Model of Adaptability of Wetlands for Environmental Viability Located in the District of Oyolo, Ayacucho Region

Julio Cesar Minga, Doris Esenarro, and Ciro Rodriguez

Abstract—**This research involved the physical and biological characterization of the Laguiña wetlands, ensuring that experimental stage 1 has better alternative soil and water conditions, these field activities included the establishment of sites, topsoil deposits, plant management, maintenance and subsequent monitoring, to achieve the regeneration of wetlands in the sector selected for transfer, the methodology used by patches, where the vegetation was extracted in small patches (huts) of 50x50x30 cm, composed mainly of Distichia muscoides and Oxychloe Andino, with a total of six (06) extraction points; then five (05) parcels of receiving vegetation were installed, resembling the physical and chemical conditions of the original habitat, but adapting the receiving soil through earthworks and replacement of the upper soil layer with topsoil from the Laguiña sector; Likewise, a test was carried out with stimulating hormone, auxin as rooting; considerable growth observed at higher concentration. The regeneration and adaptability of the vegetation in an area of 2000 m^2 was evidenced by verifying the environmental viability of the wetlands in a new physical space under similar conditions. The design for the relocation considered physical, biological and water availability parameters, defining drainage systems to guarantee water flow and achieve soil saturation. Likewise, I assure the alternative conditions of the soil and water through diverse activities, with the objective of the regeneration of the wetlands in the selected location.**

Index Terms—**Wetlands, environmental, adaptability.**

I. Introduction

In recent decades the preservation of high Andean wetlands in Peru, known as wetlandses, has taken on great importance because of its function ecological given the diversity of vegetation. The wetlandses when accumulating abundant plant material function as natural water reservoirs, containing water in the soil to saturation conditions; these come from the thawing glaciers, rain and snow, rationing the water to be used in seasons of low rainfall.

The Peruvian State, through its environmental regulations defined in the General Environmental Law N º 28611 (Section 98 and Section 99, subsection 99.2) protects the wetlands of regulating protective measures [1].

The research has been developed in the study area began its exploratory activities of the project in 2006, and later the engineering studies at the feasibility level in 2011 for the exploitation of gold and silver minerals in 2015. the Project is located in the Oyolo district, which belongs to the Paucar del Sara province, which in turn is located in the political region of Ayacucho [1], [2].

The wetlands located in the Laguiña Creek is a typical high Andean wetlands, forming part of the natural habitat of the flora and fauna of the area located in this creek. Due to its location and natural condition, it receives water from the slopes of the Huarmapata hill, the quality of which is associated with the mineralogical characteristics of the area.

Peruvian laws consider the importance of wetlands - wetlandses in the Law of Water Resources (Law 29338), because they are water reservoirs, for man and local biota, as well as in the Law of Forestry and Wildlife (Law 29763), where the protection of fragile ecosystems - wetlandses is mentioned. The description of the physical and biological environment where the project is developed. In this way, the engineering activities approved in the Environmental Impact Study of the Inmaculada Mining Project were developed (qualification and construction of the Relavera), complying with the relocation of the wetlands for the purposes of compensation and environmental management [2].

II. Methodology

The methodological approach seeks to coordinate and achieve the proposed objectives of identification and preliminary formulation of specific projects, inserted within the framework of integral socioeconomic development.

In general, the methodological approach is oriented to the orderly procedure and development of algorithms of the diverse biological, economic and social factors leading to the proposal of production alternatives that include technological practices appropriate to a specific environment. The study and definition of them involves systematic observation, interdisciplinary research, and training at the local, regional, and national levels. The study of these three levels leads to the definition of hierarchical levels of action.

Developing an investigation requires an adequate selection of the subject of the study, a good approach to the problem to be solved and the definition of the scientific method to be used to carry out the investigation. In addition to this, techniques and tools are required to help carry out the research. Among the most commonly used techniques for this research, documentary and field research have been developed.

A. Edaphology

Manuscript received October 9, 2020; revised February 1, 2021.

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doi: 10.18178/ijesd.2021.12.3.1321

The soil study was based on the interpretation of satellite images, routes of field and laboratory analysis. In the field work, the following guidelines were used from the Soil Survey Manual of the United States Department of Agriculture, in accordance with the standardized specifications by the United Nations for Food and Agriculture (FAO). This manual defines the characteristics and properties to be considered, such as color, texture and soil horizons, among other variables, that have an incidence or act as limiting factors for the various activities required for mining exploration, as well as well as its environmental implications. The final phase was the drafting of the report and the preparation of the maps, with the natural and description of the soils, as well as the classification by capacity of Major Use of land considering the regulation for the execution of the soil survey of the Supreme Decree No. 013-2010-AG [3].

For the investigation, 4 calicatas (1.0 m wide by 1.0 m long and variable depth) were opened in representative locations in the area. All these points were georeferenced with the help of a GPS, allowing their location on the map with their respective coordinates. On the walls of each calicata, the soil profile was evaluated and described by means of its layers or genetic horizons, which are strata parallel to the surface of the land. Each stratum was assigned a capital letter and in special cases a subscript, according to the characteristics it showed, as well as Arabic numbers. The latter were used as suffixes to vertically subdivide some layers. The nomenclature for naming the layers is that established by the United States Department of Agriculture (USDA). The division of the profile into layers was made by scraping with the pickaxe, and when some change in the consistency of the soil was felt, it was interpreted that this was another horizon.

The delimitation was based on the properties of the profile analysed in the field: texture, depth, colour, structure, presence and quantity of very thick fragments, consistency, roots, horizon or layer limit, drainage and permeability. For the present study, 14 soil samples were taken, corresponding to the representative layers and horizons, which were then taken to the laboratory for their soil characterization [4], [5].

B. Data Collector

This is a study that seeks to obtain a panorama of the composition of the vegetation at a taxonomic and ecological level, with the purpose of identifying sensitive points of great importance to prevent or minimize impacts that may result from the activity carried out in the project area. This process is carried out by collecting specimens, taking morphological, ecological and geographical data and preliminary taxonomic identification.

Specimen collection is the process by which one or more samples of individuals or sections of plant individuals are gathered as a sample of their presence at a specific point in the study area for a later determination of their correct taxonomic nomenclature. The plant samples are separated, coded and dehydrated for their preservation and practical management; this allows to have a guide of species and morpho species in the field. This process is accompanied by the collection of morphological data for which the researcher must perfectly handle the botanical terminology since it implies the collection of observations of the plants at a macro level that can be accompanied by photographs and/or scale drawings. These observations can be of vegetative characteristics such as the habit (herbs, sufrútices, bushes, climbers, epiphytes, etc.), presence and color of latex, stem cover, disposition of leaves; or of reproductive characteristics such as the disposition of flowers and fruits, type and colors of bracts, clothing, etc.; giving special emphasis in the characteristics that are lost in the process of preservation. Ecological data refers to the estimation of coverage, determination of plant formations, etc. The geographical area refers to the location of plant formations and assessment points in space [6].

The taxonomic process starts in the field with the identification in situ, procedure by which the taxonomist recognizes a botanical specimen and ascribes it to a scientific name. On-site identification is done based on the experience of the researchers and the degree of abundance and distribution that makes some species are well known. The cabinet taxonomic process described below and refers to the process of samples and data after field, i.e. laboratory and herbarium. With the coded plant samples, dehydrated and herborized, microorganisms are observed that can be visible only with the aid of laboratory equipment such as stereoscopes and microscopes. This last information added to the vegetative morphological data and reproductive data taken in the field will be systematized and associated to taxonomic groups [6], [7].

The identification is done in decreasing range: family, genus and finally species. The literature review makes this process possible and allows for familiarization with taxonomic groups to be treated. For the identification of the species we used keys and descriptions of specialized books for the area; and databases Electronics: Missouri Tropics Botanical Garden; Neotropical Herbarium Specimens; and the International Plant Names Index. The herborized samples and The primary nominees are compared with the ex-sicata (herbarium sample already identified) deposited in the Herbarium of the Universidad Nacional Mayor de San (UNMSM), in order to find or confirm the name of the species(s) to be investigate. When a visibly characteristic species cannot be attributed some name is given a temporary nomination, which is called morpho-species, for example Astragalus sp., where "sp." is not the specific epithet but the time designation to indicate that this species is different from other species of Astragalus. The morpho-species is a denomination designed to favor ecological research where specific precision is not the most important [7].

The designations "vel sp. aff." which means "this species or a related one" and "cf." which means "confronted with" are also used to designate a questionable identification.

There are a total of 30 sampling units or sampling transects located in the most representative sectors of the plant formations. Ten 2 × 2 m plots have been installed in each sampling transect. The number of plots installed per point was deduced from previous experiences in ecosystems with similar physiognomy, Wikum (1978). As in the Fig. 1, The plots were located in a subjective way trying to include in a representative and proportional way the different formations that would be presented and within them the different degrees of coverage and soil conservation, so that we try to obtain highly representative samples of the place [8].

Fig. 1. Ground preparation of the plots.

III. Result

According to the Patari analysis it is the appropriate sector to receive the vegetation coming from the Wetlands Laguiña, even though some of the edaphic, floristic and hydrologic characteristics are slightly different from the original sector. Therefore, to ensure the success of the transfer and adaptability of the wetland vegetation, it was necessary to set up plots of land, all of whose activities were aimed at making the physical and chemical conditions of the wetland habitat in the Laguiña sector similar.

A total of five (05) plots of wetlands vegetation reception were defined, located in Sector 1. Two aspects were considered for the authorization of plots fundamental for the survival and adaptability of the bog, which were the soil and water.

The activities carried out are described below:

A. *Edaphology*

The soil in the area receiving the vegetation to be moved needs to be pre-conditioned for such use. This conditioning requires the movement of superficial lands and the transfer of topsoil. The topsoil forms the superficial layer of the soil that contains an upper photosynthetic layer and an organic layer colonized by microorganisms, below. The required personnel, the Necessary tools and vehicles required for the transfer of topsoil and earthworks are detailed in Table I.

TABLE I: Personnel, Tools and Vehicles Required for the Transfer of Topsoil and Earthwork

Material			
Article	**Technical specifications**	**Quantity**	**Utility**
Soguilla	More than 3 mm in diameter	20 m	Demarcation of perimeter of plots.
Limestone soil	Light color	100 k	Demarcation of perimeter of plots.
Tools			
Article	**Technical specifications**	**Quantity**	**Utility**
Buguis	Deep container	6	Soil transport
Shovels	Flatbed	10	Soil extraction
Shovels	Concave bucket	10	Soil extraction
Spades	-	10	Soil removal
Bars	More than 4 cm in diameter	2	Soil removal
Winch	5 m	1	Measurement of length and width
Machinery and vehicles			
Unit	**Technical specifications**	**Quantity**	**Utility**
Bus	20 passengers or more	1	Personnel transport
Truck	All terrain	1	Transport of personnel, tools and materials
Staff			
Charge	**Quantity**	**Time in hours**	**Function**
Supervising Engineer	1	128	Logistics supervision
Biologist	1	128	Technical supervision
Worker	20	128	Support in the execution of the work
Driver	2	32	Driving the vehicles

B. *Water*

The selected vegetation of the Laguiña stream to be moved is typical of wetlandses. Wetlandses are vegetal formations that need hydromorphic soils to establish themselves. The formation of this type of hydromorphic soil requires a sufficient and constant amount of water to allow it to flood and carry nutrients. It does not contain hydromorphic soils for the most part, only some sectors are seasonally flooded. The remains of vegetation found suggest that there were previously small sectors of wetlandses, but they disappeared because the flow of the permanent courses diminished over time and became in seasonal ravines.

C. *Opening of Channels*

TABLE II: Main Canal, Irrigating Plots and Quantitative Data

Measures	Main channel
Length	300
Width	40 cm
Depth	25 cm
Average flow	67 L/s
pH range	4(winter) - 7(summer)
Range of electrical conductivity	0.28

Main. The main canal was built as a water supply for the vegetation of the five open plots. The main canal water intake is located on the right bank of Patari Creek, 270 m downstream from the confluence of Patari Creek and Laguiña Creek. This channel has an approximate length of 300 m from the water intake to its final point. The flow it carries is not stable and depends on the flow of Patari Creek, which in turn depends on the amount of rainfall received in the area of its basin. Table II below describes the main characteristics of the main channel [7], [8].

Second order. From the main canal, second order canals were opened to bring water to the five built plots. A total of five canals were opened, some up to 15 m long. Given the irregularity of the terrain in some in other cases, two second order channels had to be opened per plot, and in other a single channel diverted the course for two plots. The measures of the channels of second order, the plots they feed and the flow of water they can supply are detailed in Table III [8], [9].

TABLE III: SECOND ORDER CHANNELS, IRRIGATING PLOTS AND QUANTITATIVE DATA

2nd order channels	Length in meters	Width in cm	Average depth	Average flow
Channel 2.1	2m	15 cm	4 cm	3 L/s
Channel 2.2	5m	15 cm	5 cm	1,5 L/s
Channel 2.3	10 m	25 cm	5 cm	3,75 L/s
Channel 2.4	10 m	30 cm	6 cm	21,6 L/s
Channel 2.5	12 m	30 cm	7 cm	16,8 L/s
Channel 2.6	22 m	30 cm	7 cm	20 L/s

D. Fertilization and Stimulation

Although the results of the soil analysis presented indicate the existence of fertile soils in the 1 sector, the need for application has been determined of a foliar fertilizer for rapid regeneration of damaged vegetation during transfer process.

The vegetation has its maximum opportunity to adapt to the new terrain in the rainy season, that is to say, from December to April, so it must have the necessary nutrients. Most of the organs of nutrient absorption such as the roots and root hairs were found to be damaged, so the best solution is the application of a direct absorption fertilizer. It would be advisable to use organic fertilizers such as compost or worm humus, but their application requires that the vegetation is correctly implanted so that it can take advantage of them. The foliar fertilizer, in spite of being a synthetic fertilizer, has the advantage that it can be absorbed directly by the leaves, stems and roots, so that its use can be "emergency" until the regeneration and adaptation of the transplanted vegetation is achieved. Its use in ecosystems such as wetlands has not been tested, so field trials were conducted to determine its acceptance by vegetation and the minimum concentration necessary so that it would not stress the plants for excess salt.

A test with hormonal stimulants was also performed, in this case with an auxin-type rooting complex, already described according to its action. The use of hormones rooting has also not been tested on wetland vegetation so there are no bibliographic references to direct the experiment. [10]

Table IV below presents the results of the study carried out in the field to determine the acceptance and the minimum amount of leaf and rooting fertilizer required. As can be seen, the effect of the leaf fertilizer, although positive, does not vary considerably from one concentration to another. On the contrary, rooting hormones do cause considerable growth at higher concentrations.

The design for the relocation considered physical, biological and water availability parameters, defining drainage systems to guarantee water flow and achieve soil saturation.

An important point considered was the recording of surface water quality monitoring data, which showed values typical of the mineralogical influence of the Inmaculada Mining Project deposit given the natural conditions (geology and edaphology) present in the study area.

IV. DISCUSSION

TABLE IV: RESULTS OF THE TEST ON THE USE OF FOLIAR FERTILIZER AND ROOTING IN DISTICHIA MUSCOIDES

Samples	Substance used	Concentration Ml x L of water	Type of irrigation	Results 1 (27-03-14)	Results 2 (2-04-14)	Results 3 (9-04-14)
MDm 01	Foliar fertilizer 20-20-20	10 ml × 2 L	Creek water apparently without solids or these not visible.	0 mm	03 mm	05 mm
MDm 02		5 ml × 2 L		0 mm	03 mm	04 mm
MDm 03		2,5 ml × 2 L		0 mm	03 mm	04 mm
MDm 04		0,65 ml × 2 L		0 mm	03 mm	04 mm
MDm 05		10 ml × 2 L		0 mm	03 mm	04 mm
MDm 06	Rooted Hormones	10 ml × 2 L	Creek water apparently with solids or these not visible.	0 mm	09 mm	12 mm
MDm 07		5 ml × 2 L		0 mm	07 mm	10 mm
MDm 08		2,5 ml × 2 L		0 mm	05 mm	12 mm
MDm 09		0,65 ml × 2 L		0 mm	01 mm	03 mm
MDm 10		10 ml × 2 L		0 mm	01 mm	02 mm
MDm 11	None	-	Creek water apparently without solids or these not visible.	0 mm	0 mm	0 mm
MDm 12	None	-	Creek water apparently with solids or these not visible.	0 mm	0 mm	1 mm

The execution of the research project in the experimental part considered techniques of manual execution that have allowed the parceling and clearing that ensures the nutrients, considering an organic soil necessary for its adaptability and success of the project.

The previous work in the pilot area, which involved the addition of organic foliar fertilizer and rooting hormones, was counteracted by observation, obtaining a physiological development that has been decisive for its massification in the 2,000 m2 of wetlands, whose flowering has been evident as a result end of adaptability [6], [11].

It has been determined, as shows in Table IV, that the physical space selected meets the physical and biological conditions, in that sense it has been allowed to release the area in which the Mining Project. Inmaculada has determined that of a Tailings Deposit whose technical considerations of physical stability have been supported in the engineering studies and approved in its Environmental Impact Study so that the U.M. can develop its mining operations, complying with the relocation of the wetlandses for purposes of Compensation and Environmental Management.

The execution of this investigation leads to continue a consolidation process, maintaining a drainage and soil saturation system. The receiving area has acquired ecosystemic properties, showing a biodiversity that has been progressively increasing [4], [9], [12].

V. Conclusion

The present investigation, after its experimental phase and the evaluation of diverse factors considered like: edaphological, vegetation, agrostological, hydrobiological, water quality, among others; of by means of the Transfer and Adaptability of Wetlandses was able to execute the Compensation and Environmental Management for the Immaculate Mining Project.

Keep a daily timed record of the transplant actions to be performed, step by step, in which the phenology of each species must be indicated, in order to take corrective actions that improve effectiveness. Environmental factors in which each one is installed to find relationships between these and the survival success of the champagne.

It is recommended to install signs indicating to the local population the restrictions and prohibitions regarding their use, as well as the installation of fences around the area of the proposed sector, thus providing safety against pets and foraging activities. Also, to have an optimal trained and specialized team considering the machinery and equipment assigned for the execution of the project, as well as a Security Plan, considering specific aspects of the proper tasks of adaptation of the transfer of the wetlands.

The short distance, the climate and other physical and biological aspects, allowed to overcome the drawback of moving a type of vegetation from one defined location to another with some variations that could negatively influence the success of the transfer of vegetation, an important factor being the experimental phase.

Conflict of Interest

This research was carried out as a contribution to the knowledge, society and academic purposes in a multidisciplinary environment, "The authors declare that we have no conflicts of interest".

Author Contributions

A carried out the research design; AB analyzed the data; AC carried out the design of the ABC and D study area. We carried out the exploratory field study; the authors' contribution is reflected in all the research approved in its final version.

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