Identification and Characterization of Life Zones at Satipo District in the Tropics of Central Peru

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Abstract. At present, the life zones have undergone great changes due to anthropic activities, so the present study was carried out with the aim of identifying and characterizing the life zones of the Satipo district. The applied methodology was the Holdridge life zone classification, the meteorological variables were analyzed, the vegetation cover was identified, also using the ArcGIS, QGIS, ENVI and Microsoft Excel software, the data analysis and field information were processed. In the investigation of bioclimatic factors they show that there are four important determinants: annual biotemperature, mean annual accumulation, humidity provinces and attitudinal levels. Noticing the decline of forests, overpopulation, among others, many companies are choosing to reduce products that lead to the loss of life zones. In the district of Satipo, three life zones were identified and two of a transitory nature of the one hundred and twenty-three existing ones.

1. Introduction
Throughout several years, anthropic activities have modified the natural vegetation cover by various activities such as; exhaustive exploitation, illegal logging of timber species, livestock expansion, indiscriminate hunting of animals, overpopulation in urban areas, the establishment of large industrial companies that generates consequences such as changes in the meteorological variables of temperature, precipitation, solar radiation, winds and deterioration of the ozone layer that causes the so-called climate change, in such an effect at present the life zones are suffering these great changes. Holdridge clearly states that, “A life zone is a group of plant associations within a natural division of the climate, which are made taking into account the edaphic conditions and the stages of succession, and which have a similar physiognomy in any part of the world” [1].

Soil degradation is a difficult term to visualize and understand. The best way to know if a soil is degrading is by knowing the dynamics of its properties; this means that it is necessary to carry out periodic monitoring of indicators [2]. The change in land use is one of the topics of greatest interest today for environmental sciences and ecology, since this phenomenon constitutes one of the factors involved in global warming by altering biogeochemical cycles, such as that of water or that of carbon [3]. Soil contains the most important carbon reserves on the continents. The total mass of organic C in soils has been estimated at 30 x 10-14 kg, similar to the average of all other C reservoirs on the earth's surface, which amounts to 21 x 10-14 kg. [4].
INRENA - National Institute of Natural Resources, mentions that “Peru is a megadiverse country that is home to different species of flora and fauna, having three great natural regions such as coast, mountains and jungle, showing a diversity of climates that is home to different cultures and languages, with great tourist potential. According to the National Institute of Natural Resources of Peru in 1976 it established the geographical distribution of 84 life zones and 17 of a transitional nature of the 123 existing in the world [5]. In contrast, “The district of Satipo at a scale of 1:50 000 presents four life zones such as; humid forest - Tropical Premontane (bh-PT), very humid forest - Tropical Premontane (bmh-PT), pluvial forest - Tropical Premontane (bp-PT), and pluvial forest - Tropical Lower Montane (bp-MBT) ”, in such sense with this current problem, motivated the execution of this research work. For these reasons the following objective was set; identify and characterize the life zones of the Satipo district.

2. Methodology

2.1. Place of study

The study area is located in Peru, in the Junín region, in the province of Satipo, in the district of Satipo, it has an area of 815.09 km2 and a perimeter of 216.70 km. The physiography that the district of Satipo presents is that it has a Great Landscape, of mountainous relief, inside it is landscapes of urban areas, on the other hand, it has landscapes of plains of low non-floodable terraces, and finally it has landscapes of mountains with steep mountain tops [6].

**Figure 1.** Map of annual accumulated precipitation of the district of Satipo.

In its climatic characteristics it is shown that in the historical data of the WorldClim 1970 - 2000, the annual average temperature varies from 15ºC to 25ºC, in the case of its annual accumulated precipitation it fluctuates between the values of 1000 to 2300 millimeters, according to the historical data of the WorldClim from 1970 to 2000 (Figure 1). In the district of Satipo the following types of soils were identified: loam texture and moderate permeability, sandy loam texture and moderate permeability, and clay loam texture and moderately slow permeability [6].
2.2. Sampling method

In the first instance, the base materials were obtained, which are: historical data of the WorldClim of precipitation and average temperature of a series accumulated from the years 1970 to 2000; a Landsat 5 satellite image with 30-meter spatial resolution bands taken on August 16, 1991; five Sentinel 2A satellite images with bands of 10 meters of spatial resolution taken in 2017 and 2018; four images of the Alos Palsar digital elevation model with a solution of 12.5 meters of spatial resolution taken in 2011; the Geological Map, Soil Map, Physiographic Map, Geological Map, Greater Use Capacity Map and Life Zones Map prepared by the Junín Regional Government published in August 2015; the national, regional and district limit of Peru published in 2007 by the National Institute of Statistics and Informatics (INEI), the Population Centers published in December 2016 by the Ministry of Education (MINEDU), and the Road Network of the Ministry of Transport and Communications of the year 2016.

In order to collect recognition information in the field and have a better visual contact with the study area, it was by taking photographs and GPS points, this process allowed identifying and obtaining information on various characteristics of the vegetation cover, the current land use, the units and elements of the landscape. The information obtained from the biotemperature, precipitation, humidity provinces and the altitudinal floors, the ArcGIS software was used to combine the different layers and making use of the Holdrid bioclimatic diagram [1], to determine and identify the corresponding life zones of the Satipo district.

2.3. Statistic analysis

The geoprocessing and analysis operations were obtained with the use of ArcGIS 10.5 software; to determine and identify the life zones corresponding to the district of Satipo. For the processing of the satellite images, in the atmospheric correction: the QGIS 10.5 software was used; which helped in the process of improving the quality of the image, eliminating the effect of aerosols and the intrinsic radiance of the object of study. In the case of cloudiness correction: it was carried out to replace the cloudiness of the Sentinel satellite image with other images that do not present clouds, using the PCI Geomática 2017 software. In the supervised classification, the ENVI 5.3 software was acquired; To classify the image by means of the spectral signatures of each pixel of a cell, it was also used to determine the coverage based on the categories of: Vegetation (where we find the different formations of natural regeneration of secondary forests, low purmas and purmas high); Without Vegetation (there are various types of crops, deforested areas, burning of vegetation, urban and rural establishments); and Rivers (you will find the representative bodies of water).

For the calculation of the annual accumulated precipitation, the information corresponding to the district of Satipo was extracted towards an entity of points of each of the months, with their respective coordinates and altitudes of the digital elevation model (DEM), then the analysis was carried out and statistical calculations with Microsoft Excel 2016 software.

3. Results

3.1. Determination of bioclimatic factors

As shown in figure 2, it can be observed that the district of Satipo presents values of average annual biotemperature in which the vegetative growth of the plants takes place, according to the historical data of the WorldClim it varies between 15.52 to 25.07 °C throughout the territory, according to the linear regression, the biotemperature decreases as the elevation increases, showing a high correlation, with three of the seven ranges of the bioclimatic diagram being found; the first ranges from 15.52 to 18.00 °C. Occupying an area of 9.26 km² (1.14%) being on the border with the district of Pampa Hermosa. The second range goes from 18.00 to 24.00 °C in an area of 722.76 km² (88.67%) occupying the largest geographical area. And the third range between 24.00 to 25.07 °C with 83.07 km² (10.19%) within which are the populated centers. These results in comparison with the study of the Ecological Map of Peru carried out by INRENA (1995), the district of Satipo that presents the average annual
biotemperature between 6 to 25.6 °C, and according to the ZEE Junín (2015), it varies from 12 to 28 °C, both using data from the SENAMHI meteorological stations, finding some similarity with the research because in the district of Satipo the average annual biotemperature has been determined from 15.62 to 25.07 °C according to Historical data from WorldClim 1970 - 2000.

**Figure 2.** Biotemperature (Right) and Average Annual Accumulation (Left)

Furthermore, as shown in figure 3, the amount of water that falls on the surface of the district of Satipo in the form of precipitation, according to the historical data of the corrected WorldClim varies from 1000 to around 2300 millimeters per year, which according to the non-linear regression, precipitation presents a polynomial or curvilinear distribution, this shows that there is no correlation between altitude and precipitation, finding two of the eight ranges established by the bioclimatic diagram; which the first goes from 1000 to 2000 mm occupying 396.06 km² (48.59%) being the populated centers. And the second from 2000 to 2300 mm with 419.03 km² (51.41%) distributed in the populated centers. In contrast to the study of the Ecological Map of Peru updated by INRENA (1995), the district of Satipo presents certain similarity since it presents the annual accumulated precipitation between 936 to 5661 millimeters, the study of the ZEE Junín (2015), varies between 1400 and 2200 mm, and according to the ZEE of the Province of Satipo (2010), the annual accumulated precipitation varies between 1000 and 2000 mm, using data from the SENAMHI meteorological stations, finding some similarity in the investigation because in the district of Satipo the annual accumulated precipitation has been found that varies from 1000 to 2300 millimeters according to the historical data of the WorldClim 1970 - 2000 corrected according to the characteristics of the forest and the humidity index.

**Figure 3.** Provinces of Humidity province (left) and Altitude Floors (right)
As can be seen in figure 3 in the left side, environmental humidity is determined by the relationship between temperature and precipitation, in the territorial scope of the district of Satipo the relationship of potential evapotranspiration varies from 0.40 to 1.18, with three provinces humidity: PerHumid, Humid and Subhumid; of the twelve mentioned in the bioclimatic diagram. The province of Perhúmedo humidity occupies 9.26 km2 (1.14%) is distributed in the upper part of the district of Satipo bordering with the district of Pampa Hermosa; The Humid Moisture province occupies 794.79 km2 (97.51%) and is distributed throughout almost the entire district, with most of the populated centers. And in the province of Subhumid humidity it covers 11.04 km2 (1.35%) of the territory, located on the banks of the Satipo River on the eastern side until the confluence with the Mazamari River and the bank with the Perene River. According to the study of the Ecological Map of Peru by INRENA (1995), in the district of Satipo four provinces of humidity were found, such as; Subhumid, Humid, Perhumid and Superhumid, and in the study of the EEZ 1.14% 97.51% 1.35% 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% 0.40 - 0.50 0.50 - 1.00 1.00 - 1.18 PerHumid Humid SubHumid Ranges Provinces of humidity 37 Junín, 2015, three were found as; Subhumid, Humid and Perhumid, finding a certain similarity in the research due to the fact that in the district of Satipo.

In right side of figure 3, it can be seen that the district of Satipo presents three of the seven altitudinal floors of the bioclimatic diagram, these were determined according to the altitude and the annual mean biotemperature (°C) (see Annex 01), the altitude in the territorial scope rises from 386 to 2790 m s. n. m. finding the basal, premontane and lower montane floor. The Basal altitudinal floor varies from 386 to 670 m s. n. m. occupying 83.07 km2 (10.19%), found throughout the alluvial valley of the river Satipo and perennials between the populated centers; Satipo, C.N Rio Bertha, Santa Rosa de Cashingari, C.N Juan Santos Atahualpa, Sivichari, Marankiari, San Jacinto, C.N Shanki, C.N. San José de Quirichari, etc. The Premontane Altitudinal Floor 10.19% 88.67% 1.14% 0% 20% 40% 60% 80% 100% 386 - 670 670 - 2050 2050 - 2790 Basal Premontane Lower Montane Range in m s. n. m. Altitudinal floors 38 vary from 670 to 2050 m s. n. m. occupying 722.76 km2 (88.67%) of the territory. And the lower montane altitude floor from 2050 to 2790 m s. n. m. occupying 9.26 km2 (1.14%) of the territory, this is located to the west and bordering the district of Pampa Hermosa. According to the study of the Ecological Map of Peru by INRENA (1995), the district of Satipo presents the altitudinal variation that ranges from 300 to 3000 m s. n. m., and in the study of the ZEE Junín (2015), it rises from 250 to 3000 m s. n. m. finding in both studies three altitudinal floors; Basal, Premontane and Lower Montane. Similarity is found with the investigation in the altimetric variation that goes from 386 to 2790 ms. n. m. and in the three elevational floors identified, but there is a discrepancy in the ranges determined because the altitude is highly correlated with the mean annual biotemperature (°C) being those that determine the lines of the altitudinal floors and this varies according to the climatic characteristics of area.

**Table 1.** Comparisons with Junín ZEE “Economic ecological zoning” and ONERN “National Office of Natural Resources Assessment” results reprinted by INRENA “National Institute of Natural Resources”

| Feature | Life zones | Altitude (m. a. s.l.) | Biotemperature (°C) | Precipitation (mm) |
|---------|------------|-----------------------|---------------------|-------------------|
| **THESIS RESULT** | Dry forest - Tropical | 386 - 590 | 24.25 - 25.07 | 1000 - 1467 |
| | Dry forest - Tropical / humid forest | 590 - 670 | 24.00 - 24.25 | 1430 - 1810 |
| | Tropical Premontane | | | |
| | Humid forest - Premontano Tropical | 670 - 1400 | 21.13 - 24.00 | 1527 - 2000 |
The Table 1 clearly shows that, the less vegetation covers shown are increasing due to the increase of anthropic activity, basically agriculture with various crops, also treating them as pastures in the various soils for livestock. In this period of time, it has also seen a variant in the diversity of life in both flora and fauna, implying that during the last 27 years the decrease of these sites has been increasing and on a large scale very alarming for various countries, specifically in our studied area of life (Satipo) indiscriminate logging and urbanization in spraying of rural areas is an alarming case in our district and in comparison to it in the living areas found rainfall and temperature have been changing.

### 4. Discussion

The diversity of life zones is very essential for the conservation of both flora and fauna species. In Peru, the Amazon forest present is one of the largest in conservation and where there are different life zones; all this thanks to its altitudes, temperature, rainfall and other attributes it possesses. Amazon forests play an important role in the carbon cycle and how it is distributed. Total dry biomass (TAGB) was quantified in undisturbed central Amazon rainforests, based on detailed estimates of all living and dead plant material in a 201 Ha plot [7]. Giving itself to see that in addition to the conservation of life of wild species it is also optimal for the demand of carbon capture and the benefits that this gives to our planet. The loss of biodiversity and redundancy in biomass severely limits the long-term services of biodiversity at various spatial scales (local, regional and global). The thought of resilience promotes the systematic configurations of adverse effects and, therefore, fosters the simultaneity of analysis with the capacity...
for adaptation and transformation with the assimilation of the context, for which principles were proposed. These principles of reality thinking are analyzed in terms of land use planning and land management of the Amazon biome [8].

Model experiments predict a large-scale replacement of the Amazon rainforest by savanna-like vegetation by the end of the 21st century. Growing global demands for biofuels and other resources are creating new incentives for agribusiness expansion in the Amazon rainforest regions [9]. The overexploitation of the resources of the life zones is a great problem for the reduction of global warming among other destructive situations. For this reason, researchers must take samples from many, geographically from the Amazon basins: biomass carbon cycle, global warming, terra firma, river rainfall, amount of vegetation and estimates of living and dead plants [7]. Among other data to be collected from the life zones, the probabilities of damage that will occur in subsequent years are determined. Commodity markets are demanding greater environmental performance from farmers and ranchers. Protected areas have been established in the way of expanding agricultural frontiers with it being supported by the emerging carbon market so reducing deforestation could support these trends [9].

5. Conclusion
In the entire geographical area of the district of Satipo sing WorldClim data, it is determined that the average annual biotemperature varies between 15.52 to 25.07°C. In the three provinces found they are: perhumid, wet and subhumid; in the altitudinal floors they ascend from 386 – 2790 m.a.s.l.m finding the basal, premontane, and montane and montane low floors in which the annual accumulated precipitation goes between 1000 to 2300 ml, in the province of humidity fluctuates between 0.04 to 1.18. Three life zones and two transitional zones of the one hundred and twenty-three of the bioclimatic diagram were identified, the following mentioned: The tropical dry forest; it has an altitude of 386 to 590 m.a.s.l.m. with an average annual biotemperature ranging from 24.25 to 25.07°C and an annual rainfall that fluctuates from 1000 to 1467 millimeters. The dry forest – Tropical transitional to humid forest – Premontane where its altitude is from 590 to 670 m.a.s.l.m. average annual bio temperature of 24.00 to 24.25°C with an annual rainfall between 1430 to 1810 millimeters. The humid forest – Transitional Tropical Premontane to very humid forest – Tropical Premontane From an altitude of 835 to 2050 m.a.s.l.m. the average annual bio temperature presents between 18.00 to 23.29°C with precipitation between 1548 to 2134 millimeters. In the very humid forest – Montano Bajo Tropical with altitude between 2050 to 2790 m.a.s.l.m. with a biotemperature between 15.52 to 18.00 °C with precipitation from 2000 to 2300 millimeters. From the hypothesis we conclude that the hypothesis raised at the beginning of this thesis is rejected.

6. References
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