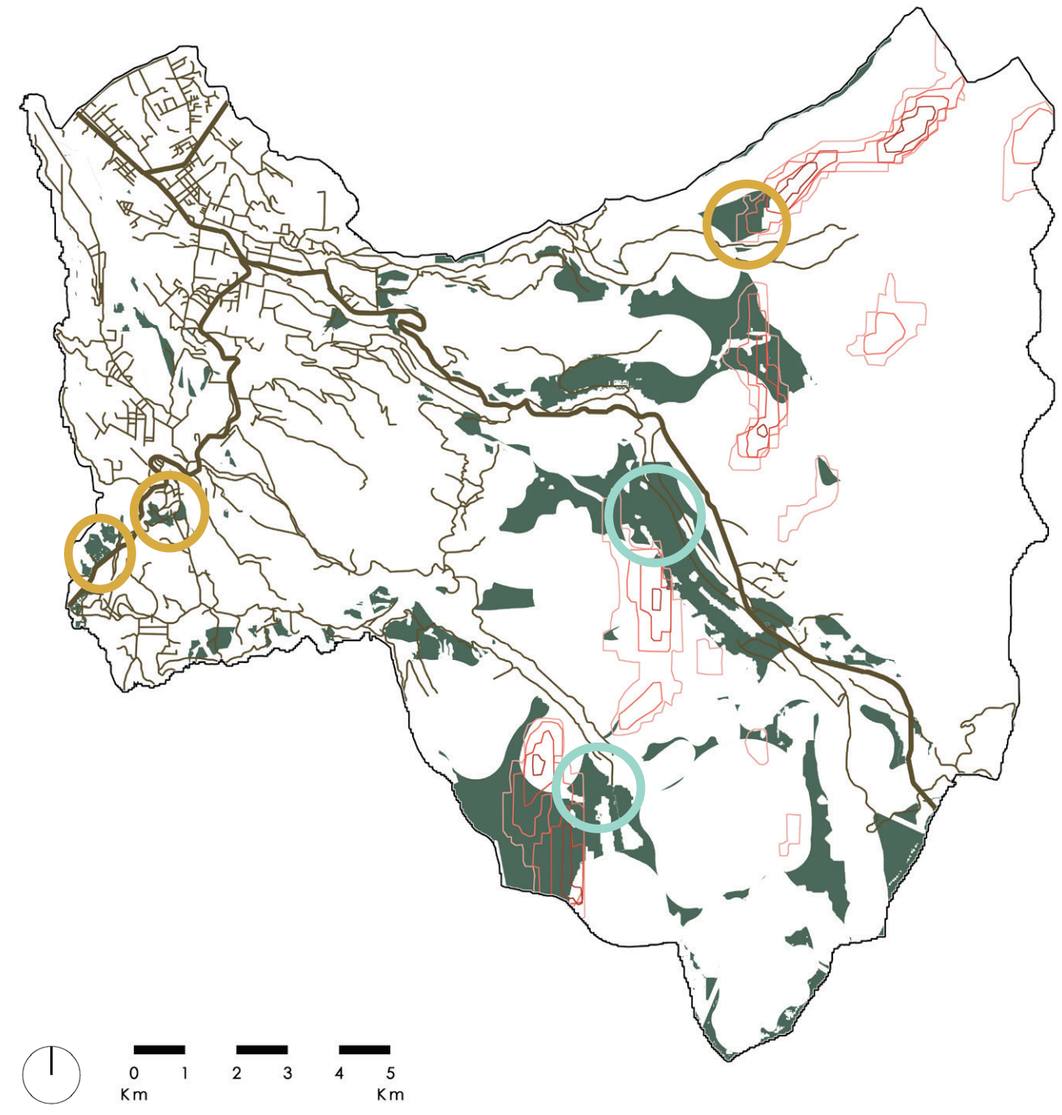


MAP 20. OVERLAY OF POSSIBLE AREAS FOR R.E. TECHNOLOGY AND OPTIMAL AREAS FOR SUN AND WIND ENERGY PRODUCTION. SOURCE: SELF

Optimal areas for Eolic Windmills have been found in the highlands of the Pifo parish. These areas combine the least sensitive areas with the higher potential for the production of energy. Sun possibilities are more spread out. Therefore, all the areas chosen as least sensitive can be possible for sun energy production. The effects of these choices are to be seen in the chapter 4 which focuses on the SEA of these results.

3.3.3. Accessibility to optimal areas

Comparing the optimal areas with the current road network expose the opportunities of minimal disruption when accessing complex areas.



MAP 21. ACCESSIBILITY TO OPTIMAL AREAS REGARDING CURRENT ROAD NETWORK. SOURCE: SELF

Adjacent accessibility. Two areas have adjacent accessibility, meaning that there may be the need to build a short road to access them.

Direct accessibility. One area has direct accessibility.

4

Stategic Environmental Assessment

Chapter 4. Strategic Environmental Assessment

The aim of this chapter is to analyze the possibilities for the implementation of R. E. technologies according to the plans seen in Ch. 3, to find new areas of opportunity that can be hidden from the zoning plans and to select the best area for this project. A selection of the most favorable technology for this specific area will be seen as well as the most appropriate location for each technology. Giving priority to the environment, the selected areas have to be analyzed and environmental conflicts found so that compensation measures can be proposed.

4.1. Definition

Strategic Environmental Assessment (SEA) is a way of approaching decision making while considering broader points of view that open up different alternatives for implementation of a specific project or program (strategic action). The alternatives should be considered in terms of site: considering many zones and finding the one that is least prone to be affected; in terms of system: considering different systems and finding the one that is the best for the specific goal and that has the least effects on the environment; in terms of technology: looking for a technology option that has the best yield and least impact considering all the variables of the area.

This process should run simultaneously to the development of strategic actions, so that the decisions are questioned and changed considering the best possibilities for the environment and sustainability. This happens by expanding "the decision maker's focus to include issues that go beyond their main area of concern" (Therivel, 2010, p. 10). According to Riki Therivel, a partner in Levett-Therivel sustainability consultants, "The ultimate aim of SEA is to help protect the environment and promote sustainability." (Therivel, 2010, p. 9)

With SEA the root of the problem has to be identified, considering the set of local objectives and promoting the participation of different stakeholders to consider different opinions and finding alternatives for the strategic actions. Therivel puts it in the following way: "The role of SEA is to help identify those dimensions of the strategic action where alternatives do exist, and do 'tell the story' of how alternatives have been developed" (Therivel, 2010, p. 146)

According to the International Association of Impact Assessment, "SEA is a process and a tool for evaluating the effects of proposed policies, plans and programs on natural resources, social, cultural and economic conditions and the institutional environment in which decisions are made." (Bridget, 2019) and according to the business dictionary "It also includes identifying ways to minimize, mitigate, or eliminate these effects and/or compensate for their impact" (Business Dictionary, 2019)

Compensation measures are important to consider in SEA because human development is generally very disruptive in the natural environment. SEA offers a way of finding options for development that can be the least disruptive while maintaining or enhancing the most important habitats, so that different species and habitats can live in communion with the human environment.

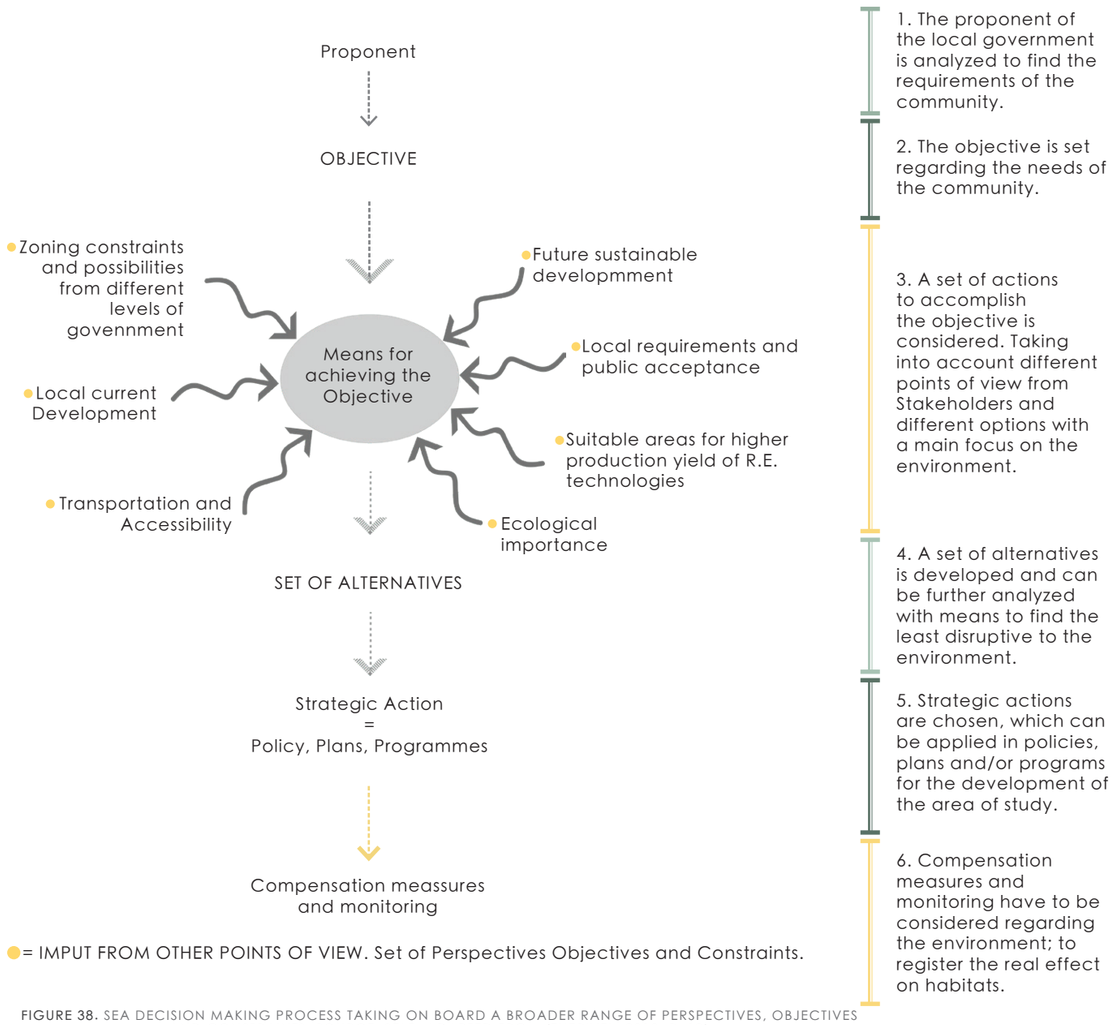


FIGURE 38. SEA DECISION MAKING PROCESS TAKING ON BOARD A BROADER RANGE OF PERSPECTIVES, OBJECTIVES AND CONSTRAINTS. SOURCE: SELF- ADAPTED FROM (THERIVEL, 2010, P. 10)

4.2. Opportunity analysis

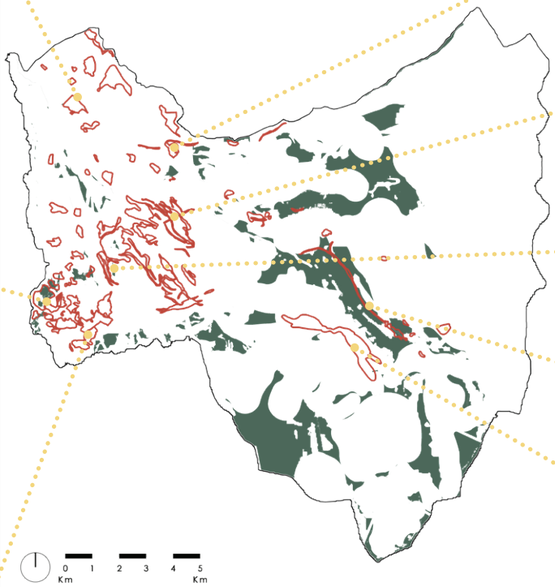
4.2.1.Identification of unseen opportunities

Unseen opportunities can be uncovered mostly in the disruption areas selected from the “visual analysis” of CH. 3. Many of these disruption areas are outside the options that could be considered form the GAD (local government) plans, nonetheless, can represent a big opportunity to place R. E. technologies. The following map shows each area that, chosen from the visual analysis, can be used for R.E. implementation.

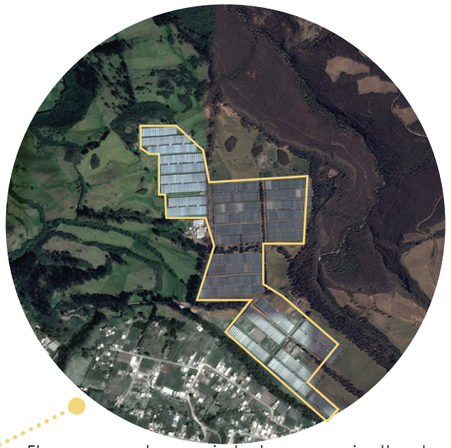
Greenhouses for flower exportation and industrial sheds within the central town can offer a future opportunity for implementation of R.E. since these are already disturbed areas, not inhabited and are fence. These areas are also close to the town which means close to the electricity network.

Quito municipal waste dump and natural gas deposit offer a big opportunity since the area is already largely contaminated.

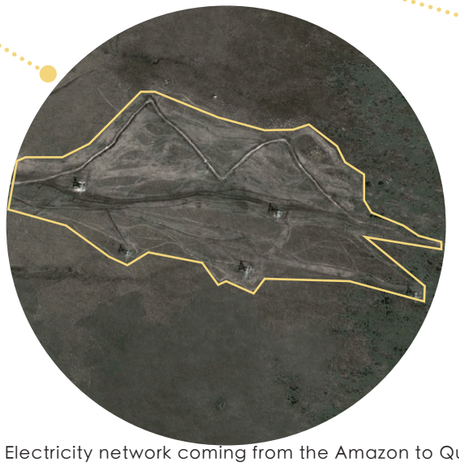
Electricity Power Station offers good proximity to connect any proposal of R.E. to the electricity network.



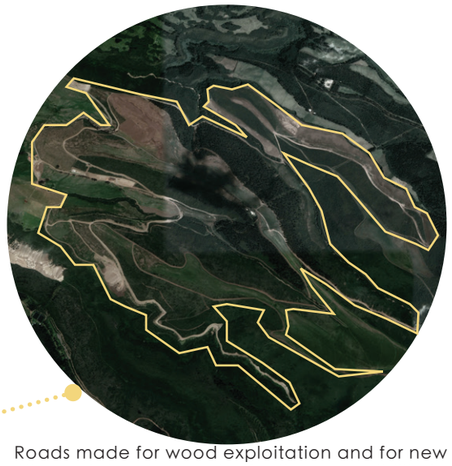
MAP 22. DISTURBANCE AREAS ACCORDING TO THE VISUAL ANALYSIS THAT CAN BE USED, OR CAN AID R.E. IMPLEMENTATION. SOURCE: SELF



Flower greenhouses in between agricultural land offer a space away from settlement and with already built electrical networks, as well as a floor with soil affected by plantations that can be used for R.E.



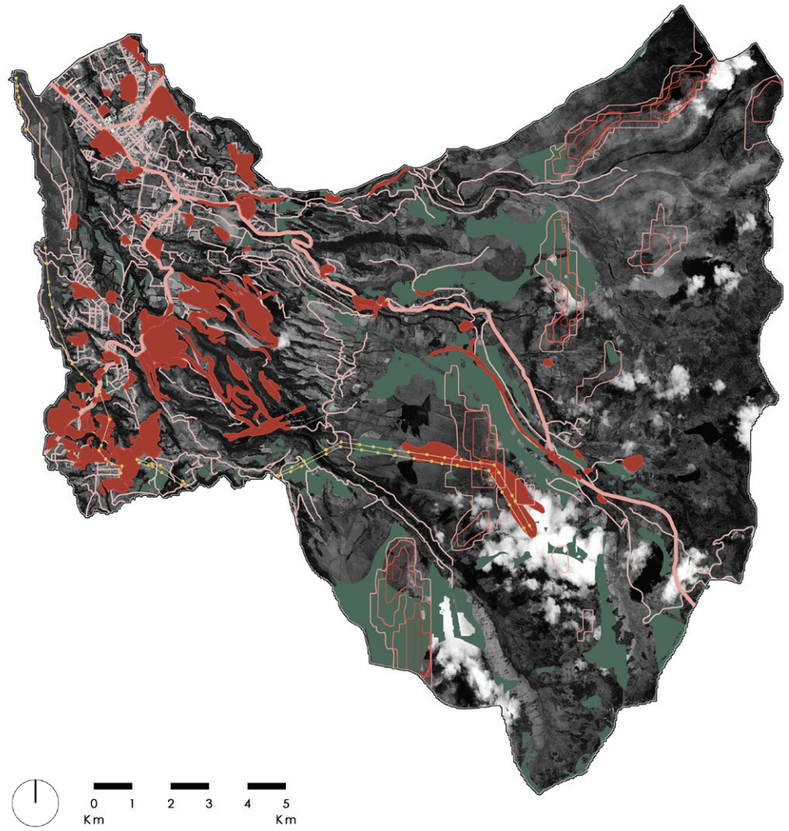
Electricity network coming from the Amazon to Quito through the highlands offers the opportunity to connect R.E. to the network in areas away from development.



Roads made for wood exploitation and for new settlement development offer the accessibility to different areas of possible R.E. implementation.

Industrial zone with access roads and expansion possibility offers an opportunity for maximizing the use of the area when implementing R.E. technologies.

Mining and flower greenhouses in the highlands offer an area that has been already damaged, where R.E. technologies cannot create more damage to the environment.



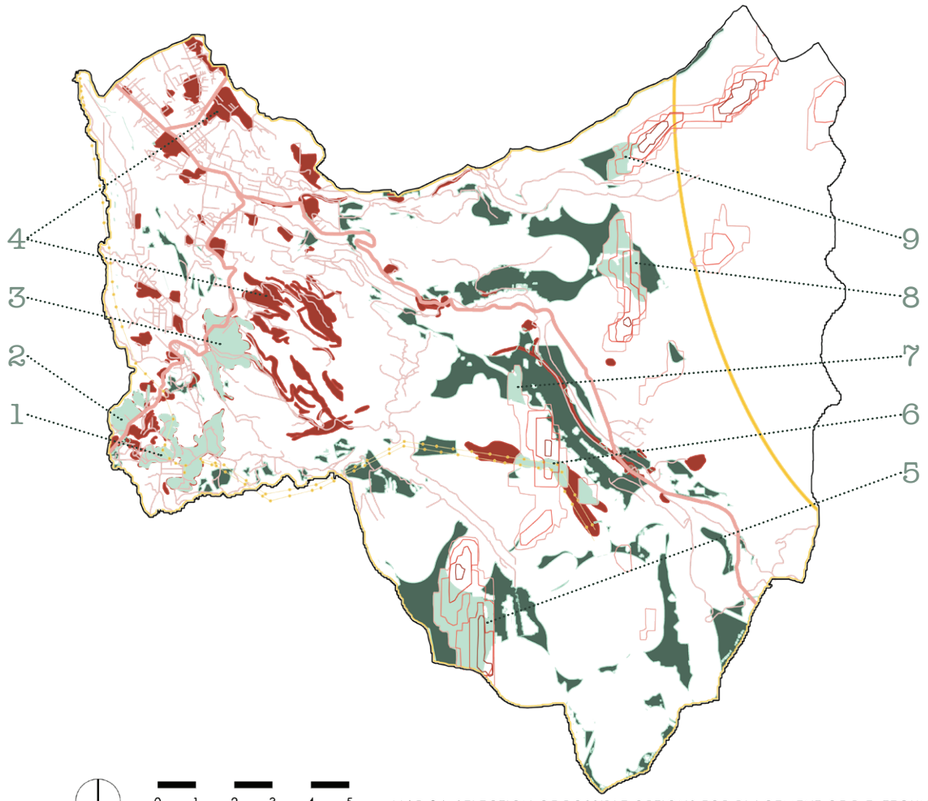
LEGEND

- Disturbance areas as seen in the visual analysis
- Optimal areas chosen from CH. 3
- Road network
- Electrical network
- Wind high speeds- optimal wind areas

MAP 23. DISTURBED AREAS AND POSSIBILITY AREAS WITH ELECTRICAL AND ROAD NETWORK. SOURCE: SELF

Roads and Electrical networks provide immense opportunities for the placement of R. E. technologies due to the affectation these installations have already generated. Its preferable to place new installations in the proximity of these disturbed areas as to create new disturbances.

This type of development creates extreme fragmentation and sealing in the landscape but provides an opportunity for this thesis project. In addition to the disturbed area, the fact that the electrical network is close to a high wind production area is an opportunity to connect the production area directly to the network, minimizing transmission loss.



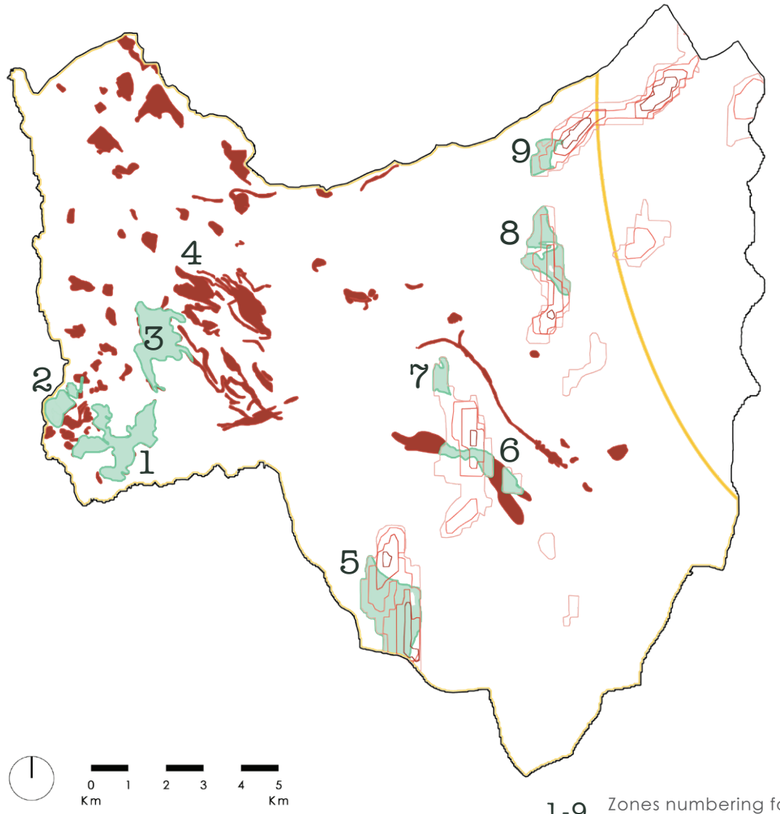
MAP 24. SELECTION OF POSSIBLE OPTIONS FOR PLACEMENT OF R.E. TECHNOLOGIES ACCORDING TO DISTURBED AND POSSIBILITY AREAS WITH PRODUCTION POTENTIAL. SOURCE: SELF

1. Option 1 considers previously disturbed areas close to the energy network.
2. Option 2 considers a disturbance area + road accessibility + location of a possible a possible area according to zoning.
3. Option 3 considers a disturbance area + road accessibility.
4. Options 4 consider only previously disturbed areas. If this possibility is considered it stablishes an EIA instead of a SEA.
5. Option 5 considers the location of a possible area acording to zoning + the potential of energy production + the proximity to a road network.
6. Option 6 considers the proximity to the electricity network + the use of a disturbed area + the pontential of energy production according to the solar and wind atlas.
7. Option 7 considers the proximity to the road network + the location of a possible area acording to zoning + the potential of energy production according to the solar and wind atlas.
8. Option 8 considers the location of a possible area acording to zoning + the potential of energy production. This area has the downside of not having evident accessibily.
9. Option 9 considers the proximity to the road network + the potential of energy production according to the solar and wind atlas.

4.3. Identification of main general conflicts

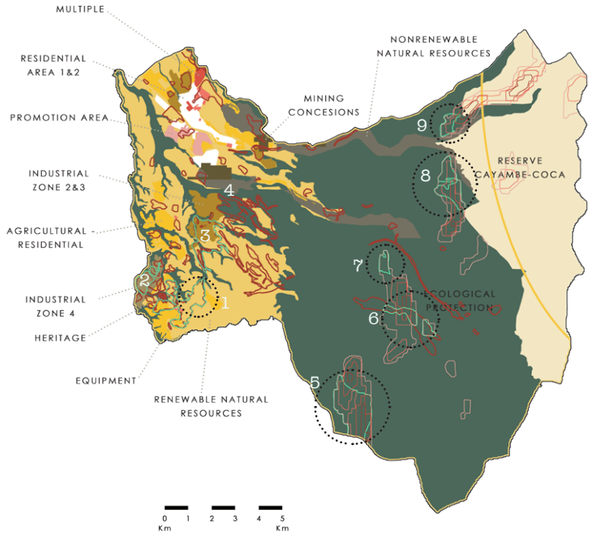
4.3.1. Conflicts regarding zoning of R.E. placement options

Conclusions can be drawn by analyzing the options (zones 1-9) mentioned before and comparing them on the maps made by the local government. With this analysis there is a possibility to see which options have anthropological and ecological conflicts, according to the plans provided from the municipality, and which have compensation potential, compared to those areas which don't. As a result, the more viable zone for R.E. placement can be selected. Compensation measures for the selected areas are detailed in Ch. 5.



MAP 25. SELECTED ZONES AS R.E. OPTIONS FOR FURTHER CONFLICT ANALYSIS. SOURCE: SELF

PUOS (Landuse plan)



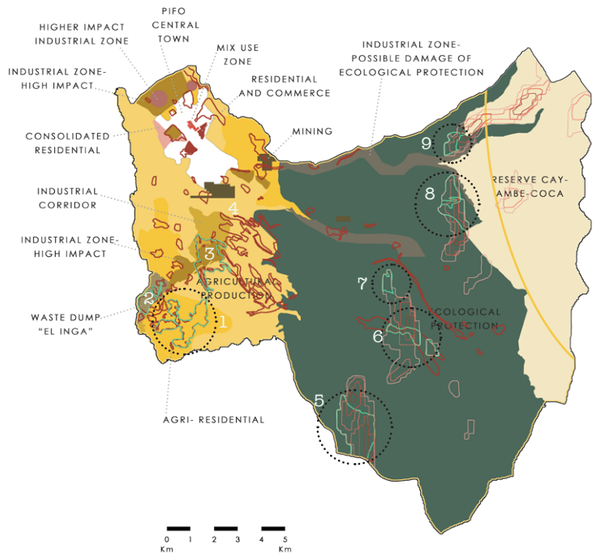
MAP 26. CONFLICTS OF SELECTED ZONES WITH PUOS. SOURCE: SELF- ADAPTED FROM PDOT MAPS (SEE ANNEX 2)

Zones 5-9 are in the "Ecological Protection" area, they have conflict but can have compensation.

Zone 1 is in between Agricultural-Residential and Renewable Natural resources and can have compensation options.

Zone 4 presents various conflicts, there are disruptions in ecological protection area, renewable natural resources and residential area which can have compensation opportunities.

Proposed development



MAP 27. CONFLICTS OF SELECTED ZONES WITH PROPOSED DEVELOPMENT. SOURCE: SELF- ADAPTED FROM PDOT MAPS (SEE ANNEX 2)

Zones 5-9 selected areas are in the "Ecological Protection" area, this is an area that can offer compensation options.

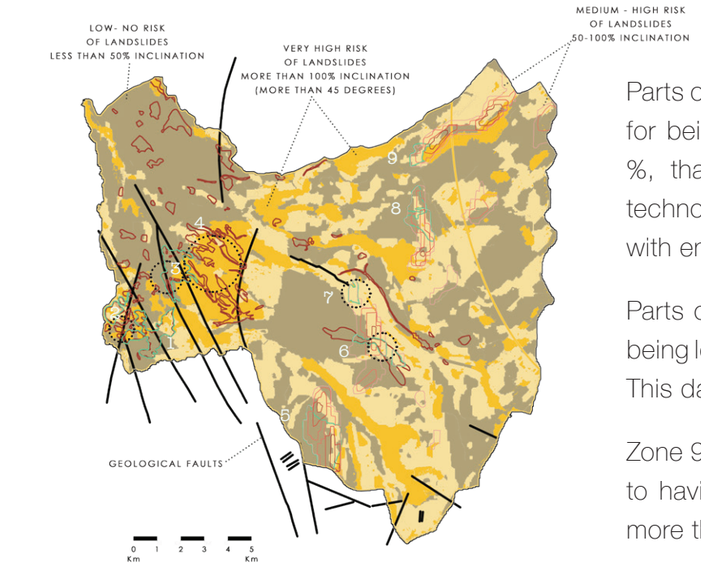
Zone 1 is in Agricultural-Residential area and has anthropological conflict but can offer compensation options.

Zone 4, as well as in the previous map, presents various conflicts with compensation opportunity.

4.3. Identification of main general conflicts

4.3.1. Conflicts regarding zoning of R.E. placement options

Geological threats



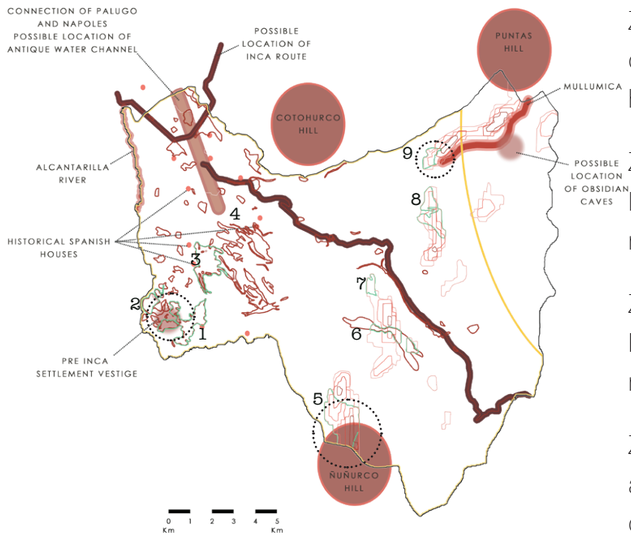
MAP 28. CONFLICTS OF SELECTED ZONES WITH GEOLOGICAL THREATS. SOURCE: SELF- ADAPTED FROM PDOT MAPS (SEE ANNEX 2)

Parts of Zone 1 and Zone 3 present dangers for being in a slope between 50 and 100 %, that, depending on the type of R.E. technology selected, can be compensated with engineering and structural elements.

Parts of Zone 7 and 8 present dangers for being located just where a geological fault is. This danger does not have compensation.

Zone 9 presents a very specific conflict due to having a large area in slopes that have more than 100% inclination.

Historical Places and Natural Landmarks



MAP 29. CONFLICTS OF SELECTED ZONES WITH HISTORICAL PLACES AND NATURAL LANDMARKS. SOURCE: SELF (SEE ANNEX 3)

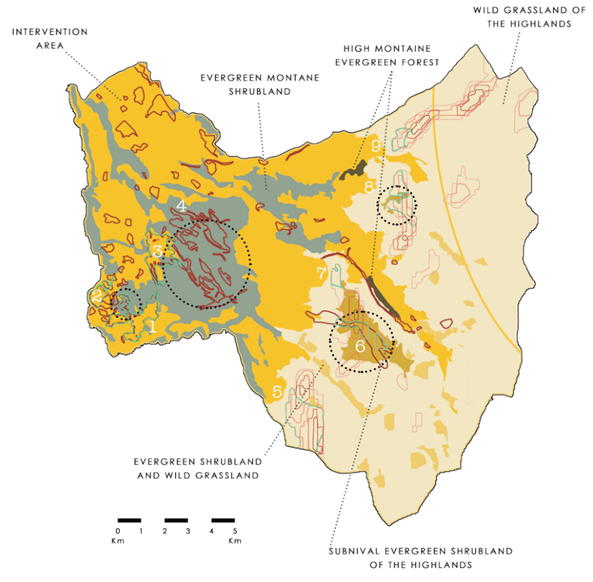
Zone 9 is located close to where the obsidian deposits are. If damaged, this area has no compensation options.

Zone 5 is on the hill of a well-known Natural landmark, if scenic views are ruined there is no compensation potential.

Zone 1 is right on the heritage site of a found Pre- Inca settlement. If disturbed, there is no compensation potential for this area.

Zone 4 has a very strong disruption in the area of Pre Inca settlement that does not offer compensation opportunity.

Ecosystems



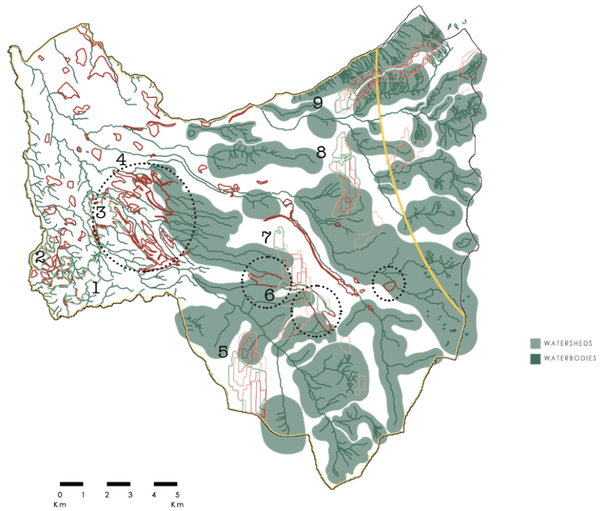
MAP 30. CONFLICTS OF SELECTED ZONES WITH ECOSYSTEMS. SOURCE: SELF-ADAPTED FROM PDOT MAPS (SEE ANNEX 2)

Zone 6, 8 and 4 present a strong conflict with the “Subnival Evergreen Shrubland of the Highlands” where many species have developed singular physiological adaptations (Cuesta, et al., 2013, pp. 147-149), and therefore can present difficulties to find compensation measures.

Zone 1, 3 and 4 present conflict with the “evergreen montane shrubland from the north Andes” that are the remnants of montane forests which have been replaced by farmland (Chinchero, Morales, & Medina-Torres, 2013, p. 76) therefore are difficult to compensate

Zone 4 presents a particularity that should be considered, it is a current disrupted area and should be subject to an EIA.

Waterbodies



MAP 31. CONFLICTS OF SELECTED ZONES WITH WATERBODIES. SOURCE: SELF (SEE ANNEX 3)

A small part of Zone 6 presents conflict with watersheds.

Zone 4 presents the biggest problems on rivers and watersheds. This type of conflict is very unlikely to be compensated due to the sensitivity of a watershed and Waterbodies. If these areas are contaminated the whole system can present contamination and all the species, including humans, depend on the quality of the waterbodies.

4.3. Identification of main general conflicts

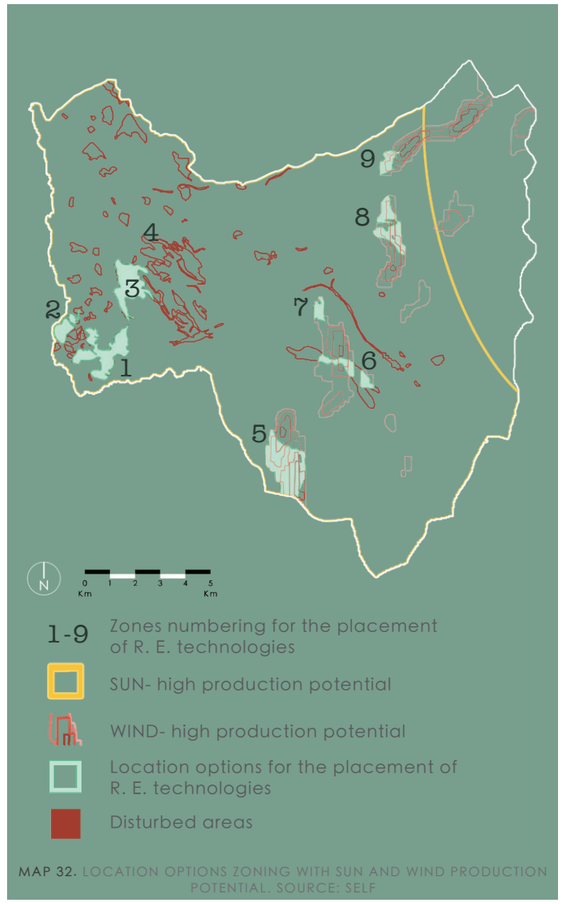
4.3.2. Conflict Classification System

CONFLICT TYPE		MAPS	ZONES								
WITH **COMPENSATION** POTENTIAL	Anthropological with compensation potential	PUOS	1	2	3	4	5	6	7	8	9
		Proposed Development	1			1					
		Historical places and Nat. Landmarks	1			1					
		Geological Dangers									
		Ecosystems									
		Waterbodies									
	Ecological with compensation potential	PUOS									
		Proposed Development				1	1	1	1	1	1
		Historical places and Nat. Landmarks				1	1	1	1	1	1
		Geological Dangers									
		Ecosystems				1		1	1		
		Waterbodies									
TOTAL	CONFLICTS **WITH** COMPENSATION POTENTIAL:							1			
			2	0	0	5	2	4	3	2	2
WITH **NO COMPENSATION** POTENTIAL	Anthropological with NO compensation potential	PUOS									
		Proposed Development									
		Historical places and Nat. Landmarks									
		Geological Dangers	1			1	1				1
		Ecosystems									
		Waterbodies									
	Ecological with NO compensation potential	PUOS									
		Proposed Development									
		Historical places and Nat. Landmarks									
		Geological Dangers									
		Ecosystems	1		1						
		Waterbodies	1		1	1		1		1	
TOTAL	CONFLICTS WITH **NO** COMPENSATION POTENTIAL:					1					
			3	0	2	3	1	1	0	1	1

SUMMARY

# 1	**ZONE 2** has no conflicts
# 2	**ZONE 7** has conflicts only with compensation potential
# 3	**ZONE 5, 8 and 9** have one conflict with no compensation and 2 with compensation potential
# 4	**ZONE 6** has only 1 conflict with no compensation but 4 with compensation
# 5	**ZONE 3** has 2 conflicts with no compensation potential
# 6	**ZONE 1** has 3 conflicts with no compensation potential but only 2 with compensation potential
# 7	**ZONE 4** has various conflicts that should be addressed individually since it refers to already disturbed areas

TABLE 3. CONFLICT CLASSIFICATION SYSTEM. CONFLICTS AS PER SELECTED ZONE. SOURCE: SELF



MAP 32. LOCATION OPTIONS ZONING WITH SUN AND WIND PRODUCTION POTENTIAL. SOURCE: SELF

As seen before, the areas analyzed from the unseen opportunities map have been compared to the zoning maps to find the specific conflicts of each area. These conflicts have been classified in the following way:

a. Anthropological conflicts that can have compensation opportunities

b. Ecological conflicts that can have compensation opportunities

c. Anthropological conflicts that do not have compensation opportunities

d. Ecological conflicts that do not have compensation opportunities

With this classification the following graphic has been developed by giving a point to each map that had a conflict regarding the pre-selected possibility zones.

Priority is given to the zones that have compensation opportunities. This way the areas that have less conflict have been found and therefore are more likely to be a good area for R. E. placement.

4.3.3. Selection of areas for R. E. locations

PRIORITY PARAMETERS			
ZONE	Conflict free	Disturbed area	TOTAL
2	✓	✓	2
7	✗	✗	0
5, 8, 9	✗	✗	0
6	✗	✓	1
3	✗	✓	1
1	✗	✓	1
4	✗	✓	1

Lack of priority sends these zones to the last position, meaning they are the least appropriate for this type of intervention.

TABLE 4. PRIORITY PARAMETERS REGARDING CONFLICTS AND DISTURBANCE AS PER ZONE. SOURCE: SELF

To find the most optimal R. E. locations from the previous selection, priority has been given to the zones that have an existing disturbance. The chosen areas for the application of this project will be as follows:

Location Options

- # 1 Zone 2
- # 2 Zone 6
- # 3 Zone 3
- # 4 Zone 1
- # 5 Zone 4
- # 6 Zone 7
- # 7 Zone 5, 8 and 9

4.4. Selection of R. E. technology

4.4.1. R. E. Comparison

Drawn from the R. E. comparison tables in Annex 4, different type of technologies can be placed in different locations. In the following abstract, there is a description of each R.E. technology. For each technology there is a selection of which zones can be used, regarding the specific characteristics of the zone.

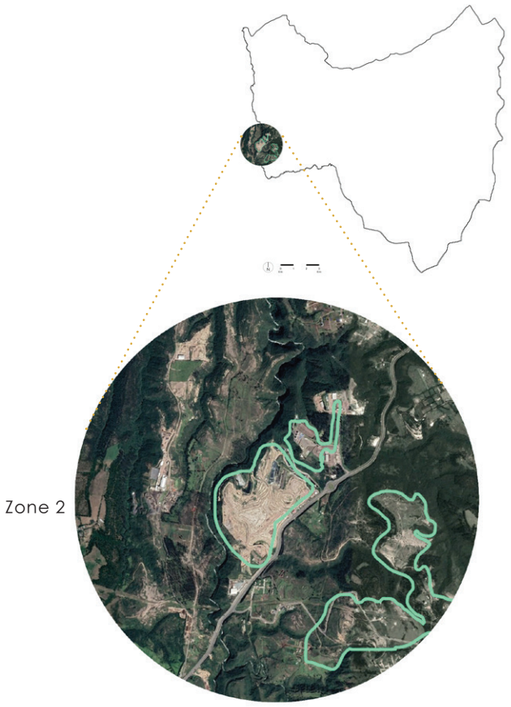


FIGURE 39. POSSIBLE LOCATION FOR BIOMASS TECHNOLOGY. SOURCE: SELF

4.4.1.1. Biomass

- Is the energy that comes from waste decomposition that produces biofuels, biogas or heating and therefore electricity.

- Needs a large space to process and store the material needed. This means that it will be better to consider areas with less or no vegetation.

- Is viable when the facilities are located near to the source of raw material. This is important considering that the area of study is nearby to a municipal waste dump, wooden products factory and surrounded by agricultural areas. **Zone 2** can be considered for this type of production.

4.4.1.2. Hydroelectric

- Is the system that collects the energy contained on waterflow. Therefore, all areas with access to rivers with water volume are eligible.

- It requires large set of facilities such as dams, turbine and machine rooms, connecting pipes, among others.

- The study area has many streams and rivers with flowing water and an important height difference in the terrain, but it lacks waterfalls. The amount of water in the region is low but constant due to the fact that the highlands are the birth points of many rivers.

- Ravines and rivers can be used for small scale hydroelectric facilities, but these areas have been set as too sensitive; especially due to the protection of the small amount of remaining natural vegetation, as seen in Ch. 1.

- The study area offers no possible areas for the placement of hydroelectric facilities.

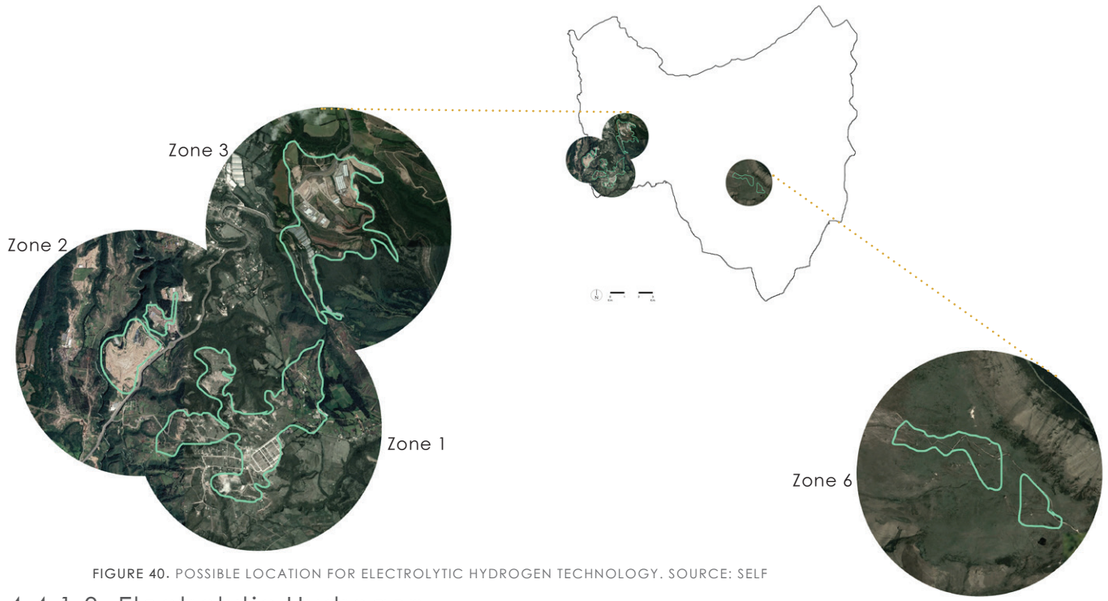


FIGURE 40. POSSIBLE LOCATION FOR ELECTROLYTIC HYDROGEN TECHNOLOGY. SOURCE: SELF

4.4.1.3. Electrolytic Hydrogen

- Is the result of the separation of hydrogen from raw material such as biomass and water.

- Has much more energy content than gasoline for the same amount of weight.

- Is expensive to produce.

- Needs electricity to be produced from water and for this reason can act as storage (batteries) for other sources of electricity production, avoiding contamination from other battery materials such as lithium. It can be implemented in zones where other technologies are being implemented such as **Zone 2 and Zone 6**.

- By exposing hydrogen to oxygen (air), electricity is produced and heat as a byproduct, being an effective cogeneration process.

- The combustion produces water in the way of vapor; hence, no contaminants are released.

- Ammonia fertilizers can be produced from hydrogen. Currently Ecuador imports these fertilizers for the lack of research and production methods. Due to the area being surrounded by agricultural land, this technology offers immense opportunity for research and implementation.

- Needs a large space for production and storage. For this reason, it would be better to place this technology on already built areas such as industry. Zones 7 and 8 are larger and can offer an opportunity for this facility.

4.4. Selection of R. E. technology

4.4.1. R. E. Comparison

FIGURE 41. POSSIBLE LOCATION FOR EOLIC TECHNOLOGY. SOURCE: SELF

4.4.1.4. Eolic

- Eolic energy is the energy of airflow, therefore, areas with the higher air density and speed are optimal for this technology. **Zones 1, 2, 3, 4, and 5** are located on the best production yield regarding wind production for this area.

- Due to sound and light disturbance wind turbines can produce, they should be placed around 10 times the towers' height away from settlement.

- The height of the towers can generate disturbance in scenic views, meaning landmarks and touristic areas have to be avoided.

- Air traffic areas must be avoided.

- Weight has to be taken into account in the size of foundation and therefore disturbance to groundwater and soil biotopes.

- Turbulence between turbines can occur and influence energy production, therefore, the distance between each tower should be around 8 times the diameter of the rotor.

- Constant maintenance to the towers must be done, this means constant access must be considered, so it is important to examine proximity to roads.

4.4.1.5. Photovoltaic

- Is the direct conversion of sun radiation into electricity.

- Because of the size and proximity to the ground of PV panels, they need particular protection from vandalism and need facilities close by for regular maintenance. **Zone 6** can be a good choice since has already built facilities and limited time of use. Is better if it's implemented in previously sealed areas. For these reasons, rooftops are a great option; making **Zone 7 and 8** feasible for this technology.

- Can cause problems of light reflections for neighbors and animals, producing "shy effects" or confusion with water for passing fauna.

- Ecuador does not have winter, making it a great location for these technologies.

- The study area has high criminality levels; rooftops could be a better choice than ground facilities, making **Zone 9** a good possibility.

- For this production to be profitable, large areas have to be installed.

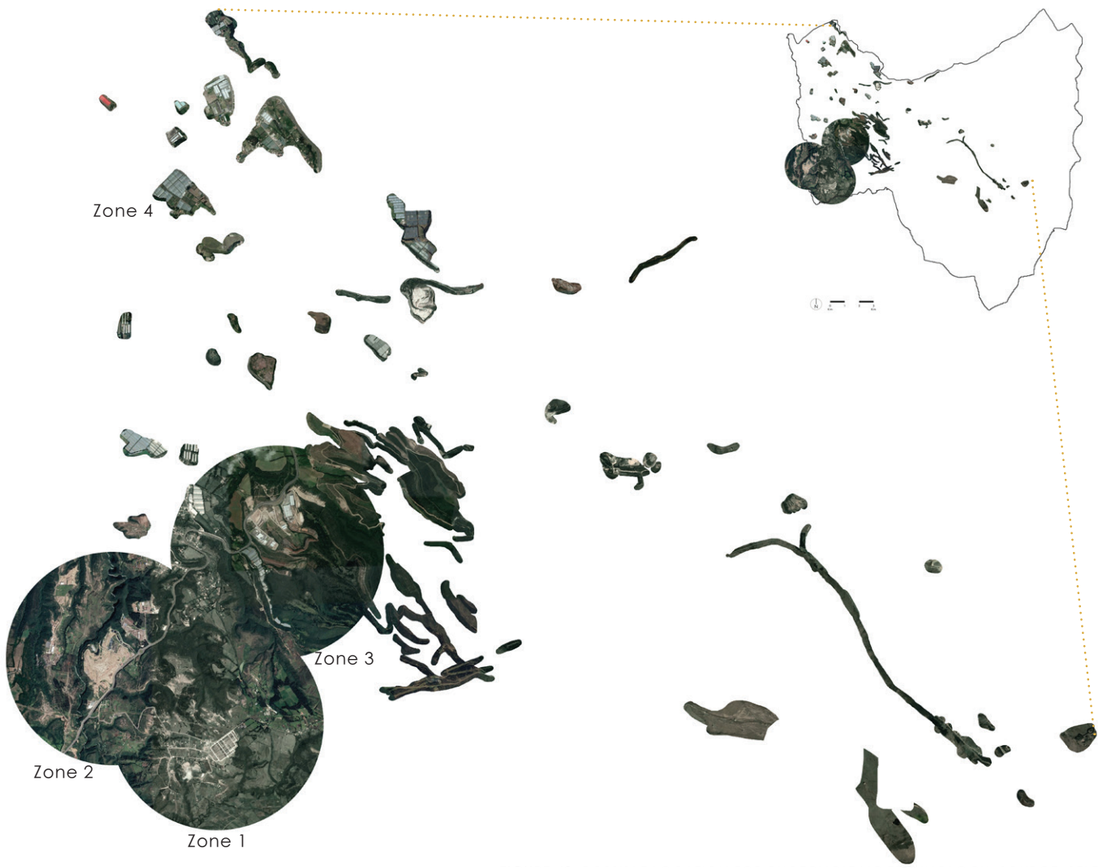


FIGURE 42. POSSIBLE LOCATION FOR PHOTOVOLTAIC TECHNOLOGY. SOURCE: SELF

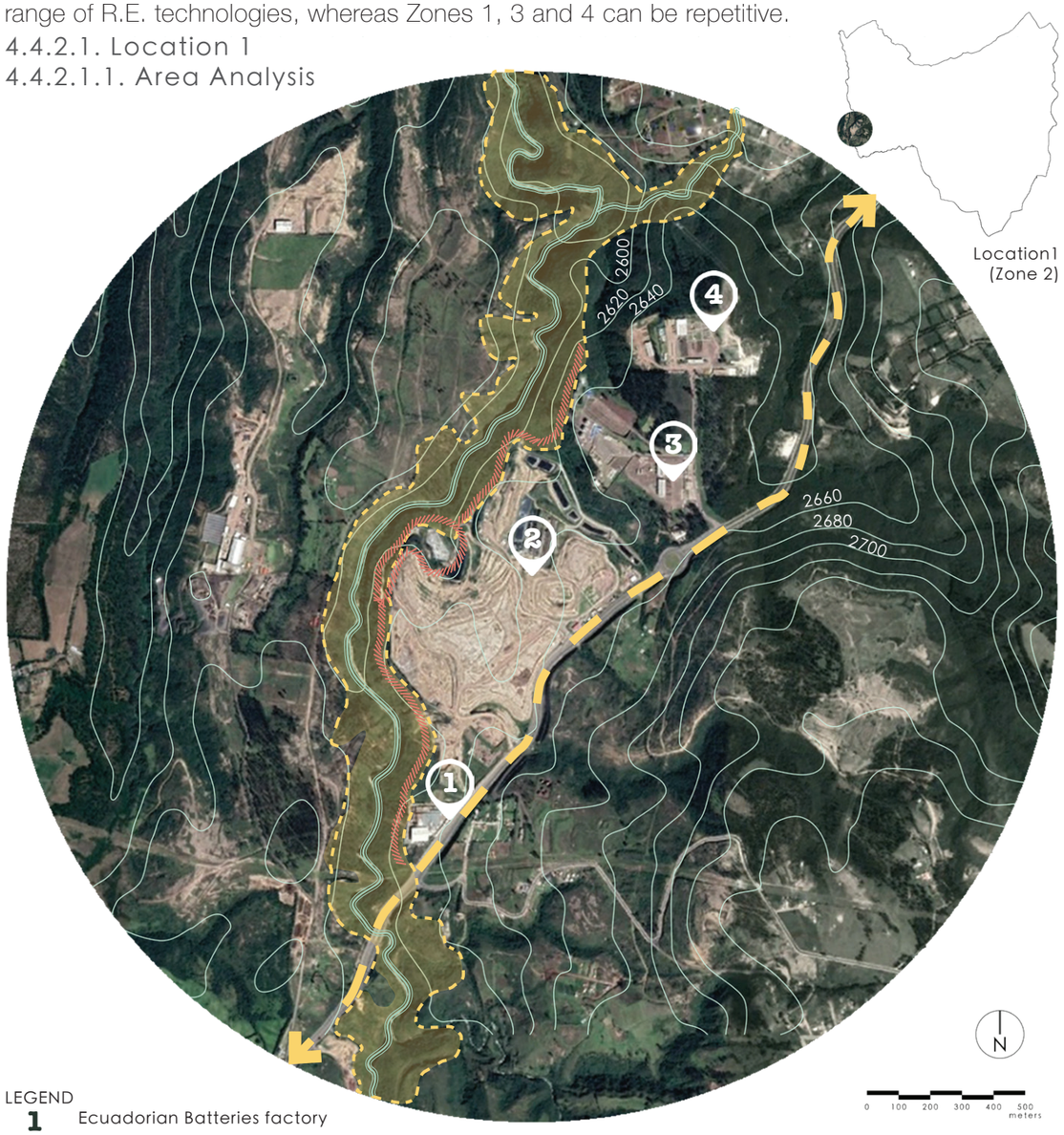
4.4. Selection of R. E. technology

4.4.2. Analysis of selected areas for each R. E. technology

For the purpose of this project, the best two locations seen in section “4.3.3. Selection of areas for R.E. locations” have been chosen for further analysis. Zone 2 has priority and is from now on named as location 1. Zone 6 is placed on the second-best ranked priority and from now on it is named location 2. Between these two options there is the possibility of looking into a broader range of R.E. technologies, whereas Zones 1, 3 and 4 can be repetitive.

4.4.2.1. Location 1

4.4.2.1.1. Area Analysis



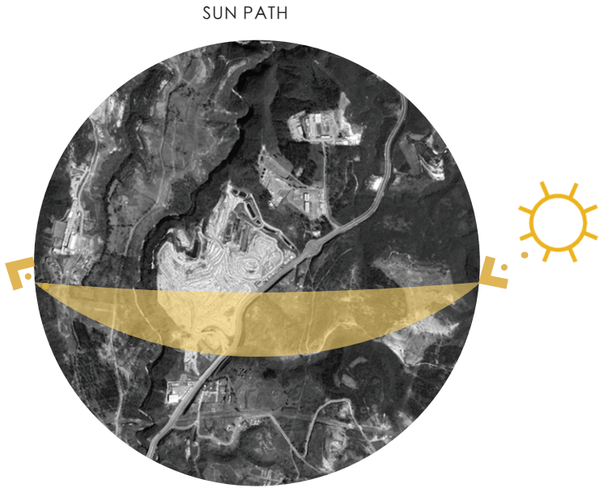
MAP 33. DETAILED ANALYSIS OF LOCATION 1. SOURCE: SELF

Location 1, considered for Photovoltaic and Biomass, is categorized as an industrial zone due to the existence of the 40 ha Municipal Waste Dump, the Petroleum Gas storage facilities and the Ecuadorian Batteries factory. A ravine and river run along the north-west side with its corresponding sensitive vegetation. On the South-east side a first-class road provides excellent access to all the industrial facilities.

CURRENT SITUATION (2017)

FIGURE 43. CURRENT SITUATION OF LOCATION 1. PHOTO. SOURCE: HTTPS://WWW.ELTELEGRAFO.COM.EC/NOTICIAS/179/11/ZONAS-ALEDANAS-AL-RELLENO-SANITARIO-DE-QUITO-RECIBIERON-USD-2-5-MILLONES

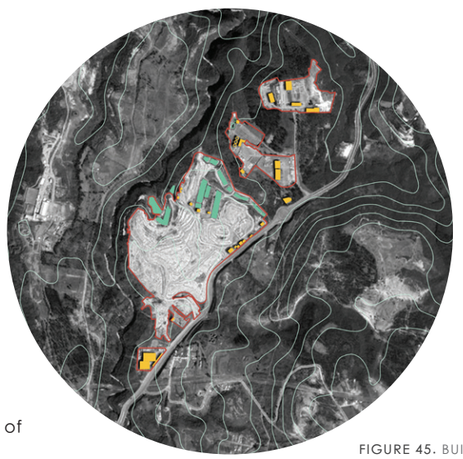
SUN PATH



Direction EAST - WEST with some inclination to the South
Lat. 0 17’ 42. 01” s

FIGURE 44. SUN PATH OF LOCATION 1. PHOTO. SOURCE: SELF

BUILT AREA



Total area: 597402.5 m2

Built Area: 17491.96 m2

Artificial Water Bodies:

Buildings
Artificial Pools
Area Limits= The boundaries seen from the disturbed area of the industrial zone

FIGURE 45. BUILT AREA OF LOCATION 1. PHOTO. SOURCE: SELF

4.4.2.1.2. SWOT Analysis

S Strengths

- Biogas plant is since 2016 already implemented in the site and producing 5 MWh (EMGIRS EP, 2019)
- Security personnel already existing
- Convenient access to site
- Disturbed area presents a flat solid ground for new structures such as PV panels
- Surrounding trees are far away and do not cast shadows to the area
- Panoramic view of Quito

W Weaknesses

- Ravines with sensitive habitats surrounding the site are home to numerous animals that can feel affected by the project: " "shy effect" or confusing the panels with waterbodies
- Bad smell from the trash under the soil can affect personnel
- Extremely degraded natural surroundings
- Pools with leached liquid are extremely contaminant
- Landscape level differences are strong therefore prone to runoff

O Opportunities

- Roof PV panels can be immediately implemented in existing buildings
- Buffer zone between ravine vegetation and site can be created with PV panels
- The waste dump has a finite time, therefore, potential of incrementing panels in the future
- Eroded area diminishes impact of PV panels on soil; PV panels can even help protect the soil from direct insolation and with it, beginnings of desertification.
- Renaturation of surrounding areas with endemic vegetation

T Threats

- Many animals can nest in the area or under PV panels creating a possible hazard
- High criminality area
- Contamination and health problems for personnel

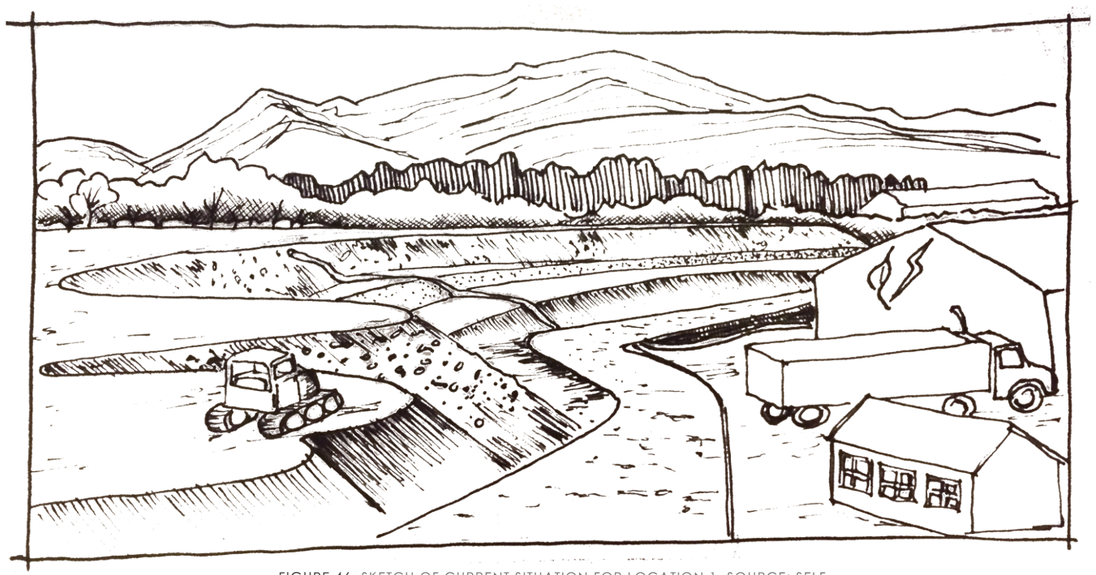
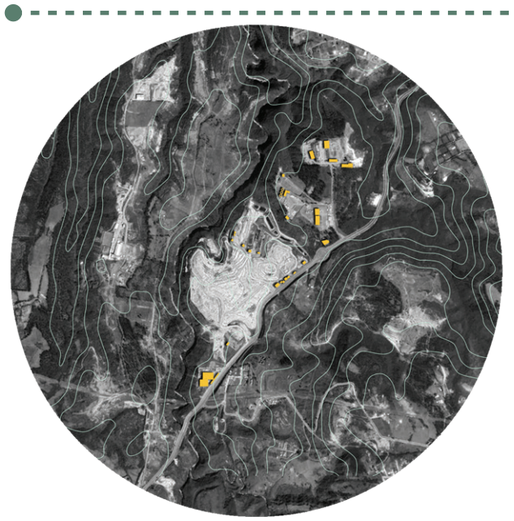


FIGURE 46. SKETCH OF CURRENT SITUATION FOR LOCATION 1. SOURCE: SELF

4.4.2.1.3. Production Yield

Since the area is still operative and is expected to be filled up until the year 2029 (La Hora, 2019), the proposal has been divided in two options. The first option regards the use of the roofs from all the industry in the area until more areas are free for implementation. Option two regards a solar farm where the waste is being dumped and filling the terrain. The solar panels considered for the proposal are Solar Panels from the brand Sun Power, model X series: X21-470-COM, with and efficiency of 21% (Ecotality, 2019) (SunPower corporation, 2019). The commercial size of this Panel is 2067mm x 1047mm which gives an area of 2.16m2. In an average production area of 5000 Wh/m2/day (CONELEC, 2008), and regarding the noted panel efficiency, each panel produces an average of 2268 Wh/day.

Option 1- PV panels in roofs



MAP 34. OPTION 1: PLACEMENT OF PV PANELS IN ROOFS. SOURCE: SELF

Total Area: 17 491 m2

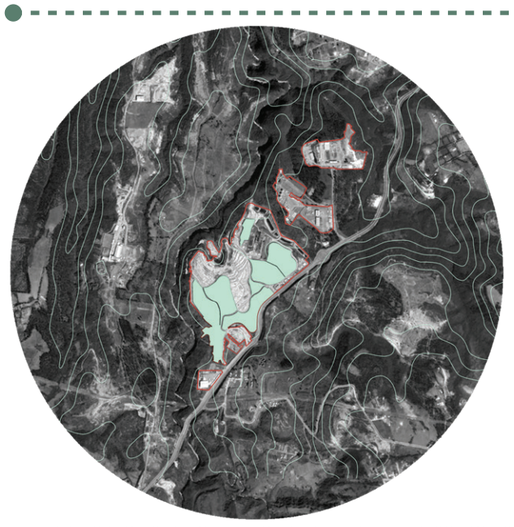
Available area: (10% is taken from the roof area as variable)

15 742.52 m2

Number of Solar Panels: 7287 Solar panels can fit in the roofs

Production: 16 526 KWh/day

Option 2- PV panels in field



MAP 35. OPTION 2: PLACEMENT OF PV PANELS IN FIELD. SOURCE: SELF

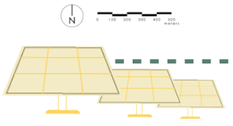
Total Area: 597 402 m2

Available area: (Built area, artificial pools, existing roadways, possible compensation area and 30 % for paths and panel structure are subtracted)

133 040 m2

Number Solar Panels: 61 593 Solar panels can fit in the roofs

Production: 139 692 KWh/day



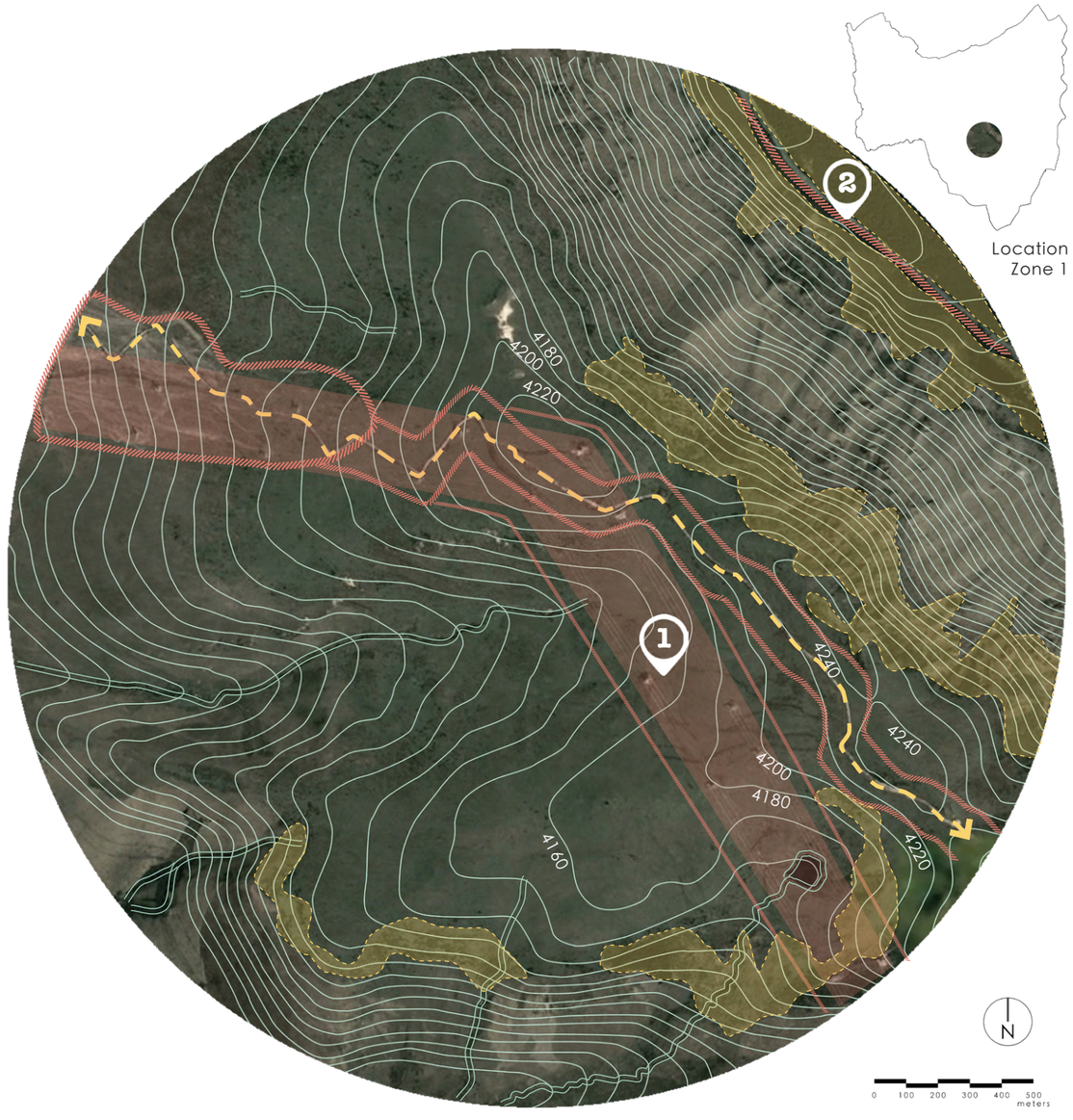
Total production:

156218 KWh/day

4.4.2.2. Location 2

4.4.2.2.1. Area Analysis

Location 2 is an extremely sensitive zone dominated by watersheds and for the purpose of this project, is now considered for Eolic energy production. It lies on a hilltop where a high voltage network has been built to transport the energy from Hydroelectric plants in the Amazon Rainforest, for which an access pathway for trucks already exists.



LEGEND
1 High voltage network
2 Petroleum pipeline path
Water creek
Natural Shrubland Vegetation
Strong existing disturbance
High contamination danger
Access pathway

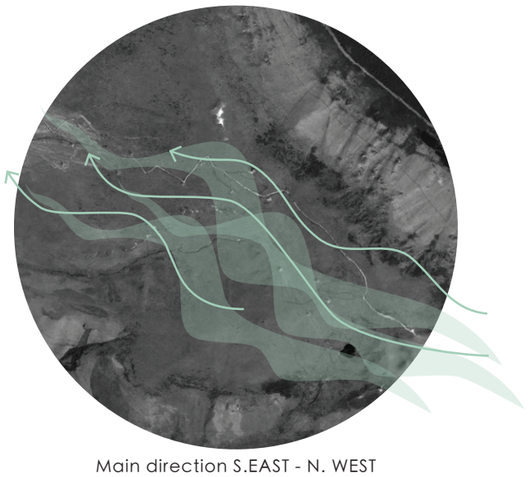
MAP 36. DETAILED ANALYSIS OF LOCATION 2. SOURCE: SELF

In the lower part of the hill the trajectory of the petroleum pipeline is visible. Sensitive watershed vegetation surrounds the site and recollects water from the atmosphere and rain (Carrera, Bustamante, & Saenz, 2016) (Cuesta, et al., 2013, pp. 147-149).

CURRENT SITUATION SEEN FROM NEAREST STREET

FIGURE 47. CURRENT SITUATION OF LOCATION 2. PHOTO. SOURCE: GOOGLE EARTH- TAKEN BY: MACDIEL GANDARA

WIND DIRECTION



Main direction S.EAST - N. WEST

FIGURE 48. WIND DIRECITON OF LOCATION 2. SOURCE: SELF

BUILT AREA

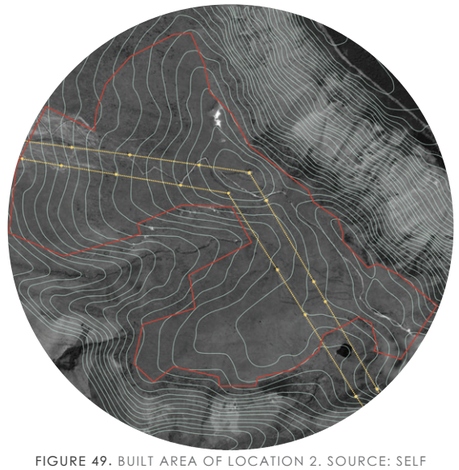


FIGURE 49. BUILT AREA OF LOCATION 2. SOURCE: SELF

Area considered: 3.60 km2

Biggest Waterbody: 8252 m2

Path legth: 3946 m

Disturbed area between towers: 503 457 m2

High voltage towers and cables
Area Limits= The boundaries that are set from the areas that shows less vegetation

4.4.2.2.2. SWOT Analysis

S Strengths

- Area has vegetation that sustains the soil from eroding
- Oil pipeline is downhill from selected site which means constant maintenance and regular revisions
- Hill top provides higher wind access without disruptions and less turbulence

W Weaknesses

- Site located in hilltop means is prone to damaging sensitive panoramic views
- Watershed landscape provides a sensitive soil and vegetation that needs to be protected
- Strong damage has been done to natural landscape by existing high voltage network
- Small and complicated access to the site
- Slow growing vegetation hinders restoration opportunities

O Opportunities

- Previously damaged landscape diminishes the impact of new structures
- Access for truck has already been made
- Proximity to high voltage network eases the network connection for new production

T Threats

- Extreme changing topography can obstruct access and site is prone to earth movements
- Soil erosion is seen in surrounding steep hillsides
- Prone to wind turbulence due to cables of electrical network
- Oil pipeline can cause a spill
- Heavy machinery can easily get buried in moor land due to watersheds

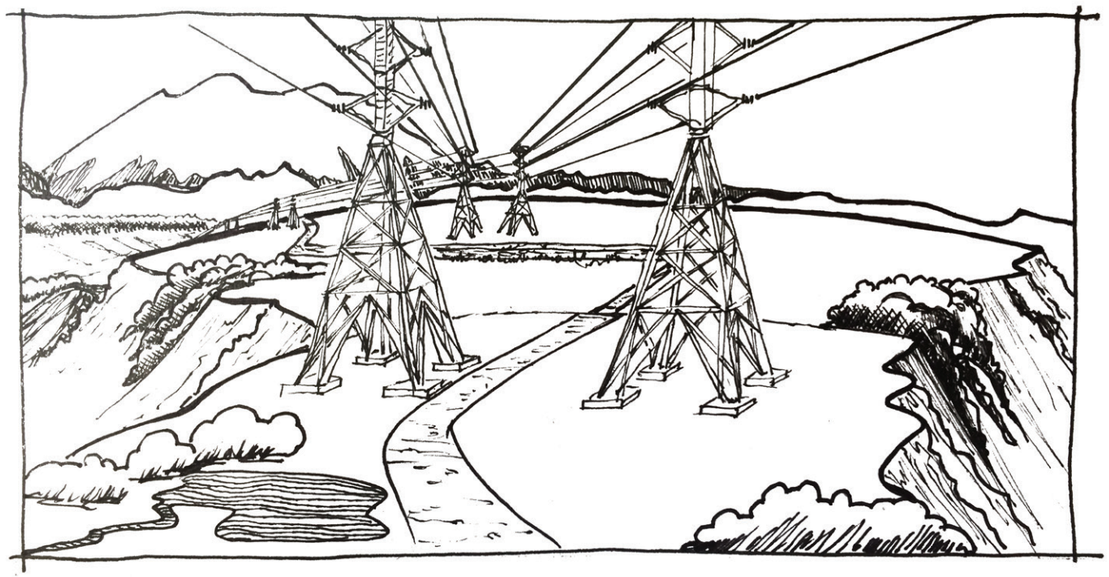


FIGURE 50. SKETCH OF CURRENT SITUATION FOR LOCATION 2. SOURCE: SELF

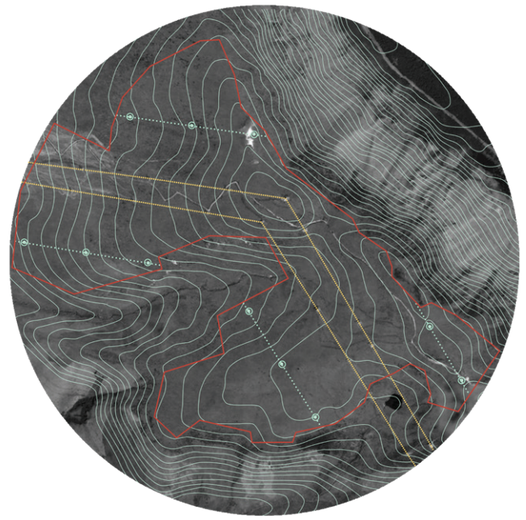
4.4.2.2.3. Production Yield

The space available for the Eolic turbines is limited and therefore the most recent Eolic Turbine models, higher than 200 m with a rotor diameter of approx. 120 m, cannot be considered for this project. Following the recommendations researched in section 4.4, the turbines are located 8 times the Rotor distance from the high voltage network and between each other, meaning that in this zone the options are not cumulative as in the previous case.

This location has an average of: Wind density potential: 650 W/m2

Wind Speed: 9.25 m/s

Option 1- Smaller Eolic Turbines



MAP 37. OPTION 1 FOR PLACEMENT OF EOLIC TOWERS, HEIGHT: 84 M. SOURCE: SELF

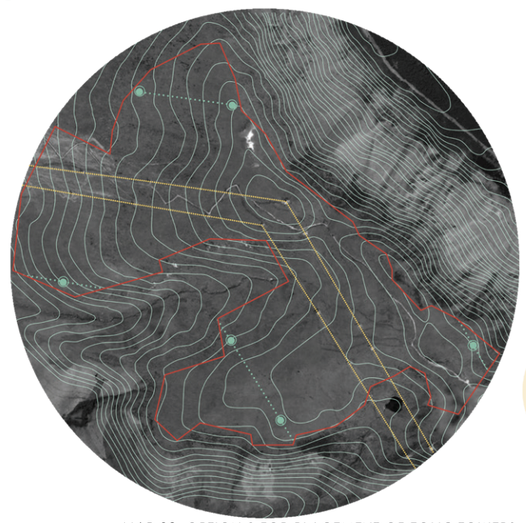
For option 1, the selected Eolic turbine Model is the same as the one used in the Galapagos island of San Cristobal- Ecuador (Case Study A). There is the opportunity of placing 11 towers with the following characteristics:

Brand: Made (Spain)
Model: AE-59
Power: 800 KW
Diameter: 59 m
Gondola height: 50-60 m
Total height: Approx. 84 m
Swept Area: 2734 m2

Production for one tower*:
14 753 075 kwh/year

Total for 11 towers:
162 283 825 kwh/year

Option 2- Larger Eolic Turbines



MAP 38. OPTION 2 FOR PLACEMENT OF EOLIC TOWERS, HEIGHT: 100 M. SOURCE: SELF

The selected model for the calculations of option 2 is taken from the Villonaco Wind Park in Loja-Ecuador (Case Study B). These turbines are placed in an area that offers similar conditions of windspeed and wind density as the study area. There is opportunity of placing 6 towers of the following characteristics:

Brand: Goldwind (China)
Model: GW70/1500
Power: 1500 KW
Diameter: 70.3 m
Gondola height: 65 m
Total height: Approx. 100 m
Swept Area: 3882 m2

Production for one tower*:
21 971 214 kwh/year

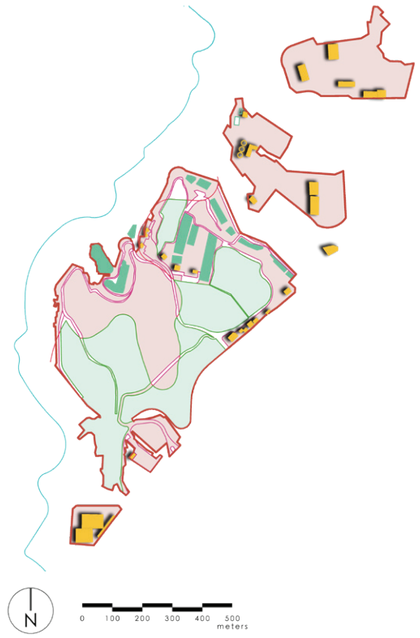
Total for 6 towers:
131 827 284 kwh/year

*PRODUCTION AMOUNTS CALCULATED IN: (HTTP://WWW.RENEWABLE-ENERGY-CONCEPTS.COM/GERMAN/WINDENERGIE/WIND-BASISWISSEN/KALKULATOR-WINDKRAFT-BERECHNEN.HTML)

4.5. Monitoring

4.5.1.Location 1

In R. E. projects, monitoring has to be constant to guarantee the success of the project. It is important to cover technical monitoring as well as anthropological and ecological monitoring. In all cases, recommendations from experts need to be taken into account. Monitoring before the implementation of the project plays an important role given that creates reference data; hence, the data recorded after the implementation of the project will be directly related to the installation and compensation measures can be specifically adapted.



MAP 39. LOCATION 1 MONITORING. SOURCE: SELF

Before the implementation of the project:

Floor stability: Structural research of the area has to be made in random points before placing the structure of PV panels.

Trial panels should be first implemented in random areas of the site to measure onsite insolation and have accurate predictions about energy production.

Violence, criminality and vandalism must be watched. Awareness of specific security levels must be taken into account.

Vegetation areas surrounding the site should be closely watched to understand how the habitats currently work.

Soil monitoring: Soil samples have to be taken; to inform about the current levels of contamination.

Amounts of water runoff and possible contamination to the ravine and river should be clearly known.

After the implementation of the project:

As the site is a landfill, any earth movement has to be noticed to have a timely PV structure reparation if needed.

Monitoring of energy production levels is important, for any changes will symbolize damages on the system.

PV should be kept as clean as possible to maximize production.

Health of cables and electrical system should be routinely monitored.

Insolation measurements should be constant to compare the expected production to real production and keep the system working at the highest efficiency possible.

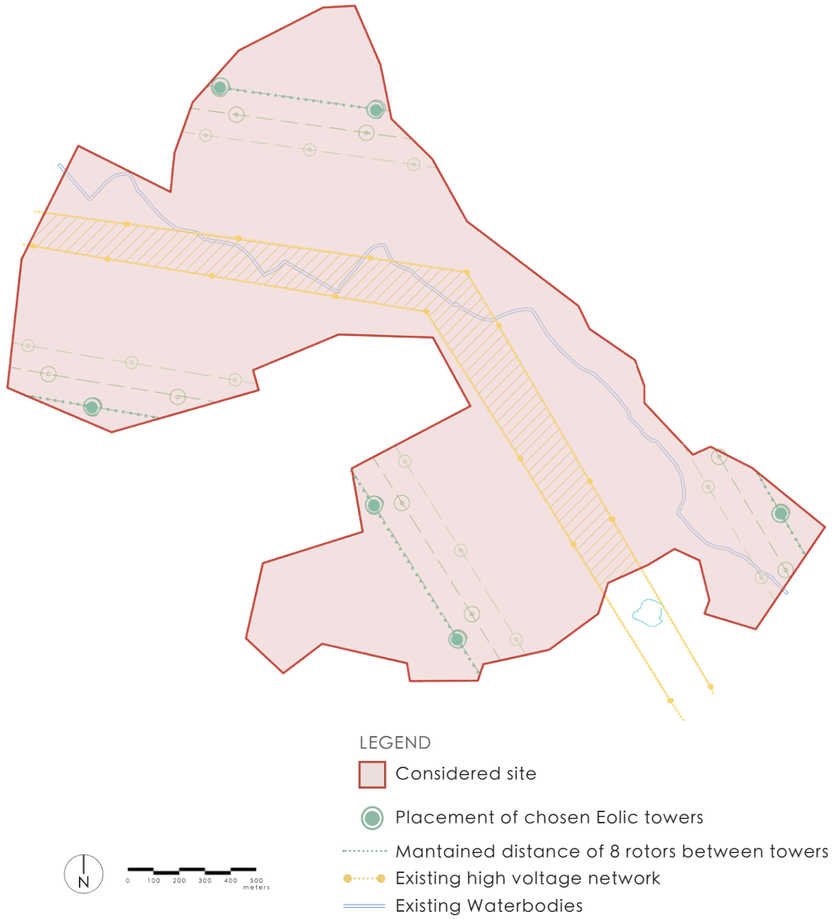
Site boundary should be inspected regularly avoiding breakthroughs and vandalism.

Rain water runoff should be controlled and measured regarding levels of contamination that can be treated before going to the river.

Undergrowth vegetation can be allowed in some areas, but clean and clear paths should provide comfortable access to maintenance of the solar panels; therefore, path maintenance must be done.

Local fauna should be observed and counted as much as possible to notice any behavioral changes and adapt the compensation measurements accordingly.

4.5.2. Location 2



MAP 40. LOCATION 2 MONITORING. SOURCE: SELF

Before the implementation of the project:

Wind monitoring with a trial tower should be done before the towers are placed. This is to determine the specific height of the towers where the highest production yield occurs.

A trial tower measures onsite wind speed and density helping with accurate predictions for the production of the site.

Soil structure and quality are very important to monitor in this site given that is a watershed and an ecological protection area.

Soil monitoring is also important to determine the foundations and best structural construction for the towers since the site has strong slopes.

Condors, bats and other flying fauna has to be closely observed and numbered. The current interaction with the existing high voltage network should be noticed.

Water quality on the watershed must be measured to stablish control data.

After the implementation of the project:

Routine wind-turbine maintenance is required with technicians that check the gondolas for parts that need repair.

Soil monitoring is important to check regarding the interaction with the foundations of the towers and the influence in the quality of soil.

Water creeks should be constantly monitored to ensure the health and quality of the waterbodies.

The base of the towers needs to be under watch to monitor any deaths of flying fauna due to the movement of the rotor.

Compensation measures should be adapted accordingly to ensure healthy surrounding habitats.

The area should also be monitored to be kept free of development, especially informal settlement and agricultural development.

4.6. Public Participation

The most important thing about public participation is maintaining the citizens informed and taking into account their opinions. Development process should be transparent and open, and information should be open and actively shared with the community.

4.6.1. Participation methods

The handbook for participation created by the city of Berlin (Senatsverwaltung für Stadtentwicklung Berlin, 2011), offers a selection of methods that can be used for different types of planning. Based on this information a program with a series of participation methods has been created. This section is a suggestion of which activities could be done with the community before and during the implementation of the project.

4.6.1.1. Goals of public participation

As seen in Ch. 1, the socio-cultural level of Pifo is marked by high levels of poverty; which transfers into high levels of school dropouts from young people that want to start working (Capservs Medios, 2015, p. 53). This means that the public, to whom the methods of participation will be focused, are people with high levels of poverty and low levels of education. Activating the public with different methods and in different stages is fundamental for the success of this proposal. The public participation considers not only sending invitations to the public, but also going to gathering zones of local citizens and bringing the subject to attention. This transfers into the following goals:

Inform the public about the current situation and characteristics of the parish, as well as the sensitivities and strengths of the area, such as the importance of the ravines and the maintenance of the highlands.

Involve the locals as active actors for the development of the parish and not only as observers.

Increase citizens' interest in public affairs.

Stablish community goals by recollecting information about how the citizens want their town to be in the future.

4.6.1.2. Chosen Participation Methods

Because of the size of the project, is recommendable that more than one method is used. Combining the methods in a timely manner can bring the best results long term. Methods should be implemented in such way that citizens will not become involved spontaneously but rather increasingly involved as they get informed.

1 Town hall meeting:

Should be done before all else to inform the citizens about the current state of the parish specially regarding environment and the sensitive areas and endangered species. The possibility of placing R. E. must be an important subject to talk about as well as an explanation of what R. E. are and how do they work. A town hall meeting should be held periodically to keep current information flowing between the community and the local government (GAD).

2 Online dialog:

After the town hall meeting a webpage should be established where "organized and moderated citizen consultation and discussion" can happen. It "acts as a permanent and barrier-free discussion platform" (Senatsverwaltung für Stadtentwicklung Berlin, 2011, p. 327).

3 Activating survey:

To stablish a more direct contact with the residents and increase interest, an open survey should be done. The goal of this method is to "activate respondents. It can raise the concerns of respondents as well as develop perspectives" (Senatsverwaltung für Stadtentwicklung Berlin, 2011, p. 321). The questions should be set regarding opinions about R.E. placement as well as the goals of the community and how people see the parish developing in the future.

4 Agenda- conference:

"Serves to summarize the current state of a process, to take stock of it, to evaluate it, and finally to set targets for the future through concrete action plans" (Senatsverwaltung für Stadtentwicklung Berlin, 2011, p. 321) . The development of the project for R.E. technologies placement should be constantly informing the public of its current state.

5 Round table:

This method is important to solve conflicts that arise and find solutions between experts and different levels of government as well as local representatives. "Ideally, the generated result is highly binding as all stakeholders were actively involved." (Senatsverwaltung für Stadtentwicklung Berlin, 2011, p. 331) .

6 Site inspections:

Once the project is implemented, site inspections with the neighbors should be done to clear doubts and exchange information between experts and local knowledge of the site. According to the handbook of participation, the groups should be manageable and therefore it recommends that a max. of 30 participants per visit are considered. (Senatsverwaltung für Stadtentwicklung Berlin, 2011, p. 328) .

7 Charrette:

At the end of the planning process, the information gathered can be useful for future planning. This method is recommended for initiation of planning and to stablish the next planning steps for different ideas such as a green network connection or more parks in the settlement. "This will enable a high degree of direct involvement of all those who come together in the development of solutions and work towards a compromise." (Senatsverwaltung für Stadtentwicklung Berlin, 2011, p. 224) .

Continuous planning and participation are recommended to reach optimal local government functioning and better planning of public space.

4.6. Public Participation
4.6.2.Citizens cooperation model

R.E. projects require very high investments and the disadvantage for the local and neighboring communities can be discouraging, as for instance, the loss of natural panoramic views. For this reason, is important that the citizens are involved in the advantages that this type of installations can provide, such as economic gain, which is considered besides the long-term gain of having clean energy.

As the case study from Rheinland Pflaz – Germany suggests, is important to create a cooperative where public-private participation is considered. This will increase public acceptance of the project and help the municipality with the expenditures. "Often, municipalities can only manage wind energy projects in combination with strong investors." (Rheinland-Pfalz, 2013). For these reasons a 'Citizens Cooperative' can be a good proposal for this project. Pifo has to consider surrounding communities as well as the areas that are going to be most benefited as well as affected by the project; as shown in the case study, "(…) it is advisable that the property owners, citizens of the surrounding communities or even the communities themselves participate in the operating company of the wind turbines." (Rheinland-Pfalz, 2013).

FIGURE 51. SKETCH FOR COMMUNITY R.E. PROPOSAL. SOURCE: SELF

Therefore, for the type of project this thesis is proposing, it is interesting to consider encouraging local citizens to form an independent company that has a share in the project. This company can act as a private investor that on the project enabling locals to have direct gain from the project. This can increase acceptance within the area as well as increasing likelihood of success. As stated by the Rheinland-Pfalz project, "acceptance of renewable energy projects by local people depends heavily on the sense of justice." (Rheinland-Pfalz, 2013) Hence, it is important that the community and citizens enjoy direct benefits hand have opportunity of involvement in the project, in such way that the gain and burden of such projects is fairly distributed. A clear example can be seen with Eolic turbines, which due to the height, the affected area is larger than in the case of photovoltaic farms; for this reason, more stake holders can be taken into account. This involvement can have a positive effect by increasing the pride and identity of the parish, as is the case of "Community Wind Farm" in Rheinland-Pfalz.

4.7. Outcome SEA
4.7.1. Recommendations

After considering all the alternatives such as PV panels, Eolic turbines and electrolytic hydrogen, the recommendation is that:

1. the solar farm can be implemented first

2. the wind farm afterwards

3. the biomass plant can be implemented in the waste dump where the biogas plant exists and use the renewable energy for the production of hydrogen where energy can be stored.

Solar farm:
Should be implemented in two steps, first in the roofs of the existing buildings, producing 16 526 kwh/day and after the dump finishes its useful life, in the field, producing 136 218 kwh/day with a total of 156 218 kwh/day which means **57 019 570 kwh/year.**

Wind farm:
The area offers space for 6 of the taller towers considered for this project or 11 for the smaller towers. The recommendation would be that the taller turbines are implemented, generating more energy per turbine and less damage to the environment. The production of this option would be **131 827 284 kwh/year.**

Electrolytic hydrogen:
Since location 1 has the proximity to gas storage facilities and the existing biogas plant (EMGIRS EP, 2019), there is the opportunity to use the facilities for energy storage in hydrogen tanks. This proposal is to store energy in hydrogen batteries instead of more common lithium batteries, avoiding contamination due to the materials as well as decreasing the demand of mined minerals.

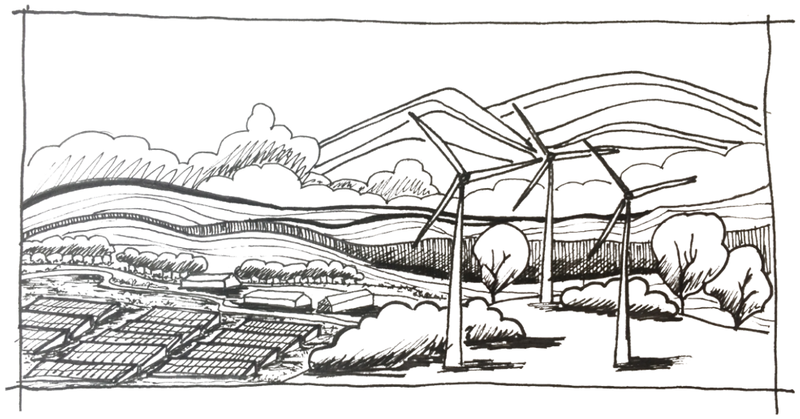


FIGURE 52. SKETCH OF OVERVIEW FOR A POSSIBLE COMBINED SYSTEM OF R.E. PRODUCTION. SOURCE: SELF

After these options have been analyzed by the means of public participation, the project should be established and legally binding for the municipality. Hence, the proposed development plan and the municipal zoning plan should be adapted to represent the proposal of R.E. and the compensation measures, which will be presented in the following chapter.

Location 1- Solar farm and Electrolytic Hydrogen

MAP 41. LOCATION 1- CONCLUSION FOR PLACEMENT OF SOLAR FARM AND ELECTROLYTIC HYDROGEN. SOURCE: SELF

Location 2- Wind farm

MAP 42. LOCATION 2- CONCLUSION FOR PLACEMENT OF WIND FARM. SOURCE: SELF

4.7. Outcome SEA

4.7.2. Summary

With the results of Ch. 2, from which a new objective was set, options of strategic actions where developed regarding R.E. technologies. The selection of locations for these technologies considered variables as accessibility, environment sensitive areas, municipal and local zoning, areas of cultural importance and geography. By overlaying the locations with the regions that offer more production potential, taken from the Ecuadorian Eolic Atlas (Ministerio de Electricidad y Energia Renovable) and Solar Atlas (CONELEC, 2008), the optimal location options were selected, showed in the tables and maps in pp. 73, 78, 82 of this thesis. Priority was given to the areas that have existing disturbance, for which the visual analysis of maps was key to discover unseen opportunities. This way location options 1 and 2 were selected, safeguarding pristine landscapes that have good production potential but haven't been damaged. The SEA analysis has given priority to keep the majority of areas untouched and only apply R.E. technologies where disturbance existed, and compensation measures can only improve the current situation instead of only balancing the project's environmental impact.

4.7.3. Results

Pifo requirements for 2050

50.16 GWh/year

Pifo production of clean energy according to proposal

131.82 GWh/year

RESULT

26.56%

of the energy produced will be used by Pifo in the year 2050

After applying the project as seen in the recommendations, the sum of energy produced will be a total of 131.82 GWh/year in the Wind farm and 57.02 GWh/year in the Solar farm producing an average total of 188.84 GWh/year. The consumption of Pifo for the year 2020 will be, as seen in CH. 2, 27.74 GWh/year; the consumption for the year 2050 will be 50.16 GWh/year. This means that for the year 2050, if the project is implemented, Pifo will produce an average of 376.47% of the energy it needs and will use only an average of 26.56% of the energy it produces. Hence, creating the possibility of increasing the Parishes' income through the possible sale of clean energy. With this prospect the identity of the parish can be enhanced as a production hub, from agricultural production to energy production.

5

Compensation measures and proposal

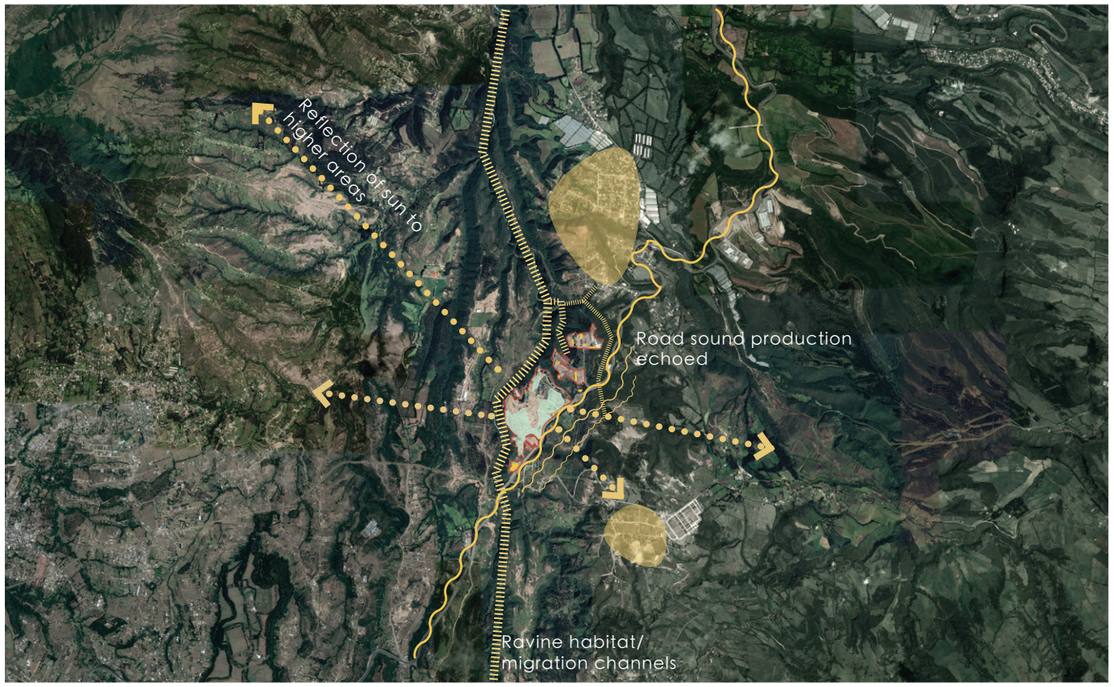
Chapter 5. Compensation measures and proposal

Compensation measures are created to mitigate the impacts of a specific project before it is implemented. The optimal compensation measure for any action is to fully avoid impact on the environment; this is done by analyzing various options before the project is implemented. To find the right compensation measures, the first step is to do an extensive evaluation and find the location option, or type of project, that has less impact in the interaction with its surroundings. “Prediction, evaluation and mitigation/avoidance of a strategic action are the core of a SEA.” (Therivel, 2010, p. 160). As seen the previous chapter, areas with existing disturbance on the landscape have priority for the placement of new projects as are Renewable Energies, since they create the least impact.

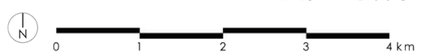
Since the options, of what activities will occur and where will they occur, have been examined in the Ch. 4 choosing PV panels for location 1 and Eolic turbines for location 2, this chapter will consider an individual analysis on how the project will interact with the surroundings. Depending on this interaction, the question this chapter considers is: can the negative impacts be reduced and the positive enhanced?

5.1. Location 1: Photovoltaic farm

5.1.1. Analysis of effects by Photovoltaic panels



MAP 43. ANALYSIS OF EFFECTS BY PV PANELS IN ITS SURROUNDINGS. SOURCE: SELF



Location 1 in relationship to Pifo

MAP 44. ANALYSIS OF WATER RUNOFF IN THE WIND FARM SITE. SOURCE: SELF

5.1.2. Effects: prediction and evaluation

Habitat: On the North-East side of the proposed Photovoltaic farm, runs a deep ravine that preserves a fringe of natural vegetation which acts as habitat and nesting grounds for different types of animals, including the endangered Condor with sightings on the nearby ravines (Alarcón, 2017). Since these ravines run along the territory it is very possible that the remaining fauna uses these spaces as migration corridors. The impact that photovoltaic panels can have on flying species can be similar to the impact that existing flower green houses have, creating a "shy effect" or confusion with waterbodies. In this manner, the impact might be not very significant, but it is still recommendable to be taken into account.

Regarding vegetation, the PV panels could in fact, have a positive impact on the existing conditions. The shadow casted from the panel's installation can protect the soil from the scorching sun of midday (ca. 90 degrees), preventing more desertification and erosion in an already disturbed soil while helping undergrowth.

Sound Production: A first-class road, constantly circulated by heavy trucks, is adjacent to the site acting as a source of sound production. The panels could act as reflectors of this sound, echoing it and possibly increasing its intensity. In the surrounding areas settlements are not very dense and the main land use in agriculture; meaning that the sound produced could be felt more due to lack of other external sound sources but less listeners would be in the surroundings. For this respect there can be an increased social disturbance by decreasing the quality of life and the price of land.

Sun reflection: The area surrounding the proposed PV farm is abundant with higher ridges. The sun reflected on the panels could affect all neighboring areas located in higher altitudes. As seen in Ch. 1, the growth of the city is coming from east to west, and the reflection caused by PV panels could be compared to the reflection of the glass in buildings. This can affect the natural fauna and scare the migrating animals. For the settlement the impact could be less significant due to the lack of density and the similitude to other human-created reflections.

Water runoff: Due to topography, the water in this terrain will have the tendency to concentrate and be collected in the center of the area while it will spread in the sides. This causes that contaminated water will be more challenging to clean since there is less area for it to spread before draining into the river. The danger of this effect is that it can affect the life of native flora and fauna as well as communities downstream.

5.1. Location 1: Photovoltaic farm

5.1.3. Compensation measures and mitigation

MAP 45. DESIGN PROPOSAL FOR LOCATION 1: SOLAR FARM. SOURCE: SELF

5.1.3.1. Proposal

Habitat

Re-naturalization with tall vegetation to increase habitat core

Buffer with natural succession of vegetation

Undergrowth

Sound production

Buffer along road

Placement of Photovoltaic panels not parallel to road

Water runoff

Buffer edge with medium height plants and low height plants

Terraced grassland

Native plants

Soil oxygenation with plants

Sun reflection

No effective measure can be considered

Social compensation and acceptance

Recreation proposal with educational purposes

Allowing grazing for community pasture animals

5.1.3.2. Explanation

Habitat: A proposed renaturation to mitigate the predicted impacts will consist on increasing the existing habitats' core by expanding the tall vegetation of trees and big shrubs; which already exist in the ravine. While expanding this area is important to consider a buffer edge towards the field of PV panels. The buffer edge has medium and lower height plants and follows a natural plant succession from the ravines' tall vegetation; while allowing interaction of species that live in the habitat core and habitat edge (Dramstad, Olson, & Forman, 1996); similar to a more natural condition. This buffer edge is lower in height and won't create shadow on the panels. At last, vegetation undergrowth should be allowed under the panels, with reasonable maintenance but allowing some areas to freely grow prairie plants to thrive and create habitats for insects.

Sound production: The sound produced by the cars on the road cannot be avoided but reflection of the sound waves can be mitigated. A vegetation buffer is proposed between the site and the road, all along the edge to decrease strength of the sound waves. By placing the panels not parallel to the highway, but preferably at an angle, the sound waves can be diverted instead of reflected.

Water runoff: The buffer edge that is considered in the mitigation measure for habitat can be treated and used to treat the water runoff. Is crucial that the buffer edge follows the topography since the natural flow of water will do the same. Where the water is converging due to topography contour, the buffer should be larger (Bentrup, 2008). A grass wetland is proposed for this area so that it helps the water spread, increasing buffer productivity and avoiding erosion. Since the site processes contaminated water, it is recommended that this grassland is designed in terraces so that the water can be oxygenated while running downhill. A natural plant succession is also recommended; therefore, a medium height buffer with native plants and shrubs is proposed. The buffer would work better if the plants used are selected regarding their cleaning capabilities and help oxygenate the soil.

Sun reflection: Near the PV panels only low vegetation can be placed in such way that it doesn't reduce the effectivity of the panels. Therefore, sun reflection cannot be mitigated but compensation measures can be considered attempting social equality and acceptance.

Social and acceptance: To reach community acceptance and attempt social equality, the proposal suggests social compensation measures. The recommendation is to create a recreation walkway area within the buffer which includes a viewing platform and offers educational opportunities. This takes advantage of the wonderful landscape view that the location offers and creates the opportunity to learn about the importance of natural habitats as well as sustainability and renewable energy. Considering that many households have pasture animals, it would be interesting to allow the small animals from the neighboring community to graze between the panels, additionally helping with maintenance and reducing costs.

5.1.4. Design suggestion

The proposal combines ecological enhancement as well as recreation possibilities. A pathway that runs within the proposed ecological buffer and connects different views can be used by locals. A viewing platform that opens up the landscape of the ravine and its specific fauna can be connected to the pathway, so that local citizens can do sport and relaxed activities; using the space and respecting the surroundings simultaneously. Monitoring should be done, as well as further details developed to avoid problems with trashing and vandalizing; most importantly securing the wellbeing of the solar panels and the surrounding vegetation.

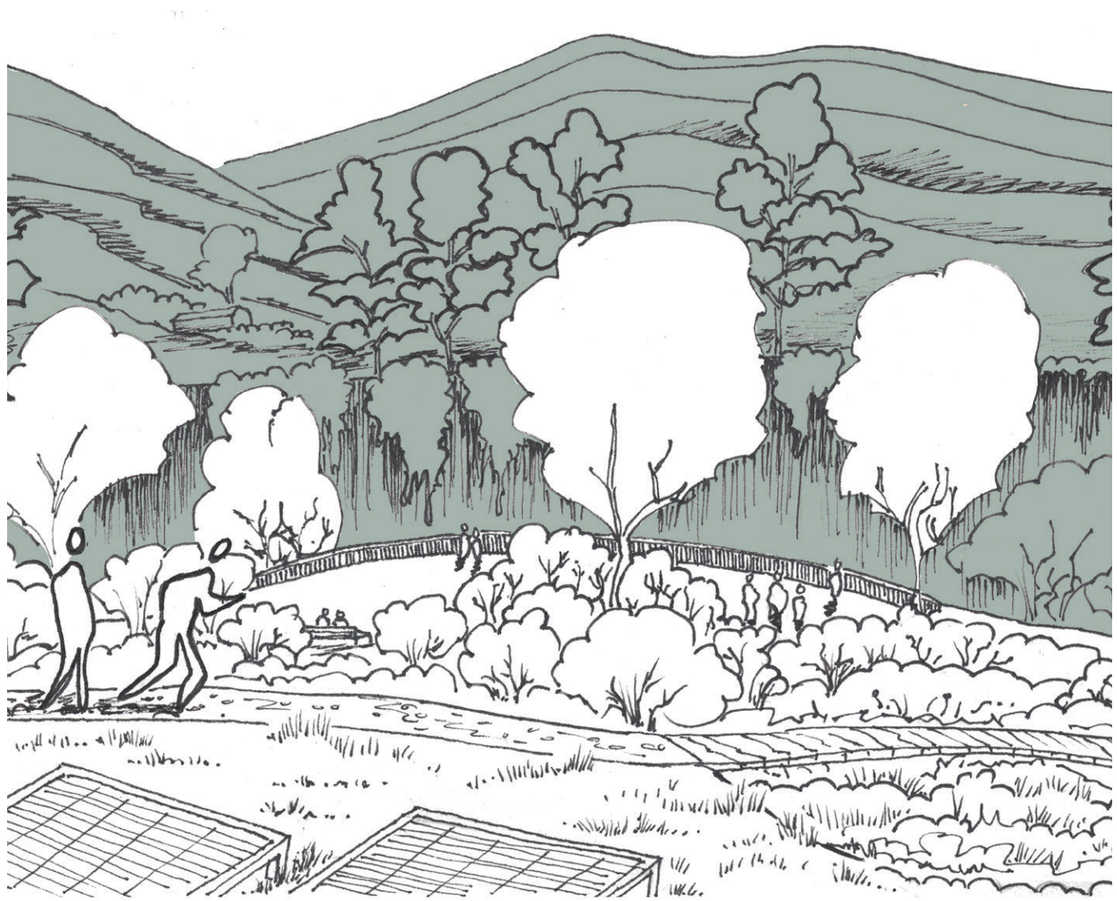
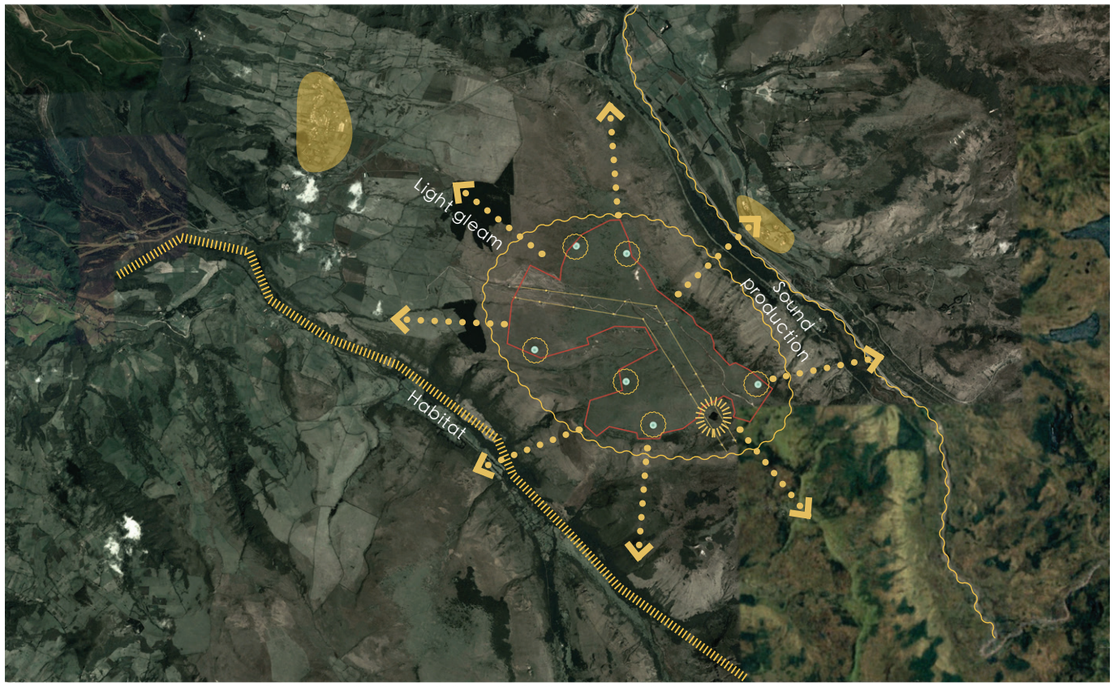


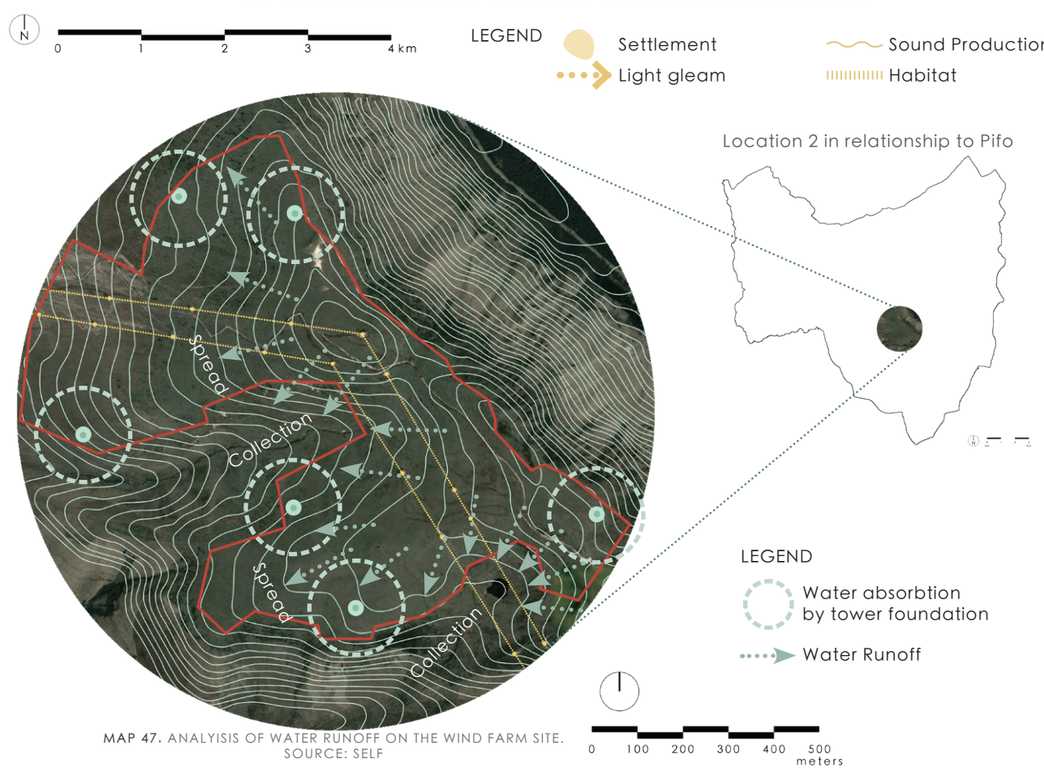
FIGURE 53. SKETCH. DESIGN PROPOSAL FOR LOCATION 1: SOLAR FARM AND RECREATION TRAIL PROPOSAL. SOURCE: SELF

5.2. Location 2: Wind farm

5.2.1. Analysis of effects by Eolic towers



MAP 46. ANALYSIS OF EFFECTS BY EOLIC TOWERS ON ITS SURROUNDINGS. SOURCE: SELF



MAP 47. ANALYISIS OF WATER RUNOFF ON THE WIND FARM SITE. SOURCE: SELF

5.2.2.Effects: prediction and evaluation

Habitat:

The ecosystem of the area is characterized by “Subnival evergreen shrubland of the highlands” as seen in Ch. 4. As shown in the “Ecosystem classification system of Ecuador” (Ministerio del Ambiente del Ecuador, 2013), this is not a very common habitat. Is characterized by a topsoil layer of 30-50 cm depth and vegetation that grows between 0.5- 1.5 m tall, specially adapted to fast and extreme changes of temperature and moisture levels (Cuesta, et al., 2013, pp. 147-149). For this reason, the fauna in this area could be scarce and not utilize the area often. It is recommended that further observation in the subject be done by experts; specially since a spectacled bear with its cub has been spotted in the surroundings (García, 2015); even though this area does not classify as this endangered species’ protected corridor (Carrera, Bustamante, & Saenz, 2016, pp. 22-25). The ravine in the South-East side and around the waterbody could show more fauna interaction.

The Eolic towers could interfere and pose a threat to flying animals such as condors and bats, but more observation and monitoring is recommended since little information on the subject has been found.

Sound Production:

Two small settlements with very low density are located near the area with a distance of approx. 1.5 km to the Eolic turbines. In this case the principle of distance range of 10 times the height of the turbines to the nearest settlement is respected. Regarding fauna, the closest habitat corridor is less than 1km away and the sound could cause problems in the sensitive hearing of animals such as the wolf or the bat.

Light gleam:

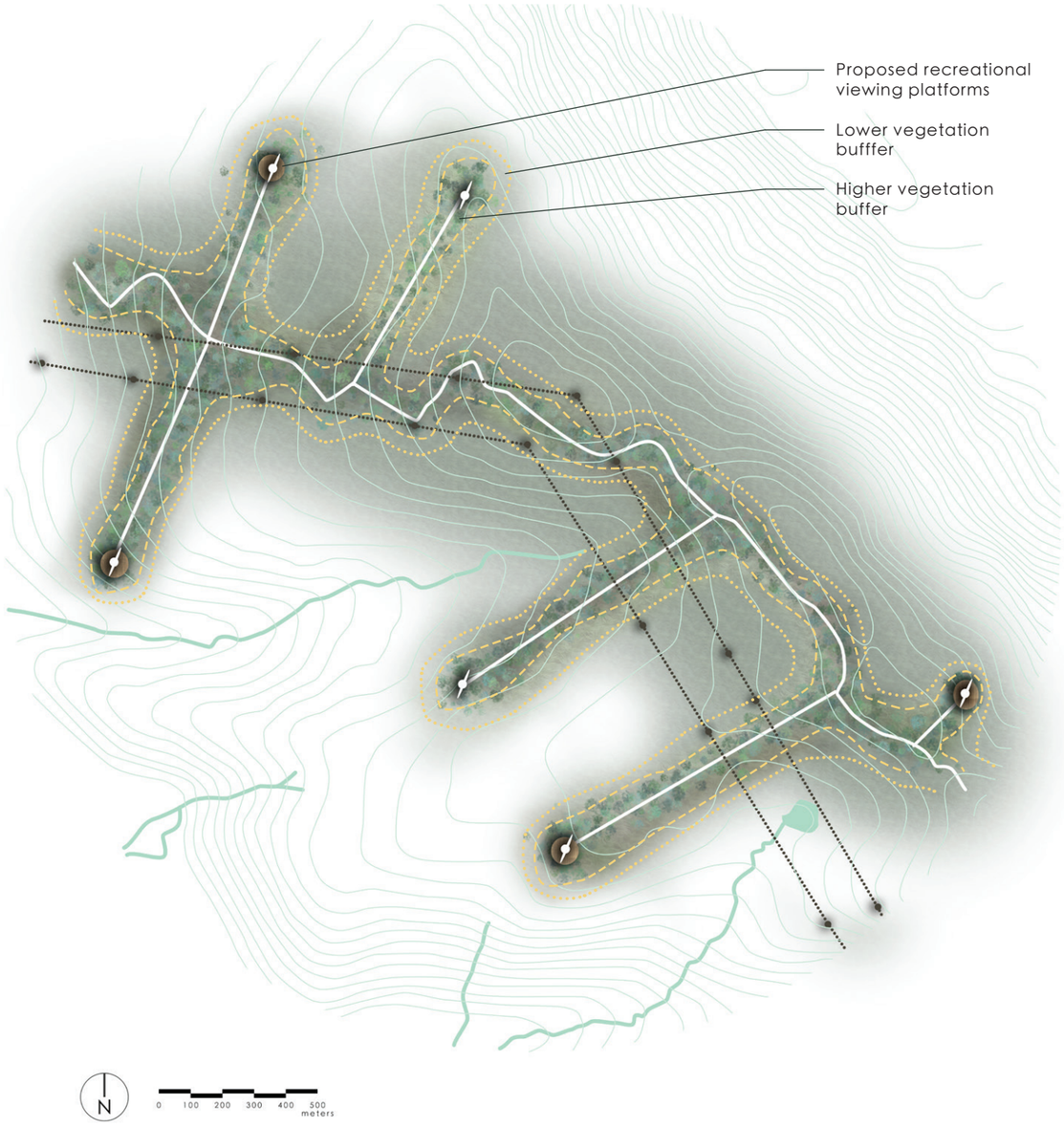
The aproach to the Quito airport is far away, but the Eolic turbines have a blinking light as a regulation. This can disturb the nearest settlements, the neighbors and animals. It risks ruining the pristine view of the landscape at night time. This type of disturbance can be poorly diminished; therefore, other sites should be explored for implementing compensation.

View:

Currently, the existing high voltage towers can be seen from the lower parts of the parish as well as from some parts of the city of Quito. This will also be the case of the wind turbines, and as stated in the case study of Rheinland-Pfalz “due to the size of the wind turbines, interference with the landscape cannot be regularly compensated” (Oberste Baubehörde im Bayerischen Staatsministerium des Innern, für Bau und Verkehr, 2019).

Water absorption by tower foundations:

the area is distinguished as a watershed. Foundations for these structures require a fair amount of concrete which can cause contamination problems in addition to absorbing a high amount of ground water and risking compaction of the soil on this site. Since this area has already been disturbed and built on, the disruption on the landscape is not new; besides, as seen in Ch. 3, the entire highland area of the parish is full of watersheds. Still the condition should be diminished as much as possible and enhanced, attempting to keep its quality.



MAP 48. DESIGN PROPOSAL FOR LOCATION 2: WIND FARM. SOURCE: SELF

5.2.3.1. Proposal

Habitat

Buffer constructions with ecosystem vegetation

Natural plant succession for buffer

Maintain natural vegetation as much as possible

Sound production

Abide by the 10 H rule proposed in the case study of Rheinland-Pflaz

Water absortion

Native plants buffer around constructions, especially around tower foundations

Light gleam and view

No real mitigation that creates an effective impact is possible

Social compensation and acceptance

Viewing platforms

Sustainable tourism

Citizens cooperation model (public participation)

5.2.3.2. Explanation

Habitat: The proposed area has a very sensitive ecosystem that is not very abundant and is composed of scattered shrubs and grasses between 0.5 and 1.5 m tall (Cuesta, et al., 2013, pp. 147-149). The mitigation proposal is to do a buffer along the access road considering that approx. 100 m at each side of the road as a distance of affectation; distance which should be reviewed by experts such as biologists and ecologist to confirm the distance is enough for diminishing the effects as much as possible. The buffer should follow a natural plant succession having the taller shrubs along the road and then native grasses towards the existing vegetation, always remaining as close to the road as possible, since buffers work better the closest they are to the disturbance source (Bentrup, 2008, p. 21). Monitoring should be done regarding birds and bats, since this type of buffer could promote nesting and is probable that the vegetation choices should be limited to the lower species, such as native grasses and small shrubs. Further precautions regarding soil damage should be considered during the construction.

Sound production: By abiding to the 10H rule recommended in the case study of Rheinland-Pfalz (Rheinland-Pfalz, 2013), the nearest communities should be safeguarded from any sound production. This action needs to be monitored after implementation as well as the growth of the settlement.

Water absorption by tower foundations: By creating mitigation to the habitat and planting a buffer with native plants, adapted to the site, the proposal attempts to help the soil keep its natural humidity. These plants help keep the wetlands by capturing humidity on the leaves and branches and transferring them to the soil (Carrera, Bustamante, & Saenz, 2016, pp. 16-17). For this reason, is important that the buffer encircles the Eolic towers, also following a natural succession of shrubs and grasses.

Light gleam and view: Because of the height of the towers, there is little or none mitigation possible for these disturbances. Therefore, is important that social compensation measures are considered to increase acceptance.

Social and acceptance: several compensation measures to the community can be considered. Referring to the goals of the community seen in Ch. 2, a sustainable tourism hub can be promoted in this area with controlled access. The area offers a privileged hilltop location that can be used for tourism. This proposal considers that the access roads could be open to “on foot” visitors and controlled tourism while taking advantage of the Eolic towers; building viewing platforms on the towers for activities such as bird watching. Controlled sustainable tourism should be monitored since disturbance by people is more consecutive as normal maintenance disturbance; creating noise and movement that can scare the fauna. Another type of compensation is considered on the public participation section, where the community has a part ownership of the energy production in a “Citizens cooperation model”.

By providing a viewing platform, the project can aid sustainable tourism and help keep the surrounding landscape pristine. The paths created for the implementation and maintenance of the Eolic towers can provide access to observation platforms; these provide viewing access to the rest of the landscape limiting the need of physical access therefore, protecting from further damaging. The proposed buffer for mitigation of damages that surrounds the paths, also helps keep the tourist constraint to an accessible area while protecting the rest of the natural landscape and keeping it untouched.

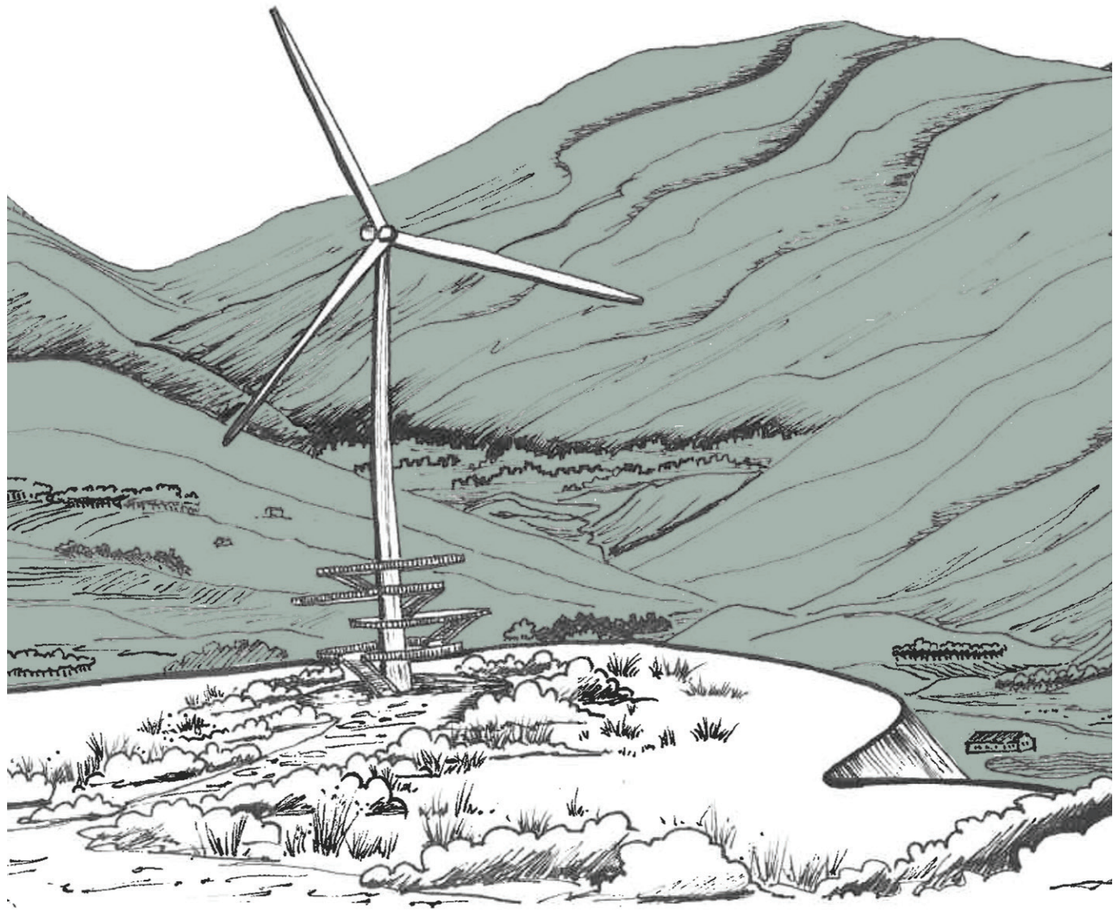


FIGURE 54. SKETCH. DESIGN PROPOSAL FOR LOCATION 2: WIND FARM AND VIEWING PLATFORM PROPOSAL. SOURCE: SELF

6

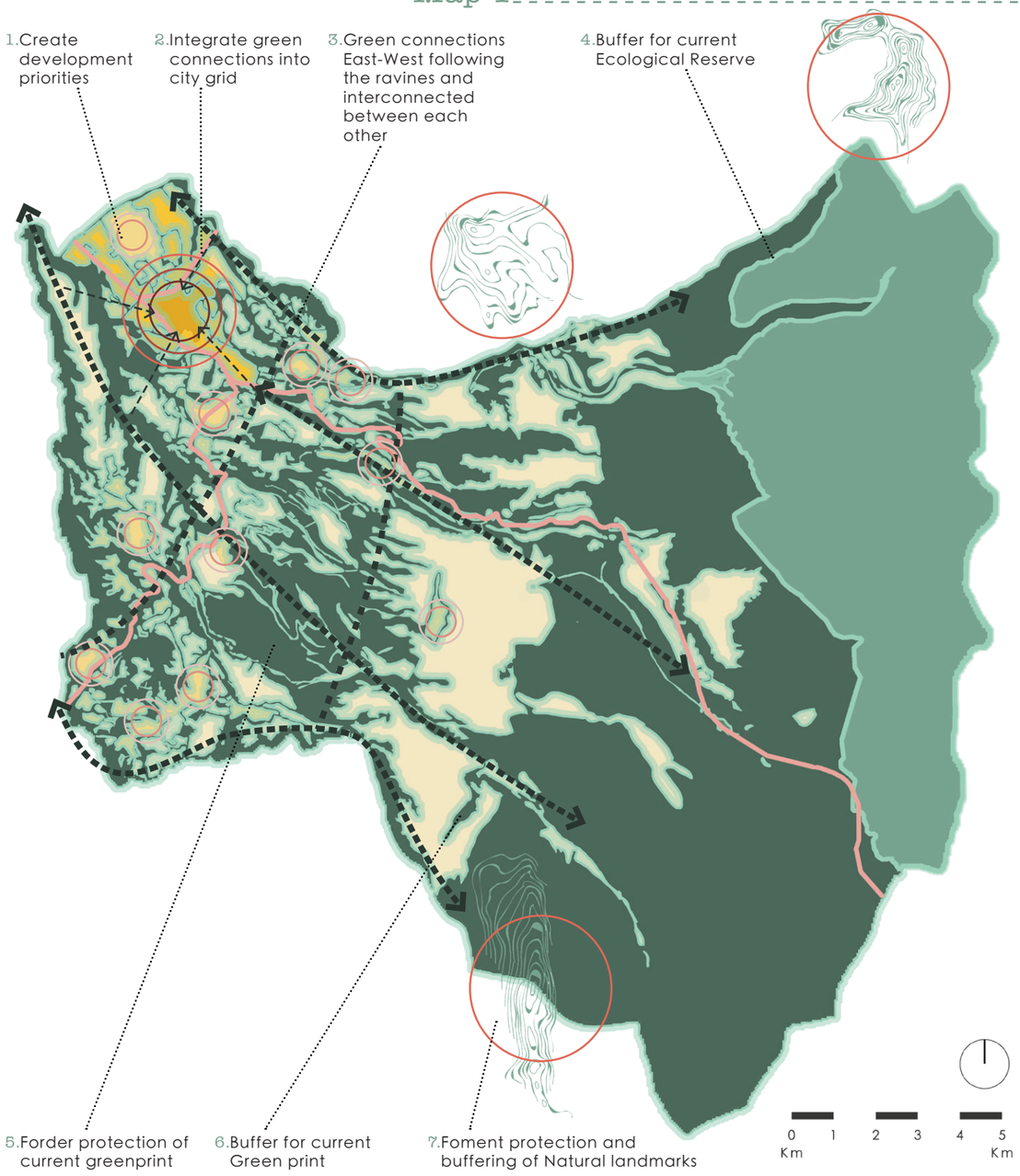
Recommendations

Chapter 6. Recommendations

The information gathered previously in connection with the R. E. proposal, provide the opportunity to create recommendations for the master plan. These recommendations can be used in the future by the local government as suggestions that can guide future development.

6.1. Master plan recommendations

Map 1



MAP 49. RECOMMENDATIONS FOR THE MASTER PLAN OF PIFO. MAP 1: DEVELOPMENT AND GREENPRINT. SOURCE: SELF

6.2. Smart growth recommendations

The recommendations for the master plan respect the zoning and land use proposal made by the Pifo GAD (local government) but include the R.E. proposal made for this these as well as the information gathered for the SEA such as the visual analysis. These recommendations give priority to the environment of the parish while maintaining current uses.

The following recommendations have been adapted from "The Smart Growth Manual" (Duany, Speck, & Lydon, 2010), by applying the information previously gathered from the SEA research as well as complying to various goals from the local government.

1. Create development priorities:
Pifo central town can be densified by creating an 'intended growth' city core. Controlled growth should happen only surrounding the core and restricted growth near agricultural zoning. The rest of the parish could be a no-growth area where the green print is protected.

2. Integrate green connections into city grid:
Integrate green connections into city grid: Encouragement of city green and recreation areas can double up as habitat corridors besides embellishing the town.

3. Green connections:
Ravines should be protected and resorted as East-West green corridors for native fauna. Likewise, they should be buffered and interconnected to avoid income of polluted runoff into the waterbodies and promote a healthy habitat core with high diversity. Eventually green connections should match with neighboring areas and higher levels of planning.

4. Buffer current ecological reserve:
A buffer for the reserve can ensure its protection from irregular development.

5. Protection of current green print:
By identifying the current green print and having a register of species and sensitive areas, protection of this zone and smart planning can be stimulated.

6. Buffer current green print:
Renaturation of adjacent areas from the current green print can help the habitats expand over time.

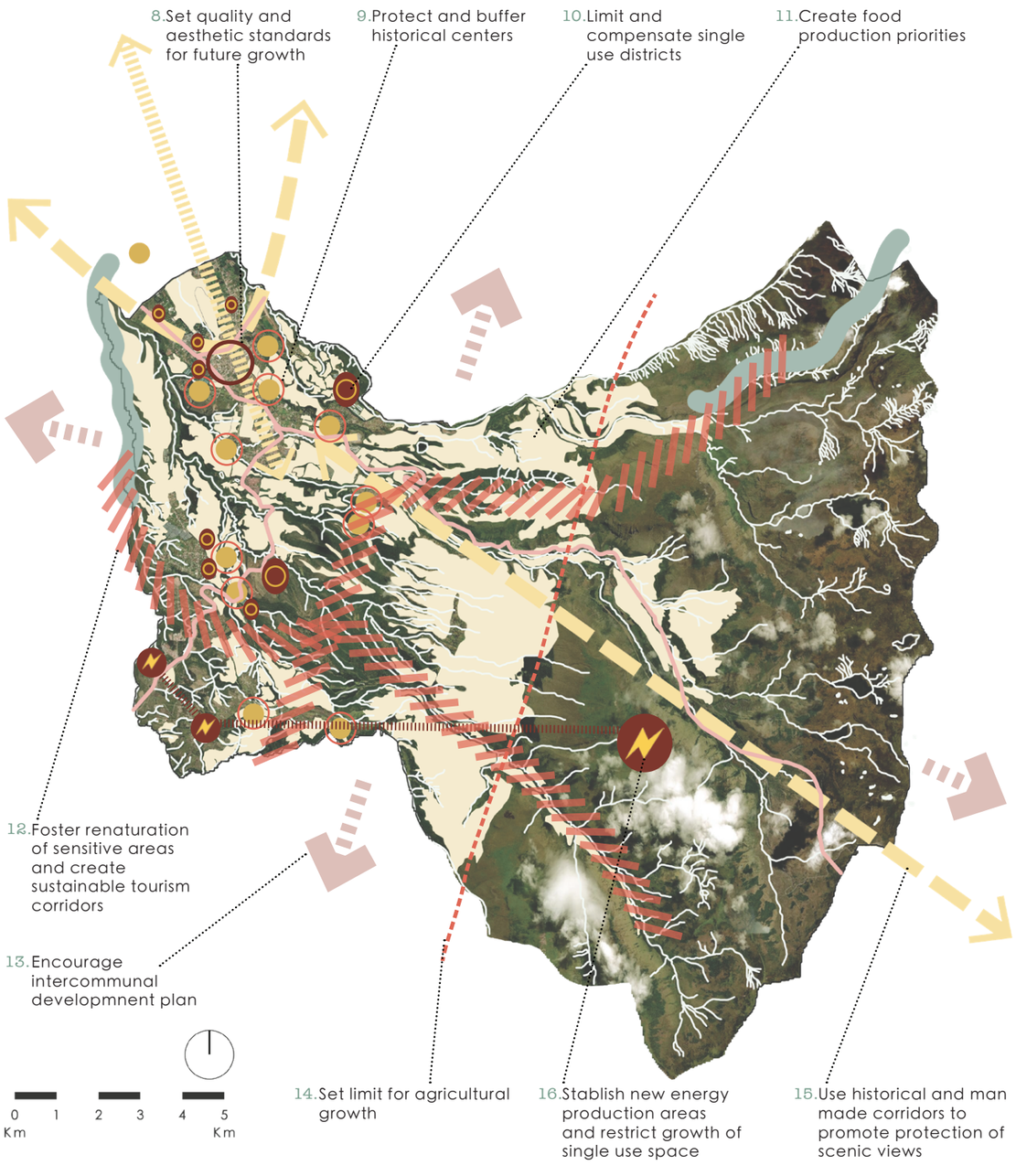
7. Foment protection and buffering of Natural Landmarks:
Habitats can be protected, additionally, sustainable tourism stimulated by guaranteeing the health of landmarks.

6.1. Master plan recommendations

6.2. Smart growth recommendations

From the gathered information there is also the possibility to make recommendations regarding programs and policies, that can help the parish flourish and meet goals as for example create jobs and promote sustainable tourism.

Map 2



MAP 50. RECOMMENDATIONS FOR THE MASTER PLAN OF PIFO. MAP 2: POLICIES AND PROGRAMS. SOURCE: SELF

8. Quality and aesthetic standards for future growth:
Identifying architectural and biological heritage within the town, can help preserve the identity of the place as well as fomenting new development that harmonizes with this identity.

9. Protect and buffer historical centers:
tourism can thrive in the future if the historical centers of the parish are identified, restored and buffered from new development.

10. Limit and compensate single use districts:
Space for necessary single use districts such as factories, greenhouses and warehouses, between others, should be limited and compensated as much as possible to avoid social and ecological fragmentation.

11. Create production priorities:
Protecting and giving incentives to small and medium agricultural producers and creating an 'only local' market can propagate the consumption of local product decreasing carbon footprint.

12. Renaturation of sensitive areas:
Sensitive areas such as watersheds and new green corridors can be encouraged boosting areas of natural habitat and possible sustainable tourism corridors.

13. Intercommunal development plan:
coordinating and exchanging ideas and programs with neighboring communities, can create a ripple effect and foster stronger sustainable development of the region.

14. Limit agricultural growth:
By setting a physical limit to agricultural growth in the master plan, unregulated spread can be controlled, and existing spread can be slowly reintroduced to the protected area.

15. Historical and man-made corridors to promote protection of scenic views:
Man-made corridors can be protected from sprawl and also be valuable touristic landscape.

16. Stablish new energy production areas:
New created areas such as the proposal recommended by this thesis should be stablished in the master plan avoiding unwanted development in the area and single use space, as recommended in section 4.5. of this thesis: Monitoring.

7

Conclusion

HTTP://WWW.PIFO.GOB.EC/WEB/INDEX.PHP/CONTENIDO/ITEM/HISTORIA

Pifo is a Parish that has much to offer, and by doing a comprehensive planning for sustainable practices, the area and the citizens can progress and increase their quality of life in a healthy environment.

7. Conclusion

By implementing a model of Renewable Energy production, where the local citizens and the environment are taken into account as the main actors, the parish can change the current path of growth to a more inclusive, sustainable and self-empowered development. The earnings created by the proposed project can also grant the parish financial independence; hence, growth can be guided and focused towards local improvements; opposite to the current situation where higher levels of government impose patterns of development that do not fully benefit the citizens.

If a combined model of Renewable Energy production is introduced in the parish, as this thesis proposes, the area can produce approximately 131.82 Gwh/year while consuming only 26%, even with the population growth foreseen for the year 2050; having spare energy to distribute to the rest of the region. This empowers the area and changes its current economic model as well as the pattern of development in a way that better zoning can be achieved, regulating the fulfillment of goals from higher levels of government in a way that promotes social justice and equality. Furthermore, identity and pride are boosted when, through these changes, the quality of life and economic situation of the local citizens improve. The proposal creates recommendations of smart growth that can help the parish accomplish various goals set by the local government in the development plan (PDOT) while maintaining and enhancing natural vegetation and habitats.

To find these results, the greatest possible number of variables available at the time of this thesis were taken into account. A combination of maps, such as the maps delivered by the local government (GAD) and self-developed maps, were used to broaden the options for possible placement of renewable energy technologies while seeking the least harm to the environment. For the unavoidable disturbance, mitigation and compensation measures are suggested. Creating areas of re-naturalization that can double as recreation areas combined with environmental enhancement. Opening the area for the use of locals increases the chances of project acceptance by the community. This proposal also guides the government to educate the citizens on environmental issues, increasing awareness about the importance of caring for the local habitat. This education can also allow new opportunities for local sustainable business, entrepreneurship and research, having a broad ripple effect in the future.

Unfortunately, through the course of this thesis, the local government went through elections and the communication with the contacted representatives was broken. However, the methodology applied is a flexible instrument that can offer the opportunity of combining mindsets and stakeholders, to broaden options for the project. By considering public participation as proposed, more possibilities can come to light as local knowledge is taken into account. The importance of participation is, not only to activate the community in development topics, but also the learning process that public engagement offers.

Although much research on the area still needs to be done by experts, such as ecologists and biologist, many findings, help this project infer that this area is important for the migration patterns of fauna and the maintenance of flora between the Eastern and Western Andes mountain range; as well as the ecosystem connections between the Andes and the Amazon rain forest. Understanding these important habitats and the sensitivity of such environmental networks, while additionally considering broader points of view and local interests, is as important for the planners as it is for the government and the citizens. Therefore, the project includes a set of recommendations that intertwine economical, ecological and development priorities, while focusing on the implementation of R.E. technologies.

The analysis for this thesis is centered in environmental and development information, although, as mentioned before, much environmental research of the region should still be done by local institutions adviced by experts. Encouraging and supporting the young generations to develop new research of R.E. technologies and sustainable practices could be fostered, encompassing different models of education, where new proposals and technologies can be developed. Therefore, planning for new programs and the adjustment of policies to the changing situation must remain always flexible, while aiming towards smart growth practices and the care of the environment.

Growth of settlement, agriculture and industry must be controlled and regulated while increasing the space of ecological reserve and protected areas. Placement of R.E. does not happen independently from the site, thus, this proposal should be combined with the increased awareness of political and private management practices, such as waste handling in the municipal landfill and care for current green print on the highlands, where this thesis considers its options of R.E. placement.

By increasing awareness and caring for the local environment and habitats, good landscape stewardship is fomented, in a way that “think globally, act locally” turns into “think locally, act individually”. The responsibility and appreciation that locals have for their home town can have an important supporting role in the search for smart and sustainable growth. For such projects, the local government (GAD Pifo) should be the main administrator, behaving as mediatory force between international stake holders, higher levels of government and local citizens; and organizing all the development that this project can generate.

Applying the proposed practices, the parish and its inhabitants become active with the development of their own region instead of being victims of the growth and sprawl of larger cities such as Quito. Energy and economic independence for Pifo, while caring for the environment and giving priority to habitat preservation are part of the benefits that this project can accomplish if implemented.

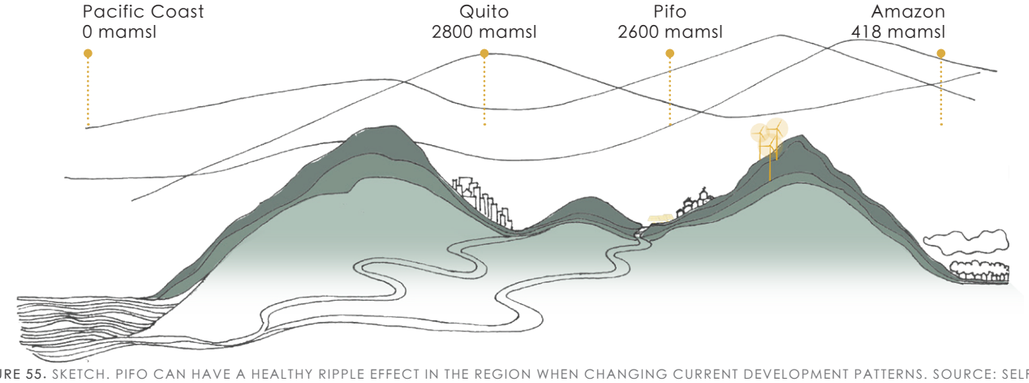


FIGURE 55. SKETCH. PIFO CAN HAVE A HEALTHY RIPPLE EFFECT IN THE REGION WHEN CHANGING CURRENT DEVELOPMENT PATTERNS. SOURCE: SELF

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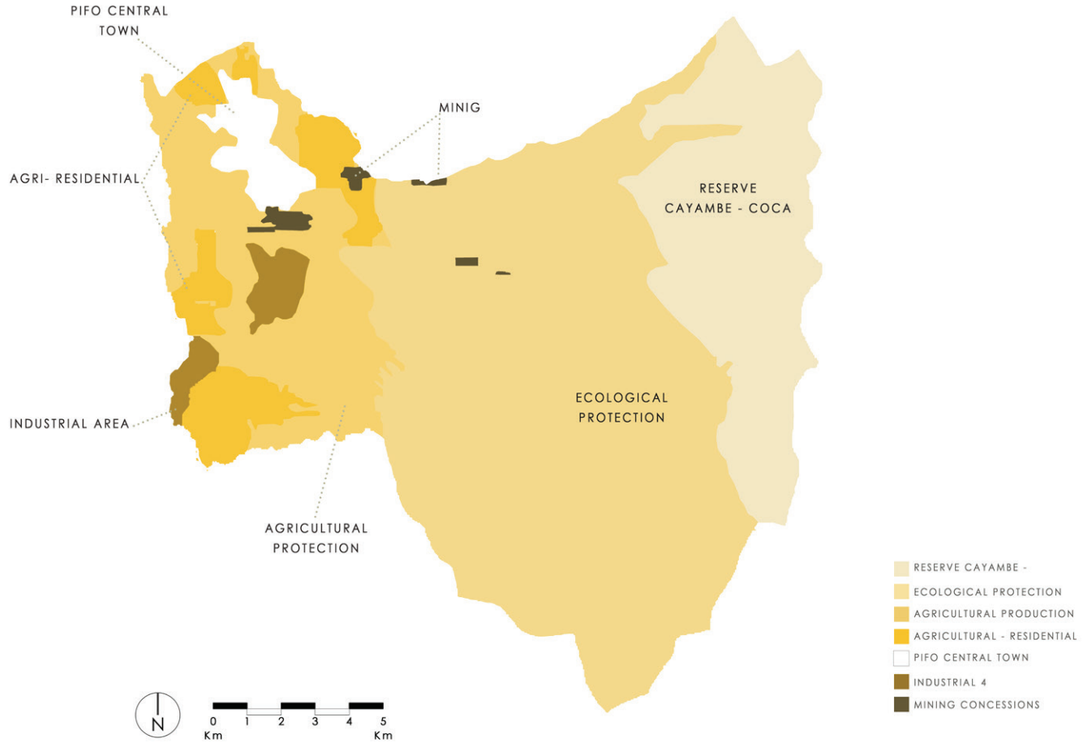
Annex 1: United Nations Sustainable Development Goals

	SUSTAINABLE DEVELOPMENT GOAL	TARGETS	COMMENTS
GOAL 7	AFFORDABLE AND CLEAN ENERGY- Focusing on universal access to energy, increased energy efficiency and the increased use of renewable energy through new economic and job opportunities is crucial to creating more sustainable and inclusive communities and resilience to environmental issues like climate change.	TARGET 7.A By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology TARGET 7.B By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programs of support	By the placement of Renewable Energy technologies in medium to small scale, in a way that does not dominate the landscape picture, can increase interest, research and knowledge of the local citizens towards R.E. Collaboration and ownership of small projects can also encourage good stewardship and facilitate access to energy, creating more justice and equality. The local government can also have independent relationships to the international community as well as to the national government and to neighboring local governments.
GOAL 9	INDUSTRY, INNOVATION AND INFRASTRUCTURE- Technological progress is the foundation of efforts to achieve environmental objectives, such as increased resource and energy-efficiency. Without technology and innovation, industrialization will not happen, and without industrialization, development will not happen. There needs to be more investments in high-tech products that dominate the manufacturing productions to increase efficiency and a focus on mobile cellular services that increase connections between people.	TARGET 9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all TARGET 9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries TARGET 9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities TARGET 9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	Encourage local research and development of new technologies that use local materials, that can be recycled in the future once infrastructure is dismantled. This type of technological development cares for the environment and even helps improve and enhances the current state of the location. Infrastructure that encourages good stewardship on the locals due to their involvement in the projects as active individuals. Private industry must also take part on this active role and be part of the community, not only producing technology for themselves but also for the community they are located on. E.g. Photovoltaic panels in the roofs of private houses and of private industry that provides to the public network.
GOAL 11	SUSTAINABLE CITIES AND COMMUNITIES- Rapid urbanization challenges, such as the safe removal and management of solid waste within cities, can be overcome in ways that allow them to continue to thrive and grow, while improving resource use and reducing pollution and poverty.	TARGET 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management TARGET 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities TARGET 11.A Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning TARGET 11.B By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	A smart growth plan that focuses on the implementation of renewable technology as well as in the quality of open spaces and maintenance of sensible ecological areas. Its important to note that the customs and identity of the place have to be understood and sustained. Imposed external solutions for local problems do not work correctly.
GOAL 12	RESPONSIBLE PRODUCTION AND CONSUMPTION- is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty.	TARGET 12.1 Implement the 10-year framework of programs on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries TARGET 12.2 By 2030, achieve the sustainable management and efficient use of natural resources TARGET 12.A Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	Local jobs can be created when local technology is developed and collaborative research centers are placed in the locality. With involvement of the citizens there is also an education and conscientization process that helps achieve the goals. Besides, by prioritizing local and seasonal production and strengthening the local economy long term objectives can be achieved.
GOAL 13	CLIMATE ACTION- Take urgent action to combat climate change and its impacts: Affordable, scalable solutions are now available to enable countries to leapfrog to cleaner, more resilient economies. The pace of change is quickening as more people are turning to renewable energy and a range of other measures that will reduce emissions and increase adaptation efforts (...) countries adopted the Paris Agreement at the COP21 in Paris, which went into force in November of 2016. In the agreement, all countries agreed to work to limit global temperature rise to well below 2 degrees Celsius	TARGET:13.2 Integrate climate change measures into national policies, strategies and planning TARGET: 13.A Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	Reducing emissions also happens with the planning of high quality open space, new local jobs and recognizing the price of social and environmental intervention; not only economical assistance and involving the local governments, but also caring for the citizens and educating about the international agreements and goals.
GOAL 17	PARTNERSHIPS FOR THE GOALS- A successful sustainable development agenda requires partnerships between governments, the private sector and civil society. These inclusive partnerships built upon principles and values, a shared vision, and shared goals that place people and the planet at the center, are needed at the global, regional, national and local level.	TARGET:17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favorable terms, including on concessional and preferential terms, as mutually agreed TARGET 17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation TARGET 17.16 Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries TARGET 17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships	Besides promoting the development of technologies, is important to provide the knowledge so that new research can be locally made and local solutions can be settled. As well as the National Government, the local governments also must have the independence to make international contributions and partnerships for achieving local goals that must be in accordance to national and international regulations. Another Important partnership is the collaboration of local private with local public institutions so that local economy is boosted and the systems works to achieve a common goal.

Annex 2: Maps from the PDOT (Development and territorial organizational plan) - Provided by the Pifo GAD (Local government)

Map 1: Existing Model



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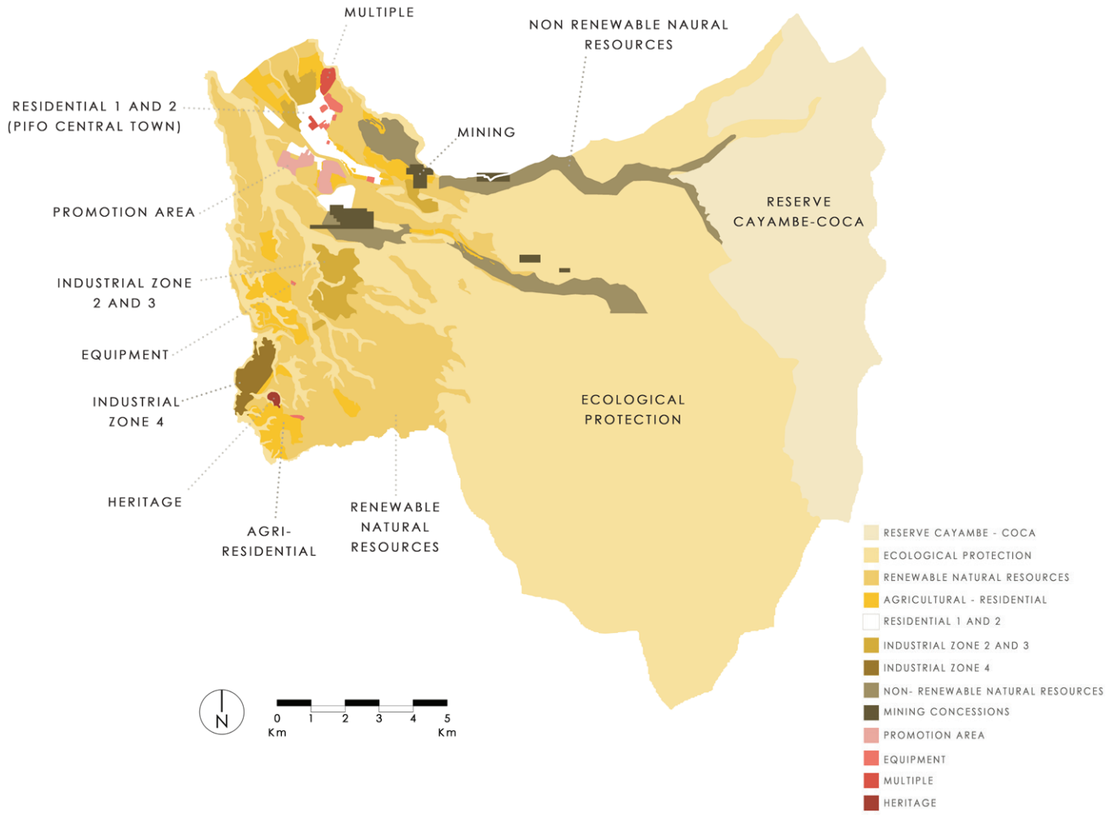
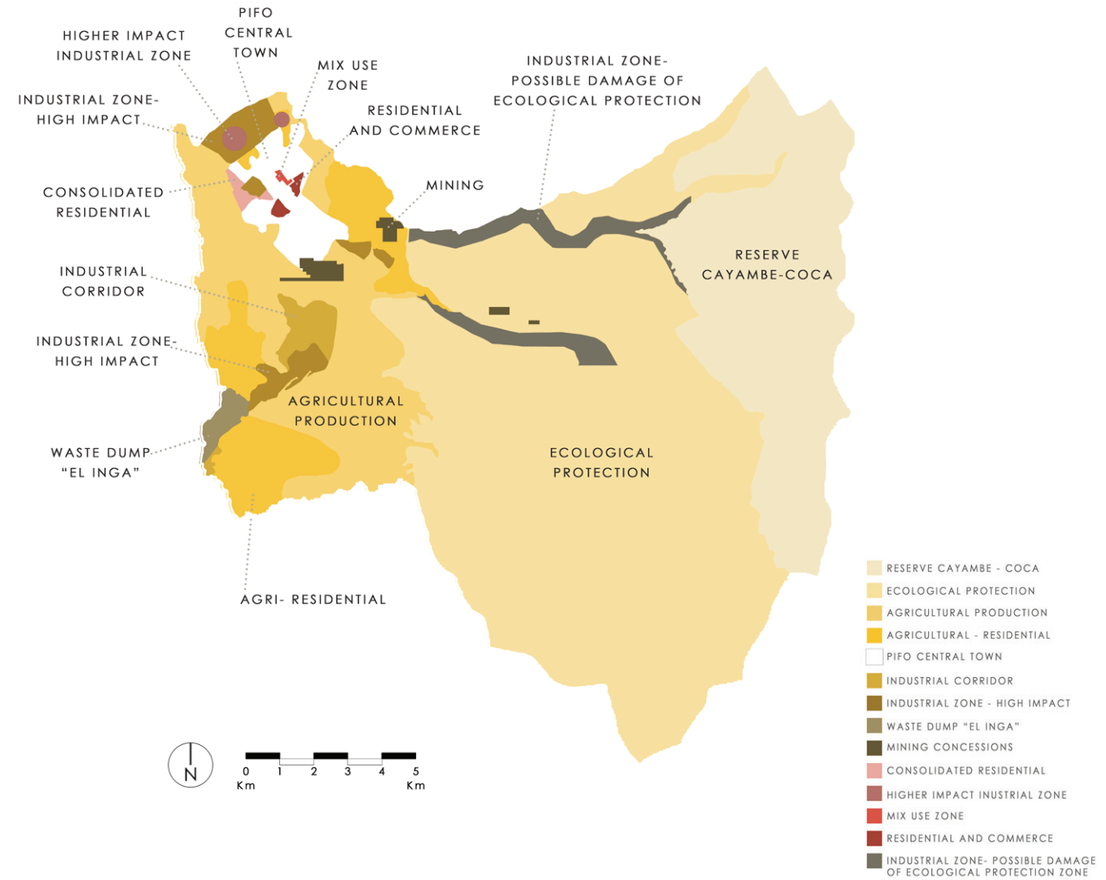
Annex 2: Maps from the PDOT (Development and territorial organizational plan) - Provided by the Pifo GAD (Local government)

Map 2: PUOS plan (Landuse plan)



Map 3: Proposed Model- proposed by the GAD (local government)



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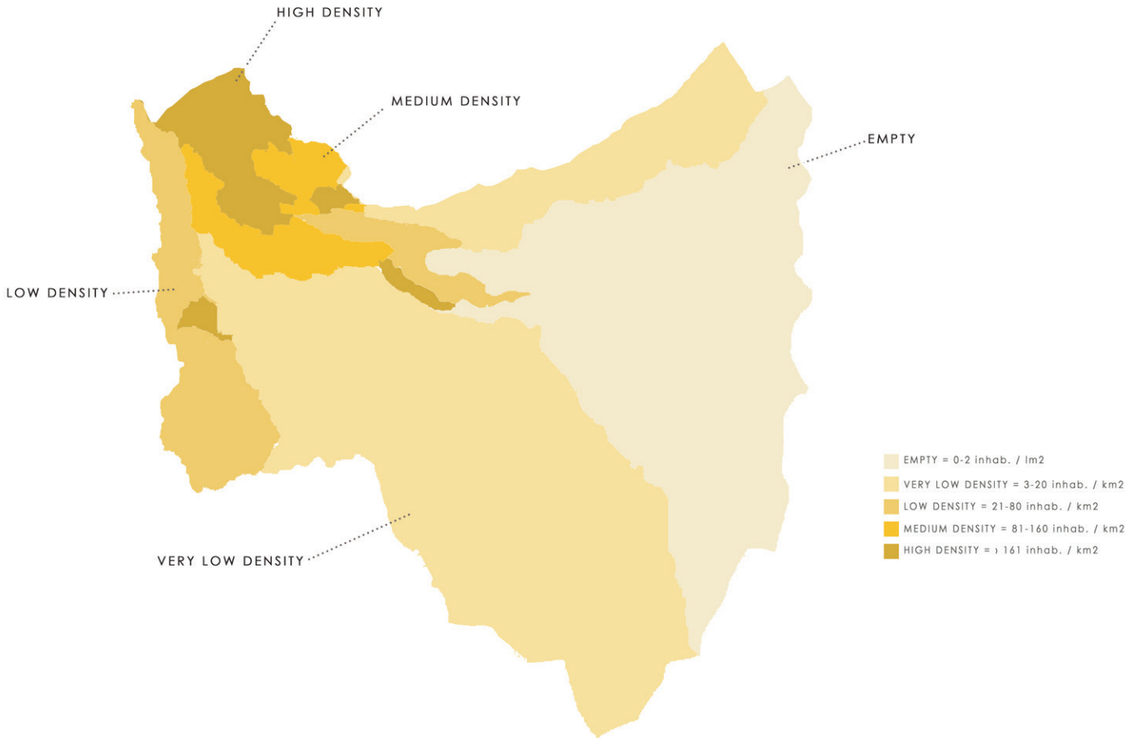
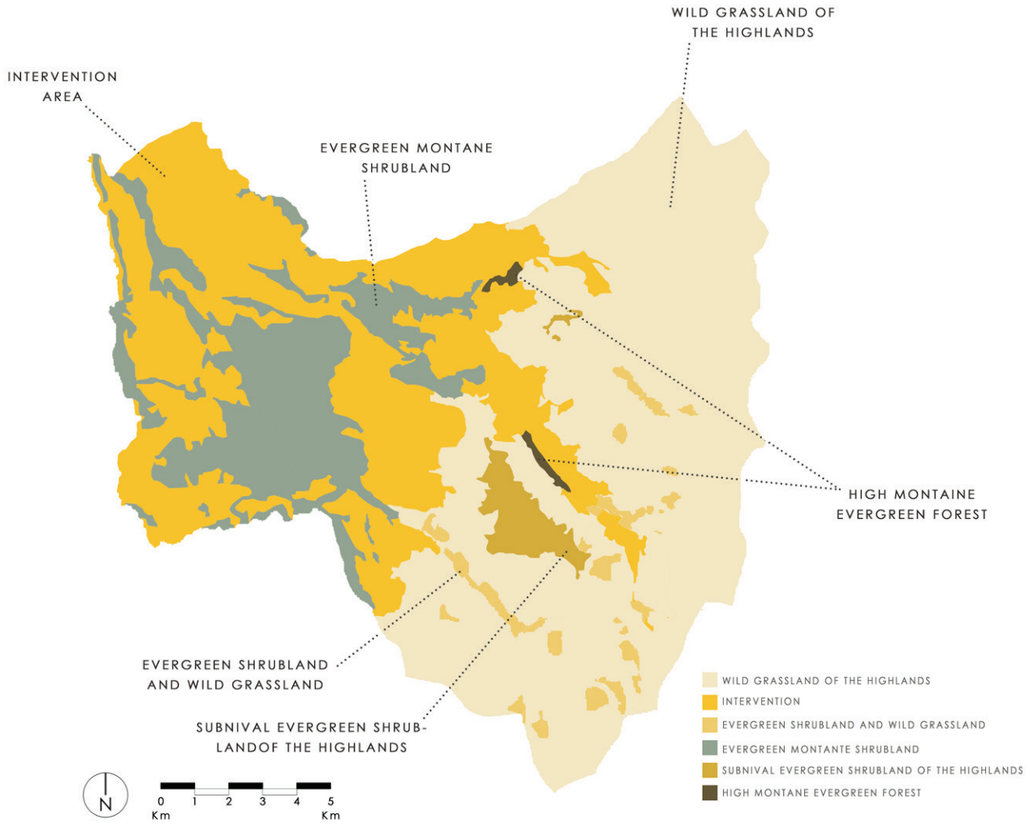
Map 4: Settlement density



Map 5: Ecosystems



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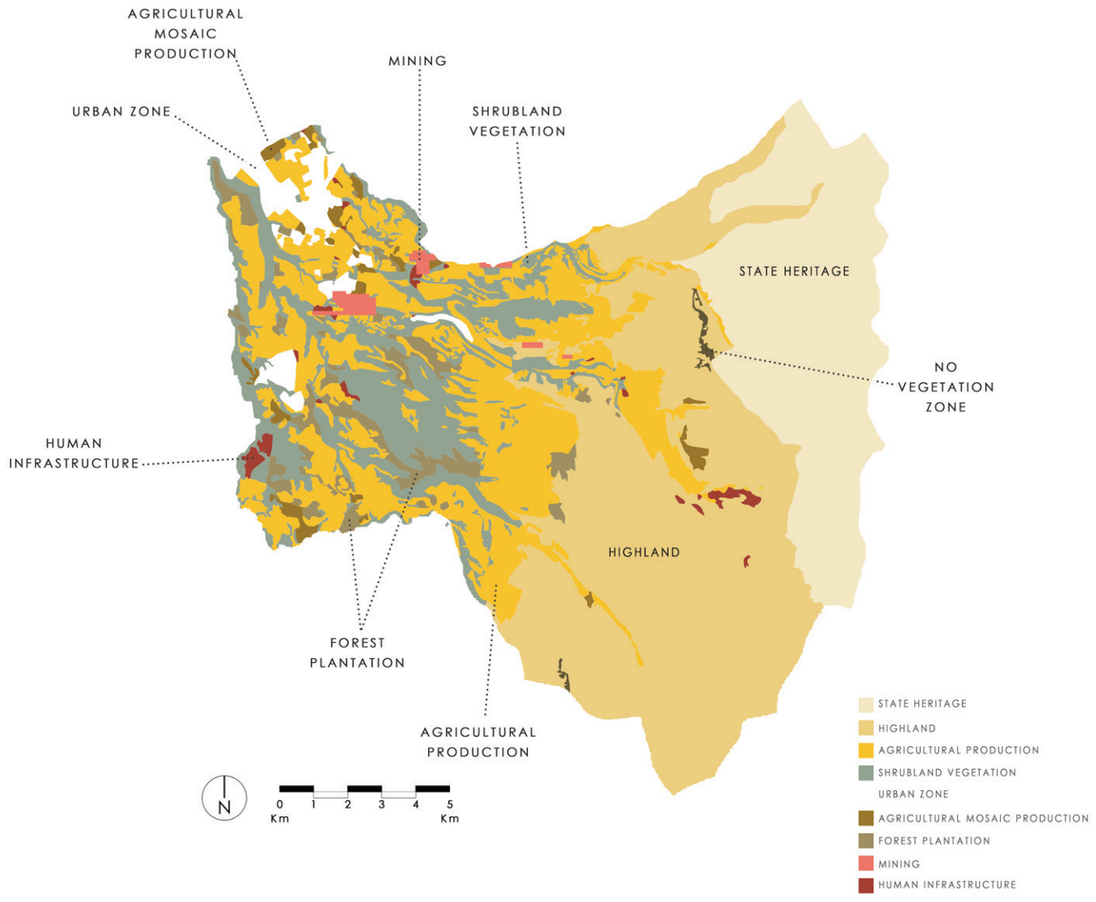
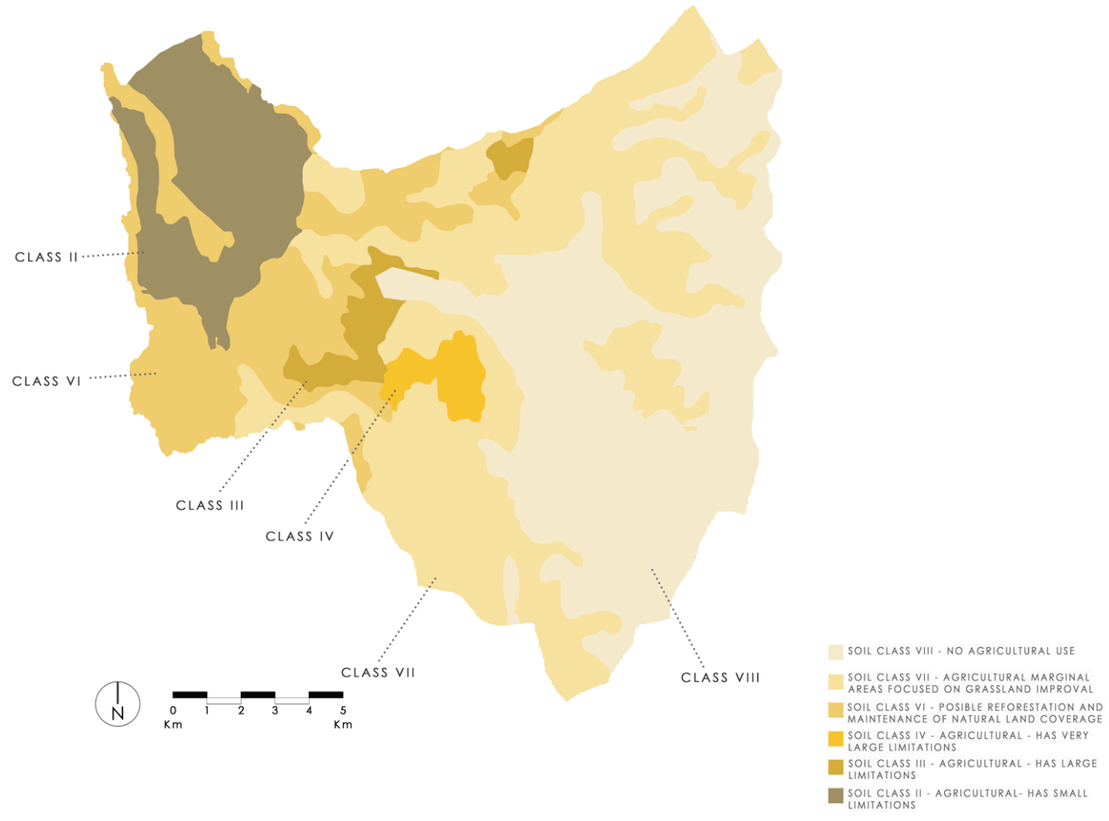
Map 6: Soil coverage (ecosystem services)



Map 7: Soil classification



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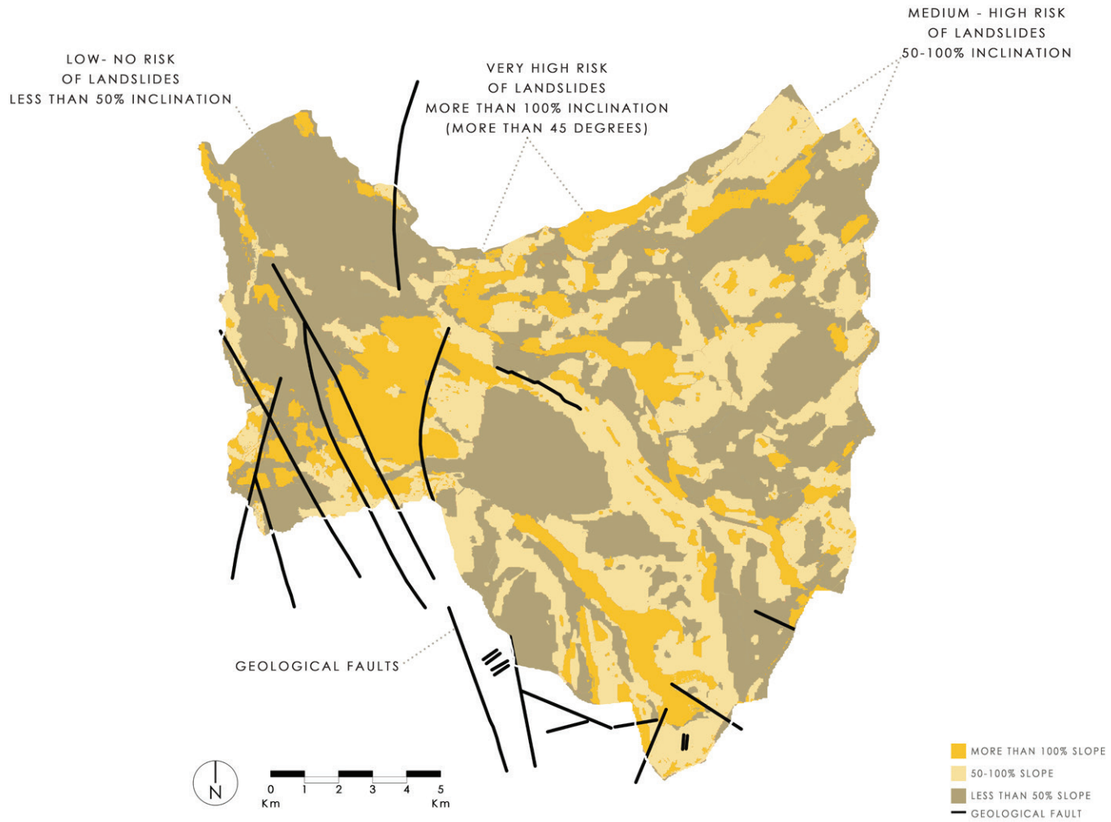
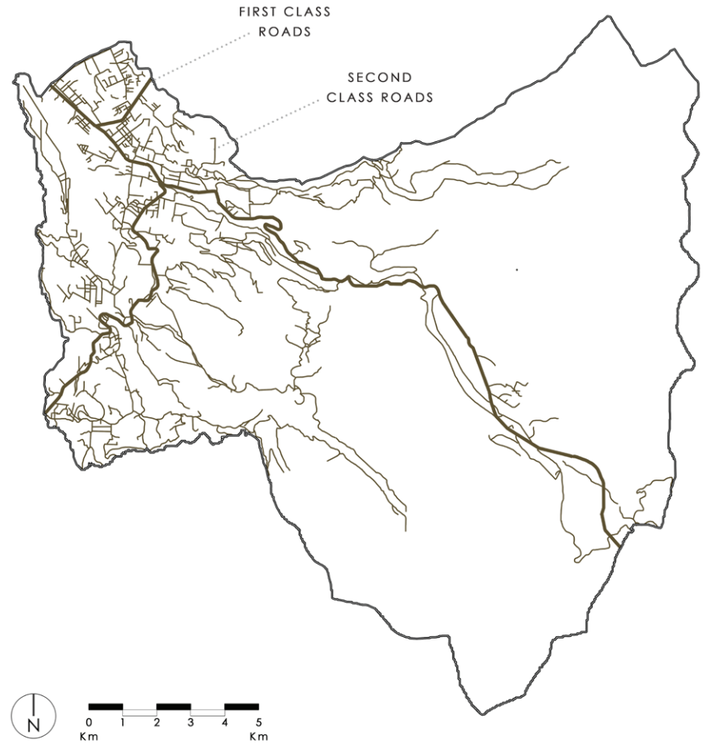
Map 8: Geographical Threats



Map 9: Roads



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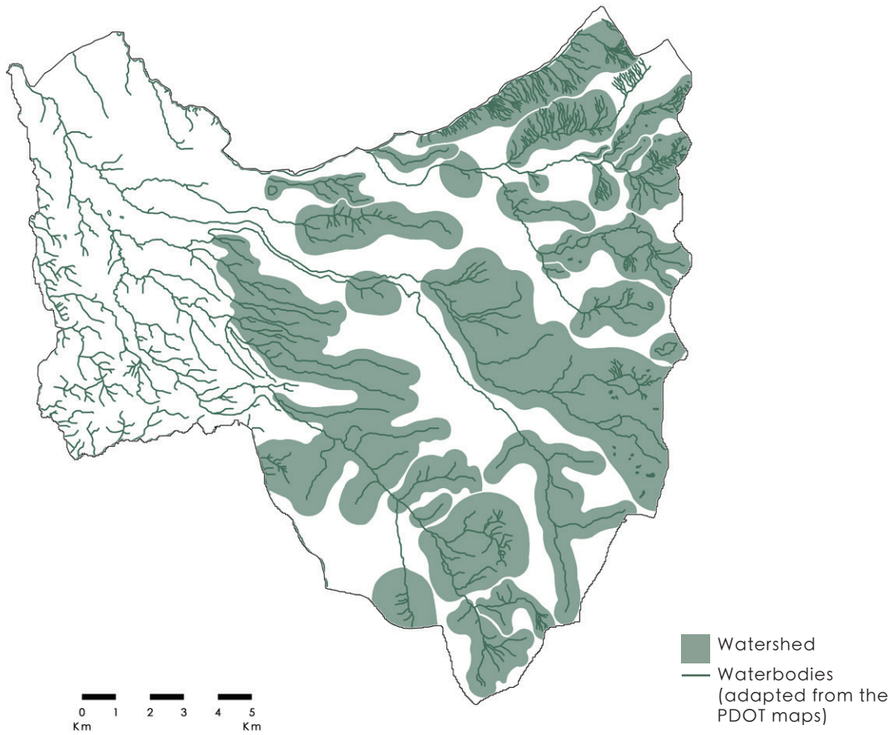
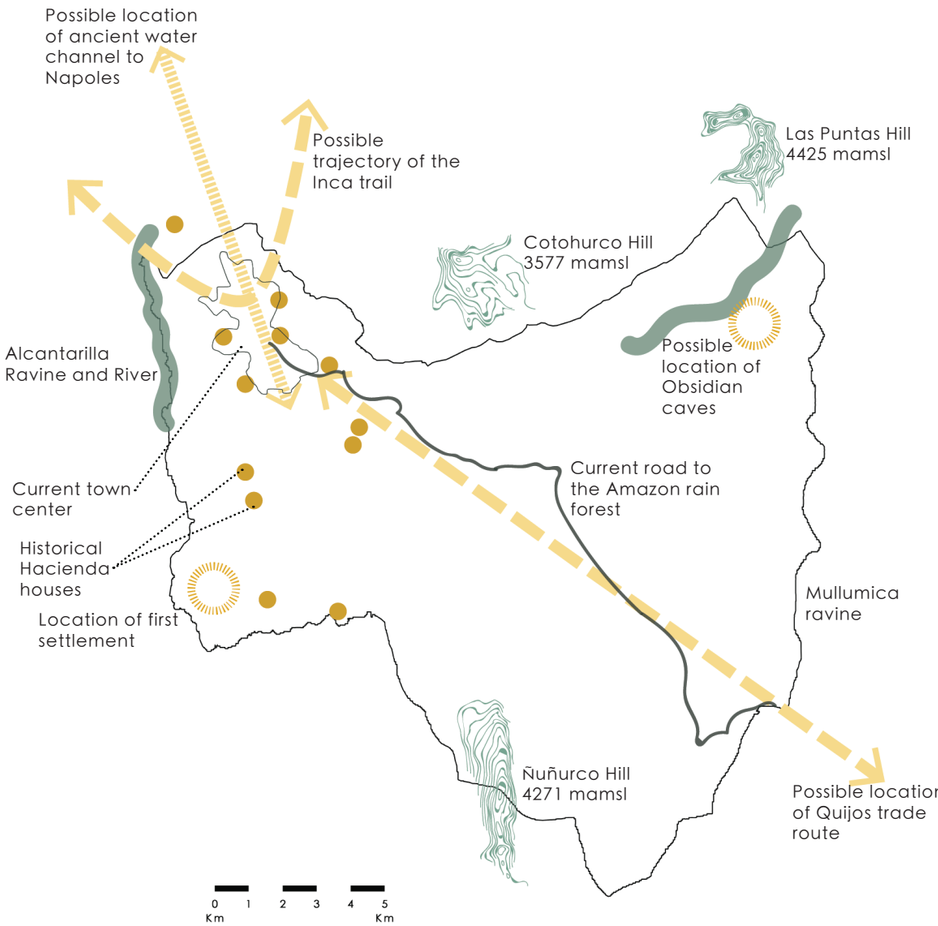
Annex 3: Self developed maps

Map 1: Waterbodies map



Map 2: Historical places and Natural Landmarks - recolected information taken from the book "The history of Pifo" (Larrea Araujo, 2013)



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Annex 4: Renewable Energy comparison tables - Biomass

TYPE	BIOMASS
TECHNICALITIES	
	• "Biomass regards all biodegradable organic material derived from plants, animals, or microorganisms (UNFCCC, 2005) (…) which has the potential to be used as a source of renewable energy and / or bioproducts." (Pelaez Samaniego & Espinoza Abad, 2015)
	• Processes using biomass usually aim to obtain fuels in the following forms:
	1. Liquids: like ethanol, biodiesel, methanol, pyrolysis oil, vegetable oil, green gasoline. "Materials for these process include wood and its residues, agricultural crops and residues from harvesting and processing, municipal organic waste and animal waste, among others." (Pelaez Samaniego & Espinoza Abad, 2015)
	2. Solids: which include charcoal, torrefied biomass, wood and garbage that "can be burned directly to produce heat. (Pelaez Samaniego & Espinoza Abad, 2015)
	3. Gaseous: like biogas, methane, synthetic gas obtained by gasification (Basu, 2010) (Pelaez Samaniego & Espinoza Abad, 2015). "Biogas forms when (…) waste decomposes in landfills, and it can also be produced by processing sewage and animal manure in special vessels called digesters." (U.S. Energy Information Administration, 2019)
	• Energy can be achieved through Thermochemical processes, Chemical and Biological processes:
	1. Thermochemical Processes: Combustion, which means "burning Biomass with an excess of oxygen to produce heat and water vapor." (Pelaez Samaniego & Espinoza Abad, 2015); Gasification is "to obtain a gaseous product by means of partial combustion. (...) This gas can be used to generate thermal or mechanical energy or to obtain liquid fuels."; and Pyrolysis which consists of a thermochemical process at moderate temperatures (lower than in the case of gasification) in the (partial) absence of oxygen, where the process produces solid (charcoal), liquid and gaseous products. "The most important by-product is bio-oil. Its superior calorific value (...) is much lower than that of oil and / or derivatives (Mayer, 2009)" (Pelaez Samaniego & Espinoza Abad, 2015)
	2. Chemical Processes: These processes normally "require some type of alcohol and a catalyzer (…) for the chemical conversion into esters, as the main product, and glycerol as a by-product" (Pelaez Samaniego & Espinoza Abad, 2015). Biofuel is one of the results that can be achieved through chemical process, these "are transportation fuels such as ethanol and biodiesel that are made from biomass materials." (U.S. Energy Information Administration, 2019)
	3. Biological Processes: "The conversion of biomass for the production of liquid fuels (ethanol) or gas (biogas) through biological processes requires the use of microorganisms. The two most used biological processes are fermentation to produce ethanol and anaerobic digestion to produce biogas." (Pelaez Samaniego & Espinoza Abad, 2015)
	• Ethanol is made from crops such as corn and sugar cane that are fermented to produce fuel ethanol for use in vehicles. Biodiesel is produced from vegetable oils and animal fats and can be used in vehicles and as heating oil. (U.S. Energy Information Administration, 2019)
ASPECTS	
Positive	1. Helps local development when the facilities are located near the source of raw material, "that is to say in the field, an aspect that benefits rural areas by generating employment for the cultivation, harvesting, pre-treatment and use of biomass". (Pelaez Samaniego & Espinoza Abad, 2015)
	2. Waste Dumps can take advantage of its material, reducing the amount of waste and producing energy.
	3. Some equipment is easily adapted to small scale, home and small agricultural systems.
	4. The charcoal produced form the Pyrolysis process, has "shown that it can improve soil quality, while also serving to sequester carbon and reduce emissions to the environment." (Pelaez Samaniego & Espinoza Abad, 2015)
	5. Due to the different ways of energy production, it provides a wide range of implementation opportunities for the different developing sectors as well as for private enterprises.
Negative	1. Gases produced should be studied due to possibility of being highly polluting. "The main problems encountered by all the investigators have to do with purifying the gas residue and with operational problems when mixing biomass fuels for which the particular design of the gasifier may not be prepared." (Pelaez Samaniego & Espinoza Abad, 2015)
	2. Installation can be expensive if compared to the current fuel used in households which is mainly Petroleum Liquid Gas (GLP) which has a subsidy by the Ecuadorian Government
	3. It can be a worrisome subject considering possible deforestation created from different areas, such as illegal charcoal manufacturers or big enterprises, that want to make a gain out of this energy source.
	4. "The by-products of roasting (some chemical components that can be harmful to the environment) have not been fully solved. At present, the roasting vapors are generally combusted to avoid environmental damage." (Pelaez Samaniego & Espinoza Abad, 2015)
	5. Many of the processes require a fairly large amount of water, which is increasingly an element that has to be protected. "Many require as much as 4 times the amount of the Biomass quantity. (...)To neutralize the pH and wash the solids, additional water is used." (Pelaez Samaniego & Espinoza Abad, 2015)
	6. Combustion represents problems to the atmosphere "related to deficiencies in the combustion systems, which causes serious environmental problems."(Pelaez Samaniego & Espinoza Abad, 2015)

RECOMMENDATIONS	
	• The facilities need to be located close to the areas of product source, to take best advantage of the biomass production. (Pelaez Samaniego & Espinoza Abad, 2015)
	• Among other aspects, it is also necessary to study the impacts on water use, life cycles of lignocellulosic materials, suitable farming methods to optimize the yield of land dedicated to the cultivation of biomass for energy purposes and environmental impacts. (Pelaez Samaniego & Espinoza Abad, 2015)
	• According to Leung et al. (2004), the use of these systems is recommended in geographical areas where electricity supply is difficult and biomass is highly available. (Pelaez Samaniego & Espinoza Abad, 2015)
	• "There is enormous potential for the use of municipal waste through gasification for energy production and the recycling of materials. The country (Ecuador) should explore these options." (Pelaez Samaniego & Espinoza Abad, 2015)
	• Large scale processing plants as a biorefinery, which has the production of, for example, heat and electricity, wood pellets, bioplastics, agglomerates and composites and other chemical products, as well as fuels, can convert a biomass processing plant into a very attractive business that contributes with the reduction of environmental pollutants through the use of renewable materials and the reduction of waste. (Pelaez Samaniego & Espinoza Abad, 2015)
	• Depending on the system used for energy production through Biomass, the personnel must be correctly trained to achieve wanted results.
COMMENTS	
	• Could be proposed for the factories that are in the area and for the industrial area as a way of waste control.
	• It can also be used for the Municipal Dump in the area.
	• When (if) Biogas is produced in the study area, it should be possible to adapt a central gas system to reach as many households as possible - costs of installation and maintenance could be very high.
	• Water is abundant in the area and rivers flow along many fields. This water can be used for the required processes.
	• Training of personnel for the correct functioning of the different systems have an extra cost but can bring a ripple effect in the general knowledge of the locals regarding use of biomass.
	• Wood industry in the area can provide excess material for the production of energy for the city.
	• Biomass is more recommended for the production of gas for households as for the production of electric energy due to its low efficiency in the latter.
CITATIONS AND REFERENCES	
	• Pelaez Samaniego, M., & Espinoza Abad, J. (2015). Energias Renovables en el Ecuador. Situacion actual, tendencias y perspectivas. Cuenca: Universidad de Cuenca.
	• U.S. Energy Information Administration. (2019, March 21). Renewable Energy Explained. Retrieved from Energy Explained: https://www.eia.gov/energyexplained/index.php?page=renewable_home

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Annex 4: Renewable Energy comparison tables- Electrolytic Hydrogen

TYPE	ELECTROLYTIC HYDROGEN
TECHNICALITIES	
	• Hydrogen has the highest energy content of any common fuel by weight (about three times more than gasoline), but it has the lowest energy content by volume (about four times less than gasoline). (U.S. Energy Information Administration, 2019)
	• Obtaining hydrogen can come from several sources such as mineral coal, hydrocarbons, biomass, water, ethanol, methanol, etc. (Pelaez Samaniego & Espinoza Abad, 2015)
	• There are various methods of producing hydrogen (U.S. Energy Information Administration, 2019):
	1. Steam reforming: is currently the least expensive way to produce hydrogen, and it accounts for most of the commercially produced hydrogen in the United States. This method is used in industries to separate hydrogen atoms from carbon atoms in methane (CH4). The steam reforming process results in carbon dioxide emissions.
	2. Electrolysis: uses electricity to split hydrogen from water. The process can be used on a large or small scale. Electrolysis does not produce any emissions other than hydrogen and oxygen.
	• The electrolysers are equipment used for the production of hydrogen from water using electrical energy. The basic structure of these devices, like the fuel cells, consists of a positive electrode and a negative electrode separated by an electrolyte. Therefore cost of producing hydrogen by electrolysis is highly dependent on the cost of electric power (Ivy, 2004) and therefore justifiable when the cost and production of energy is low. (Pelaez Samaniego & Espinoza Abad, 2015)
	• it is possible to obtain electrical energy and, as a byproduct, heat, in a cogeneration scheme. (Pelaez Samaniego & Espinoza Abad, 2015)
	• Some of the most important technical characteristics of electrolysis are (Pelaez Samaniego & Espinoza Abad, 2015):
	1. It provides in a direct way hydrogen and oxygen, both with a high level of purity.
	2. It is known and well established in the market.
	3. It presents high conversion efficiency. This efficiency can reach values between 80 and 95%, depending on the conditions of pressure and temperature (Ivy, 2004).
	4. For its implementation, it is first necessary to produce electrical energy (from a primary source of energy), and then produce hydrogen. (Pelaez Samaniego & Espinoza Abad, 2015)
	• Means of transportation for Hydrogen include: underground pipes (in gaseous state) and / or through tanker trucks. (Pelaez Samaniego & Espinoza Abad, 2015)
	• Uses for Hydrogen can be as a Raw Material or as Fuel (Pelaez Samaniego & Espinoza Abad, 2015):
	1. As a raw material Hydrogen can be used as a chemical input: 51% is used for the synthesis of ammonia (NH3) and methanol (it also includes the synthesis of hydrogen peroxide, aldehydes, ketones, polyethylene, polypropylene, alcohols and hydrochloric acid), 44 % is used in oil refineries for the hydro-treatment of heavy fuels and 4% is used for the hydrogenation of unsaturated hydrocarbons.
	2. The use of hydrogen as a fuel can be carried out directly or mixed with others. Its high calorific value and the environmental benefits (because its combustion produces water), are the main elements that drive this use.
ASPECTS	
Positive	1. The diversity of sources of raw material to produce hydrogen makes it a "universal fuel" (Holladay et al., 2009). (Pelaez Samaniego & Espinoza Abad, 2015)
	2. There are existing vehicles with fuel cells are a special type of electric vehicle and are considered to be zero-emission vehicles (ZEV-Zero Emission Vehicles). (Pelaez Samaniego & Espinoza Abad, 2015)
	3. There is the possibility of producing hydrogen from biomass. This possibility can be taken advantage of in the municipal dump which can produce biomass.
	4. The heat produced by turning hydrogen into electricity can be used as a way to heat water. (Pelaez Samaniego & Espinoza Abad, 2015)
	5. The oxygen resulting from the electrolysis process can also be marketed. (Pelaez Samaniego & Espinoza Abad, 2015)
	6. With a hydrogen production plant, ammonia fertilizers can be produced and the country can start producing instead of importing, changing the local economy system.
	7. Oxygen as a result of the production of hydrogen from water can be used for medical purposes.
Negative	1. Currently, the most widely used method for the production of hydrogen on an industrial scale is the reforming of natural gas (NG) with steam (NREL, 2006). But generates negative effects for the environment. (Pelaez Samaniego & Espinoza Abad, 2015)
	2. The vehicles with hydrogen fuel cells are much more expensive than the vehicles with gas fuel motor. (Pelaez Samaniego & Espinoza Abad, 2015)
	3. For now, Hydrogen production costs is dependent on oil costs. (Pelaez Samaniego & Espinoza Abad, 2015)
	4. BARRIERS FOR USE: One of the most important is the lack of infrastructure. Hydrogen is normally not available to consumers at fuel service stations. (Pelaez Samaniego & Espinoza Abad, 2015)
	5. Large space needed for the production, storage and distribution of Hydrogen, as well as the costs that it will involve.
RECOMMENDATIONS	
	• Hydrogen can be used as a raw material or as a fuel (Pelaez Samaniego & Espinoza Abad, 2015):
	1. as raw material for the production of ammonia
	2. as an input in oil refining
	3. for the generation of electric power (in cogeneration systems)
	4. as fuel in vehicles with fuel cells.
	• Gaseous hydrogen, compressed in trucks is recommendable when there is low demand, that is, small-scale consumption. (Pelaez Samaniego & Espinoza Abad, 2015)
	• Liquid hydrogen is justified for large distances and appreciable demand. Pipeline distribution is ideal for high demand. (Pelaez Samaniego & Espinoza Abad, 2015)
	• The use of hydrogen can be done in small scale production of electricity, either through micro-turbines or through fuel cells. These schemes could be of great interest in remote regions of urban centers that lack electricity distribution networks, but with hydraulic potential to install mini or micro hydroelectric plants. (Pelaez Samaniego & Espinoza Abad, 2015)
	• Research shows that it is possible to produce hydrogen at costs less than USD 3.00 / kg only if electricity is available to operate the electrolysis plant for 24 hours a day, with electricity costs below USD 30 / MWh. (Pelaez Samaniego & Espinoza Abad, 2015)
	• The electricity used in electrolysis can come from renewable sources such as hydro, wind, or solar energy. If the electricity used in electrolysis is produced from fossil fuels, then the pollution and carbon dioxide emissions produced from those fuels are indirectly associated with electrolysis. (U.S. Energy Information Administration, 2019)
	• According to the proposal presented, using hydrogen to produce ammonia requires the installation of a plant for this purpose, as well as a plant that produces nitrogenous fertilizers from this ammonia. At present there are no such plants in our country. However, its implementation would have an enormous impact from the strategic point of view, since the country would stop being an importer of nitrogen fertilizers to be an exporter of this product. This generates employment, boosts agriculture and allows the introduction of new technologies. (Pelaez Samaniego & Espinoza Abad, 2015)
	• Research is underway to develop other ways to produce hydrogen, such as (U.S. Energy Information Administration, 2019):
	1. using microbes that use light to make hydrogen
	2. converting biomass into gas or liquids and separating the hydrogen
	3. using solar energy technologies to split hydrogen from water molecules
	• Nitrogen fertilizers for agricultural use are made from ammonia. The annual world production of fertilizers from ammonia is over 162 million tons per year (Rafiqul, et al., 2005) and Ecuador import was 125,700 T in 2008 and 243,122 T in 2011 (MAGAP, 2013). (Pelaez Samaniego & Espinoza Abad, 2015)
COMMENTS	
	• Pifo can be a good area to locate a center of Hydrogen production and research, that supports the developing industries in the surroundings as well as possible proposals for local transportation.
	• If Pifo has a independent way of producing electricity, then electrolysis can be a viable future for a new developed economical - industrial model.
	• The area of study is, until now, centered in agriculture. If research and implementation of hydrogen fertilizers (through ammonia) are placed in the industrial area, it can be an important focus for the local economy and production of jobs as well as keeping the identity through the concept of supporting agriculture.
CITATIONS AND REFERENCES	
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	• U.S. Energy Information Administration. (2019, March 21). Renewable Energy Explained. Retrieved from Energy Explained: https://www.eia.gov/energyexplained/index.php?page=renewable_home

XI. Annexes
Annex 4: Renewable Energy comparison tables- Eolic

TYPE	EOLIC (WIND TURBINES)
TECHNICALITIES	
	• The kinetic energy of the wind with the rotor blades of the wind turbine is converted into mechanical energy and then via a generator into electrical energy. It is composed of 4 parts: The foundation, Tower, Gondola and Rotor. The expected operating time of wind turbines is approximately 35 years.
	1. Foundation: is usually made of reinforced concrete. Is important to check the load bearing capacity of the soil. Includes and adapter, lightning protection and the installation of empty pipes for cableways which are also part of the foundations of a wind turbine.
	2. Tower: can be made of reinforced concrete or a steel tube depending on the area. The tower length is usually 1 to 1.8 times the rotor diameter. Share of costs lie between 15 and 25 percent of the total investment.
	3. Gondola: accommodates the complete machine house including the generator, cooling, control, hydraulics and, depending on the design, a gearbox. This part contributes 10 to 25 percent of the investment costs for the wind turbine.
	4. Rotor: consists of the rotor hub and the rotor blades. The rotor blades on the most powerful wind turbines on land reach a length of over 60 meters. They are built on the model of aircraft wings and work on the buoyancy principle.
	• Turbulence: must be researched if the distance to the neighboring wind turbine is less than eight rotor diameters.
ASPECTS	
Positive	1. Wind from the mountains (high speed) can be taken full advantage.
	2. As this technology is being broadly developed the technology advantages are higher.
	3. Difficult to vandalize due to the size.
	4. Can have surrounding crops, meaning, it can be easier to place in agricultural fields (already disrupted).
	5. Already being implemented in Ecuador and supported by government policies.
	6. Proven more effective compared to other R. E. Technologies
Negative	1. Visual disruption.
	2. Concrete foundations can disrupt soil biotopes in sensible areas.
	3. Suitable access roads have to be built to reach the site of installation generating a larger area of affection.
	4. Transportation of parts can be difficult in thin roads along the mountains.
	5. Because of the Hight can be a disruption of Air traffic (Abundant in the selected area).
	6. Is problematic for Birds and Bats. Specially migrating flocs.
RECOMMENDATIONS	
	• According to the case study of the Ministry of Economy, Weather protection, Energy and Land Planning of Rheinland-Pfalz in Germany, the ideal location of Wind energy towers should be at a distance of 10 times their height to protected residential areas, this is called the 10H control.
	• After the operating time is over, the wind turbine has to be dismantled and the materials disposed. The cost of dismantling have to be saved during the functioning of the plant to secure dismantling.
	• Wind turbines are being dismantled increasingly more often before the expiry of the expected operating time and replaced by new, more powerful systems, known as repowering. This measure can be cost-effective for operators, as new wind turbines can achieve more than twice the output and can generate more than five times more electricity per year than they did 10 to 15 years ago.
	• Exclusion areas (no wind energy) examples include: air traffic facilities, radio links, low-altitude flight corridors, drinking water protection areas, sensitive areas of groundwater catchment areas of public water production facilities, nature reserves, bird sanctuaries, protection of the landscape, conservation of monuments.
	• Balanced decision: Public should be involved and the reasons for the selected locations must be clear as well as the consequences that can be expected.
	• Scope of development plan: Depends on available area of community (…) To calculate the space required for a wind energy plant, Energy-Atlas Bayern has set a factor of 5 ha per megawatt of installed capacity in the mixing console (…)

COMMENTS	
	• If used, could be placed in between agricultural fields away from settlement.
	• Another suitable place could be between the green houses of the flower industry, where the light and sound wont disturb the settlement during the night and the access roads for trucks are already built.
	• In the study area, Electricity High Voltage Towers have been placed, Wind turbines can be located in the nearby of the towers creating a direct connection to the electric network as well as taking advantage of the access roads build already in the area.
	• Must be careful with the highland moor area, where soil has a high level of water saturation and high percolation happens due to the low density of the soil. This areas can be contaminated easily.
	• The area has a large space of water recollection area which should be protected
	• Important to consider mountain peaks as important landmarks that should be maintained. E.g. Cotohurco hilltop looks like a lion, therefore people call it "the sleeping Lion"
CITATIONS AND REFERENCES	
	• Rheinland-Pfalz. (2013). *Windenergie und Kommunen, Leitfaden fuer die kommunale Praxis.* Mainz: Ministerium fuer Wirschaft, Klimaschutz, Energie und Landesplanung Rheinland-Pfalz.
	• Bauleitplanung für Windenergieanlagen Ein Merkblatt für Städte und Gemeinden, Planer und Projektträger, Bürgerinnen und Bürger

XI. Annexes
Annex 4: Renewable Energy comparison tables- Hydroelectric

TYPE	HYDROELECTRIC (WATER TURBINES)
TECHNICALITIES	
	• Hydroenergy production.- is the energy of the water flow to the reservoir of the hydroelectric plants, therefore this hydropower can be stored, transformed, unused and lost, according to the movement of the level of the reservoir, to the turbine. (Pelaez Samaniego & Espinoza Abad, 2015)
	• The amount of precipitation that drains into rivers and streams in a geographic area determines the amount of water available for producing hydropower. (U.S. Energy Information Administration, 2019)
	• Energy is produced in a "Hydroelectric Power Station, which is defined as the set of facilities that take advantage of the energy contained in a body of water transforming it into electrical energy, through transporting water from the level in which it is found in nature to a lower level in which the hydraulic turbines are installed. These, powered by water activate generators that produce electrical energy."(Pelaez Samaniego & Espinoza Abad, 2015)
	• Hydroelectric plants are subdivided into the following categories (Pelaez Samaniego & Espinoza Abad, 2015):
	1. Jump height: a) High fall: greater than 150 m; b) Average drop: between 50 m and 150 m; c) Low fall: between 2 m and 20 m.
	2. Generation capacity: a) Plants with more than 50 MW; b) Power plants between 10 MW and 50 MW; c) Plants of less than 10 MW.
	3. Type of operation: a) With reservoir or regulation; b) Flowing water (without reservoir).
	• Main components of a hydroelectric power plant: (Pelaez Samaniego & Espinoza Abad, 2015)
	1. Dam: They are used to store and divert the channel of a river to the hydraulic conduction system of the power station, in addition to increasing the necessary jump for the generation of energy.
	2. Flood control mechanisms: they are structures attached to the dam whose main function is to protect it against flooding.
	3. Work of intake and conduction: The intake work consists in facilitating the entry of water into the pipeline, preventing or hindering the passage of solid elements to the plant. It also has a system of gates that allow regulating the flow of arrival to the powerhouse for generation. (...) It is done either by pipes or channels (surface).
	4. House of machines: equipment that is responsible for the transformation of potential energy (water jump) to mechanical energy (turbines), to later transform it into electrical energy (generator). Surface or underground
ASPECTS	
Positive	1. As seen in the projects from the EEQ(Electric Company of Quito), turbines can be used for waste water as well; generating production in areas that are already intervened or disturbed.
	2. Efficiency levels are very high in comparison to other energy production methods.
	3. Financing for these projects is mandated as responsibility of the Ecuadorian State with resources from the general budget (Pelaez Samaniego & Espinoza Abad, 2015). This means that bigger projects can be created, since the budget is larger as that of any independent municipality's budget.
	4. Technology for this production method is very advanced and can be applied in a great variety of situations.
Negative	1. The ecology of the river gets extremely affected and the consequences of riparian areas downstream can be high.
	2. Extremely invasive practice as it has to build tunnels, machine housing and, depending on the type of hydro plant, Dams.
	3. Built space and installations are not taken into account when talking about contamination factors.
	4. "The water resource is transported, in most cases, through excavated tunnels covered by concrete and steel." (Pelaez Samaniego & Espinoza Abad, 2015). This can ruin many habitats and biotopes, considering that 25% of living organisms live under soil level.
	5. Big projects have the risk of imposing this construction into small areas without any gain from the locals.
	6. It is projected mainly for the benefit of larger areas and can leave the development of smaller areas without much attention.
	7. Plants with internal combustion engines need fuel and oil to operate Pelaez Samaniego & Espinoza Abad, 2015), with the corresponding contaminants it generates.

RECOMMENDATIONS	
	• Based on the hydrological, geological and geotechnical characteristics of the site, the flow and height necessary for the best hydroenergy utilization of a power plant are analyzed; variables that will depend on the capacity and number of generation units to be installed, thus giving the total power that the project will have. (Pelaez Samaniego & Espinoza Abad, 2015)
	• Needs Transformers. In a hydroelectric plant, the generators supply voltages of around 26,000 V, (...) The mission of the transformers is to raise the value of the voltage generated so that the current to be transmitted is reduced in the same proportion, reducing in this way the losses at the time of transmission. Generally the voltage rises to voltages between 138,000 and 765,000 V so that it is possible to transfer the electricity to the distribution system. (Pelaez Samaniego & Espinoza Abad, 2015)
	• For the production of energy, thermal power plants with internal combustion engines (MCI), turboprop units, turbogas, use different types of fuel such as fuel oil, diesel, naphtha, bunker, waste and bagasse (biofuel).
COMMENTS	
	• Because of the amount of water sources in Ecuador, this energy source has been exploited extensively and keeps on being used for new prospects, as "the Electric Company from Quito has a catalog of more than 50 projects in the ranges between 0.5 and 30 MW, for the use of water resources in electricity generation." (Empresa Electrica Quito, 2015)
	• The area of study has a lot of Ravines and Rivers, which can be taken advantage of with smaller Hydropower plants.
	• Ground coverage of the area is dominated by Ecological Reserve, Ecological Protection areas as well as Agricultural production, therefore such an invasive practice in the surroundings can be counterproductive and create irreversible Ecological damage.
CITATIONS AND REFERENCES	
	• Pelaez Samaniego, M., & Espinoza Abad, J. (2015). Energias Renovables en el Ecuador. Situacion actual, tendencias y perspectivas. Cuenca: Universidad de Cuenca.
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XI. Annexes
Annex 4: Renewable Energy comparison tables- Photovoltaic

TYPE	PHOTOVOLTAIC (SOLAR)
TECHNICALITIES	
	• There are different ways of collecting solar energy: Thermal Power Stations, Photovoltaic Panels and Passive Solar Energy
	1. Photovoltaic solar technology consists of the direct conversion of the Sun's radiation into electricity, which is converted through photovoltaic modules or generators. (Pelaez Samaniego & Espinoza Abad, 2015).
	2. This conversion occurs in solar cells that take advantage of semiconductor materials (...) which allows the circulation of current under certain conditions. (Pelaez Samaniego & Espinoza Abad, 2015)
	• A solar cell, is a nonmechanical device that converts sunlight directly into electricity. (U.S. Energy Information Administration, 2019)
	1. PV cells are electrically connected in a packaged, weather-tight PV module or panel.
	2. The efficiency of most commercially available PV modules ranges from 5% to 15%.
	• "Solar parks", are large-scale systems for generating electricity from solar radiation by means of collectors, in which the solar energy is converted into electricity and usually fed into the public grid (grid coupling). (Herden, Rassmus, & Gharadjedaghi, 2009)
	• The operation of many PV modules in open spaces requires a number of (primarily infrastructural) changes in the operating area that can have an impact on the environment and the landscape. (grid coupling). (Herden, Rassmus, & Gharadjedaghi, 2009)
	1. fence and security facilities
	2. roads, parking and technical facilities
	3. regular maintenance of equipment
	4. cable work and connection to the public grid
	5. modification of landscape picture. Not only for site but also for neighbors. Light reflections
	6. the (partial) covering of the soil surface by modules (small-scale shading, possibly dehydration)
	7. vegetation maintenance (mowing, grazing) necessary for the project, which leads to a change of structural parameters of the habitat complex
ASPECTS	
Positive	1. The location of Ecuador allows our country to take advantage of the solar resource throughout the year with an average radiation level of 4574.99 Wh / m2 / day, according to the ATLAS SOLAR DEL ECUADOR prepared by the National Council of Electricity - CONELEC (Pelaez Samaniego & Espinoza Abad, 2015)
	2. Solar energy systems do not produce air pollutants or carbon dioxide. (U.S. Energy Information Administration, 2019)
	3. Because of the irregular terrain, the visual impact of the PV panels can be diminished for the neighboring areas
	4. Due to the strong sun radiation on Ecuador, many erosion areas are created after tall vegetation has been felled and PV farms in these areas could offer an opportunity for healthy vegetation undergrowth
	5. Constant innovations such as underground wiring diminish the amount of maintenance and costs as well as offering less landscape obstruction. (Herden, Rassmus, & Gharadjedaghi, 2009)
Negative	1. This technology can be very expensive and requires batteries to save the amount of electricity produced.
	2. The amount of sunlight that arrives at the earth's surface is not constant. The amount of sunlight varies depending on location, time of day, season of the year, and weather conditions. (U.S. Energy Information Administration, 2019)
	3. The amount of sunlight reaching a square foot of the earth's surface is relatively small, so a large surface area is necessary to absorb or collect a useful amount of energy. (U.S. Energy Information Administration, 2019)
	4. The modules can create "Shy effects" on animals or significantly affect the landscape. (Herden, Rassmus, & Gharadjedaghi, 2009)
	5. The risk of collisions of airworthy animals with the modules e.g. due to the confusion with water surfaces. (Herden, Rassmus, & Gharadjedaghi, 2009)
	6. The accessibility of the installation makes it easier for criminal activity and vandalism to happen

RECOMMENDATIONS	
	• In order to protect the interests of the natural environment and the landscape and to improve public acceptance, (...) the areas that are eligible for use according to the law(are already sealed areas, military or economic conversion areas and arable land, where either a zoning plan pursuant to § 30 BauGB must exist or a planning approval procedure pursuant to § 38 BauGB is carried out has been. When using arable land, conversion into green areas is mandatory. (Herden, Rassmus, & Gharadjedaghi, 2009)
	• It should be ensured that long-term building or roof installations prevail. (Herden, Rassmus, & Gharadjedaghi, 2009)
	• Parameters should be site specific and measured locally, such as: Height of the modules, building materials used for the elevation, row spacing or the usage regime of the open spaces as well as the construction-related interventions; it is also important to assess the effects on the sensitivity of the affected area.
	• Depending on the technology there is a minimum and maximum installation area that needs to be taken into account. The area can range from 5.8 m²/KWp to 18.0 m²/KWp, giving us an average of 12.35 m²/KWp
COMMENTS	
	• The amount of area available for PV farms needs to be considered in a way that the installation becomes profitable
	• The study area shows a high level of criminality, which can be threatening the investment on PV farms
	• Promoting roof installation for individual domestic systems and connecting these to the public grid can result more viable as PV open air farms for this specific area.
	• The production of energy with solar power does not create any type of pollution, However, attention has to be paid when maintenance is done. How is the disposal of replaced or damaged parts going to be done?
CITATIONS AND REFERENCES	
	• Herden, C., Rassmus, J., & Gharadjedaghi, B. (2009). *Naturschutzfachliche Bewertungsmethoden von Freilandphotovoltaikanlagen.* Bonn: Bundesamt für Naturschutz.
	• Pelaez Samaniego, M., & Espinoza Abad, J. (2015). Energias Renovables en el Ecuador. Situacion actual, tendencias y perspectivas. Cuenca: Universidad de Cuenca.
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