Spatial planning of the timber industry and the social-environmental and economic impact in Pucallpa-Ucayali (Peru), 2000-2019

CARLOS MEZA ARQUIÑIGO[1], ALIDA ISIDORA DIAZ ENCINAS[2], NÉSTOR MONTALVO ARQUIÑIGO[3]
[1]National University of San Marcos, Lima, PERU
[2]National University of San Marcos, Lima, PERU
[3]National Agrarian University - la Molina, Lima, PERU

Abstract: This research was conducted in the districts of Calleria, Manantay and Yarinacocha in the province of Calleria, department of Ucayali (Peru). The goal was to assess the spatial planning of the timber industry and the social-environmental and economic impact in the 2000-2019 period with the aim of improving the quality of life and the environment. For this purpose, spatial analysis was performed using cartographic modelling and the buffer tool was applied to determine the zones of influence of the pollutants from the timber industry, for which the timber industry locations were georeferenced and digital maps were integrated for the spatial analysis of the three districts.

The results revealed that the timber companies were mainly concentrated in the district of Manantay, followed by Calleria and Yarinacocha. The locations of the industries have no established order – the sites are spatially dispersed. However, the municipalities are drawing up land-use plans to zone urban areas, and they are acclimatising to a certain extent – for example, charcoal kilns are located at a distance from the towns, and companies are selling sawdust for chipboard manufacturing.

Nevertheless, what is lacking is control of the wetlands and wastewater treatment. As a result, respiratory diseases are at "very high" levels (26%, 50 metres away) and "high" (42%, 100 metres away). The environmental impact is "very high" (37%, 50 metres) and "high" (47%, 100 metres). Dumping of waste is "very high" (37%, 50 metres) and "high" (47%, 100 metres); and the effect on vegetation cover is "very high" (5%, 50 metres) and "high" (32%, 100 metres).

With regard to the socioeconomic status of the surveyed population, this was measured by the materials used in the construction of residents' homes, where wood and cement construction prevails at a medium level (79%, 150 metres), in comparison to other building materials. In other words, the nearer the houses are to the timber industries, the greater the effects of contaminants, and the further away, the lower the effects in terms of industry, nature and society.

Keywords: spatial planning, environmental, industries, location, planning, social.

Received: April 20, 2021. Revised: May 24, 2021. Accepted: May 25, 2021. Published: May 31, 2021.

1 Introduction

The research project "Spatial planning of the timber industry and the social-environmental and economic impact in Pucallpa-Ucayali, 2000-2019" has been carried out with funding from the National University of San Marcos through the Vice-chancellorship for Research and Postgraduate Studies. The growth of the timber industry and the population, and the increase in socio-economic and environmental concerns, were studied. The following issues have been raised:

- What measures have been taken regarding the spatial planning of the timber industry and the social-environmental and economic impact in 2000-2019 period with the aim of improving the quality of life and the environment?
- Where is the timber industry located in the area of study? What are the levels of pollutants in the area of study? Have social-environmental and economic conditions improved? And what legal standards have been implemented in the interest of the environment and the planning of the timber industry and its surrounding area?

In this respect, the study is justified by the fact that records show the strong growth of the timber industry in the region of Ucayali, located in the urban area, and the subsequent socioeconomic impact on the environment as a result of increased forest clearance and pollution.

The project will contribute to and have an impact on identifying suitable spaces for the growth and expansion of the timber industry, with the aim of zoning the suitable areas in the city of Pucallpa, in Yarinacocha and Manantay. In addition, the results of the research shall be reported to local, regional and national authorities.

Consequently, the results of the study will be shared with universities nationally and internationally, in addition to their publication in indexed journals, and in seminars and congresses.

The study focuses on proving the following general hypothesis: "The measures taken regarding the spatial planning of the timber industry and the social-environmental and economic impact in 2000-2019 period have not allowed permissible limits to be exceeded in order to improve the quality of life and the environment". In addition, the specific hypotheses are: 1) The timber industry borders the Rivers Ucayali and Manantay, and urban areas; 2) the levels of pollutants in the study area have not exceeded the permissible limits; 3) the social-environmental and economic conditions have not improved; 4) the legal measures that have been implemented in the interest of the environment and the planning of the timber industry and its surrounding area have had no effect.

We therefore hope to achieve the following general goal: assess the spatial planning of the timber industry and the social-environmental and economic impact of the 2000-2019 period with the aim of improving the quality of life and the environment. To corroborate this, we have outlined the following specific goals: 1) Locate the timber industries bordering the Rivers Ucayali and Manantay and urban areas; 2) Identify the levels of pollutants in the study area; 3) Analyse the social-environmental and economic conditions in the study area; 4) Assess the legal measures that have been implemented in the interest of the environment and the planning of the timber industry and its surrounding area.

.

2 Theoretical framework and background

In order to comply with the objectives and the systematic approach, the theoretical framework and background for the development of the research project are based on the following: "Land-use planning is a state policy and a planning instrument that facilitates the smooth organisation of the nation and the spatial projection of social, economic, environmental and cultural development policies of society, guaranteeing a suitable standard of living for the population and the conservation of the environment" [1]. Accordingly, "The goal of spatial planning is to define the allocation of the different uses of land or physical territorial space". "Spatial planning is the set of criteria, standards and plans that regulate the activities and settlements on the territory in order to achieve an optimum relationship between territory, population, activities, services and infrastructures". "To play a strategic role in guiding the government for the proper location and advantages of industrial clusters and achieving great economic and social benefits [2]. Spatial planning can, therefore, be interpreted as the projection in an area of economic, social, cultural and environmental policies of society and of the territorial system.

Peru has a forest reserve of 78.8 million hectares, of which seven million are located in the Ucayali region, making it a renewable resource with enormous potential that can serve as a foundation to support the economic and social development of the region. The sawmill industry is the most important wood-processing activity in Peru. Production consists of air-dried and kiln-dried sawn timber. Most of the sawmills are located in Ucayali and Junín. The demand for timber products is growing constantly, both in national and international markets. According to the FAO, global demand for these products doubles every seven years. There are more than 2000 predominant tree species in the region's forests, and currently there are 28 tree species that in 2002 reached a log production of 227,303 m^3, which is 12.17% less than 2001 production. The most important wood species include tornillo (25,052 m^3), silk floss tree (35,188 m^3), virola (20,097 m^3), assacú (22,370 m^3), pau mulato (20,918 m^3), mahogany, (5441 m^3), and Spanish Cedar (9,944 m^3). Likewise, industrial production indicators according to industrial lines for 2001 and 2002 are as follows: plywood 23,273 and 29,183 m^3 and parquet 1,189 and 4,429 m^3, respectively (BCR-Iquitos (Central Reserve Bank of Peru)); and companies engaged in forestry processing total about 507, according to the Regional Production Office, (2003). Walter Isard (1956) presents a general equilibrium model where the optimal location of each company, the optimal combination of outputs to be produced and the quantities of factors to be employed according to the size of the company are simultaneously resolved. Applying a mathematical problem, he deduced that the marginal rate of substitution between any two transport inputs must equal the reciprocal of the ratio of the corresponding prices (or transport fares). His model is a reformulation of Weber's theory expressed in terms of substitution of transport inputs. Smith also introduced the concept of "subtracted value", which consists of negative effects (pollution, etc.) that have to be compared to positive ones and that can create negative externalities. In a nutshell, "the total contribution of the industry must be assessed taking into account profits and losses, in addition to technical, economic, social and cultural factors. The study of the industrial location should be seen as an interdependent part of the whole industrial system" [3].

Spatial analysis is a relatively recently developed branch of research. By relying on statistical methods and mathematical models, using maps, geographic information systems (GIS) and different simulation tools, and integrating the results of surveys on behaviour in the area and its representations, spatial analysis is applied to many other fields besides geography, such as spatial economics (or regional science), history, agronomy, archaeology, environmental science, etc.

As the locations usually depend on where the raw material comes from, in other words, at a distance from the urban areas, the company employees are, above all, affected by noise; hence, ear protection should be mandatory. In contrast, the urban areas in the city of Pucallpa, according to INADUR (National Institute for Urban Development), gradually increased from 38.4 ha (1942), 129 ha (1952), 322 ha (1962), 859 ha (1971), 1090 ha (1981), 2321 ha (1993) to 2351.8 ha (1996) [4]. Likewise, its urban population has been increasing over the years: 26,391 inhabitants in 1961, 60,547 inhabitants in 1972, 90,653 inhabitants in 1981, 172,286 inhabitants in 1993 and 268,735 inhabitants in 2007 (2007 INEI Census (National Institute of Statistics and Information)) and 326,040 inhabitants in 2017 (2017 INEI Census).

According to Carlos Meza (2011 "The timber companies are mainly concentrated in the district of Manantay, followed by Calleria and Yarinacocha. The locations of the industries have no established order – they are spatially dispersed and the municipalities should draw up land-use plans to zone urban areas. Particle pollution is 179,615 µg/m3 which exceeds by 29,615 µg/m3 the permissible limit of 150 µg/m3. Furthermore, there is pollution from particles smaller than microns (fine dust), generated by the sample sawmill. There was evidence of respiratory and ear diseases among people surveyed. Monitoring the health of the population in the areas surrounding the companies is recommended". Furthermore, he mentions that "In the field work, contamination was preliminarily found in the Rivers Manantay and Ucayali, where black particles were observed from sewage on the riverbanks, where waste, untreated by the sawmill companies, is dumped. As a result, it has affected river biodiversity, flora, fauna and people (corroborated by environmental health information). In the first meetings, the residents of the area under study reported respiratory ailments, and hearing and vision disorders. On the second trip, we spatially checked the areas affected by these sawmill companies to test the pre-established location model" [6].

3 Description of the study area

3.1 Location

The study area covers the Calleria, Manantay and Yarinacocha (urban area) districts**,** where the sawmill, parquet and plywood industries are situated. It is located in the city of Pucallpa, Ucayali region, on the left bank of the Rivers Ucayali and Manantay, between the UTM coordinates 542214.5, 9077404.5 and 553281.5, 9069310.5 and at an altitude of 154 MASL.

3.2 Urban space

The area includes Manatay, Calleria and Yarinacoha. According to Meza (2010) they are characterised by their high levels of annual urban population growth – the population in 1940 was 2368 inhabitants; in 1961, 26,391 inhabitants with 12.2%; in 1972, 57,993 inhabitants with 7.4%; in 1981, 89,604 inhabitants with 5.0%; in 1993, 172,286 with 5.6%; and in 2007, 268,735 inhabitants with 3.2%. As shown, the highest annual urban growth rate was between 1940 and 1961 and the lowest between 1993 and 2007. According to the 2011 project, spatial development over the years in urban areas has been increasing from 38.4 ha (1942), 129 ha (1952), 322 ha (1962), 859 ha (1971), 1090 ha (1981), 2321.8 ha (1993) to 2351.8 ha (1996); and according to our research, the urban areas increased by 2950 ha in 2003 [7]. This data is complemented by INEI (2017) data, according to Table 1, which reflects 292,828 inhabitants in 2007 and 328,831 inhabitants in 2017, with densities of 26 and 30 inhabitants per km^2, respectively [5].

Thus, according to the data collected and the information from the thematic maps, there was a greater increase in urban expansion between 1981 and 2003 and 2010, coinciding with a growth in the population [7].

3.3 Climate

The study area presents a warm, humid, tropical climate typical of the lowland rainforest, which is expressed in the data collected in the field and whose elements have been analysed using Köppen criteria, as climate is defined as the long-term statistical average of meteorological elements (rainfall, temperature, sunshine and wind) and it is a determining factor for plant growth. Furthermore, it plays a major role in human activities, and therefore is a key element to be considered in planning.

The heaviest rainfall occurs in October, November, December, January, February and March, with a maximum of 226.9 mm; the lowest rainfall is in April, May, June, July, August and September, with a minimum of 51.6 mm (July) and with an annual total of 1557.6 mm. The maximum relative humidity is 86.7% in February and March; the minimum is 81.5% in September, and the annual mean is 84.6%. The maximum mean monthly temperature is 32.0°C in September and October, with a maximum mean annual temperature of 31.1°C; the minimum mean monthly temperature is 18.2°C (August), with a minimum mean annual temperature of 20.0°C; with maximum oscillations of 12.9°C (August) and minimum fluctuations of 10.2°C (February) and an annual mean of 11.1°C. The average annual mean temperature is 25.5°C. The maximum evaporation is 72.0 mm (August), minimum 47.2 mm (February) and with a total annual mean of 676.6 mm. Potential evapotranspiration is 144.1 mm (November), minimum of 112.6 mm (July) and a mean annual evapotranspiration of 129.5 mm (November). (Climate Weather Station, National University of Ucayali, 2006). [8].

Solar radiation is at a maximum in July with 219 hours of sunshine, and the minimum is in February, with 114.9 hours of sunshine. The mean total is 1931.4 hours of sunshine. Luminance can be seen in overcast skies in September, October, November, December, January and March, as a maximum of 179.67 ft-cd (March); and with little cloud cover in February, May, June and July, with a minimum of 77.79 ft-cd (February) (Climate Weather Station, National University of Ucayali, 2006). [8].

Winds come from the SE in May, June and July; and from the N, NW, NE, NW, NE, NE, NE, NE, NE, NW, NW in January, February, March, April, August, September, October, November and December respectively; with a predominant NW direction, and with an average wind speed of 1.7 m/s. (Climate Weather Station, National University of Ucayali, 2006) [8].

The study area covers two well-defined seasons: rainy, influenced by the NW winds, with heavy rainfall and overcast skies typical of October, November, December, January, February, March and April. The other season is dry, with minor rainfall, high amount of sunshine and low cloud cover, and influenced by southerly winds, with high temperatures in the months of May, June, July, August and September characterised by a tropical humid or hot humid climate [9].

3.4 Hydrography

In terms of hydrography, Lake Yarinacocha, located in the northeast, and Lake Cashivococha, in the north, have been studied. They both have very important landscape features and are used for communication. On the other hand, Lake Pacacocha, which is in decline due to the urban development processes in the surrounding areas. We should also highlight the presence of wetlands, streams and marshes. River Ucayali is the backbone of river communication and stretches from south to north. The River Manantay flows along the right bank of the River Ucayali; in addition, the stream of Asnacaño, which crosses the border of Callería, as can be seen on Map 2, is conserved.

The river rises between December and May, with a maximum level of 147.28 MASL, and the low water level or emptying of the river occurs between June and November, with a minimum level of 136.25 MASL. It is a means of transporting timber to the sawmills and the waste from wood processing [10].

3.5 Geomorphology

In terms of relief, it corresponds to the low rainforest region of the Amazonian plain, with the following geological formations: terraces, flood plains, tributaries, lakes, oxbow lakes, meandering rivers, such as Ucayali and Manantay. The difference in elevation is about four metres and the slope tends to zero, which allows for the accumulation of sediments and waste, especially in the River Manantay and the tributaries of Asnacaño, among others.

3.6 Economic activity

Pucallpa is considered to be the most important timber centre in Peru for its sawmill and wood-laminating industries, in addition to an oil refinery. It is a very important centre for commercial activity in the region. The main thoroughfare is the Federico Basadre road, which connects with the river port – of vital importance, as communications are also provided by the River Ucayali. There is also an airport with daily flights connecting with Lima and other bordering regions (Meza 2010) [6].

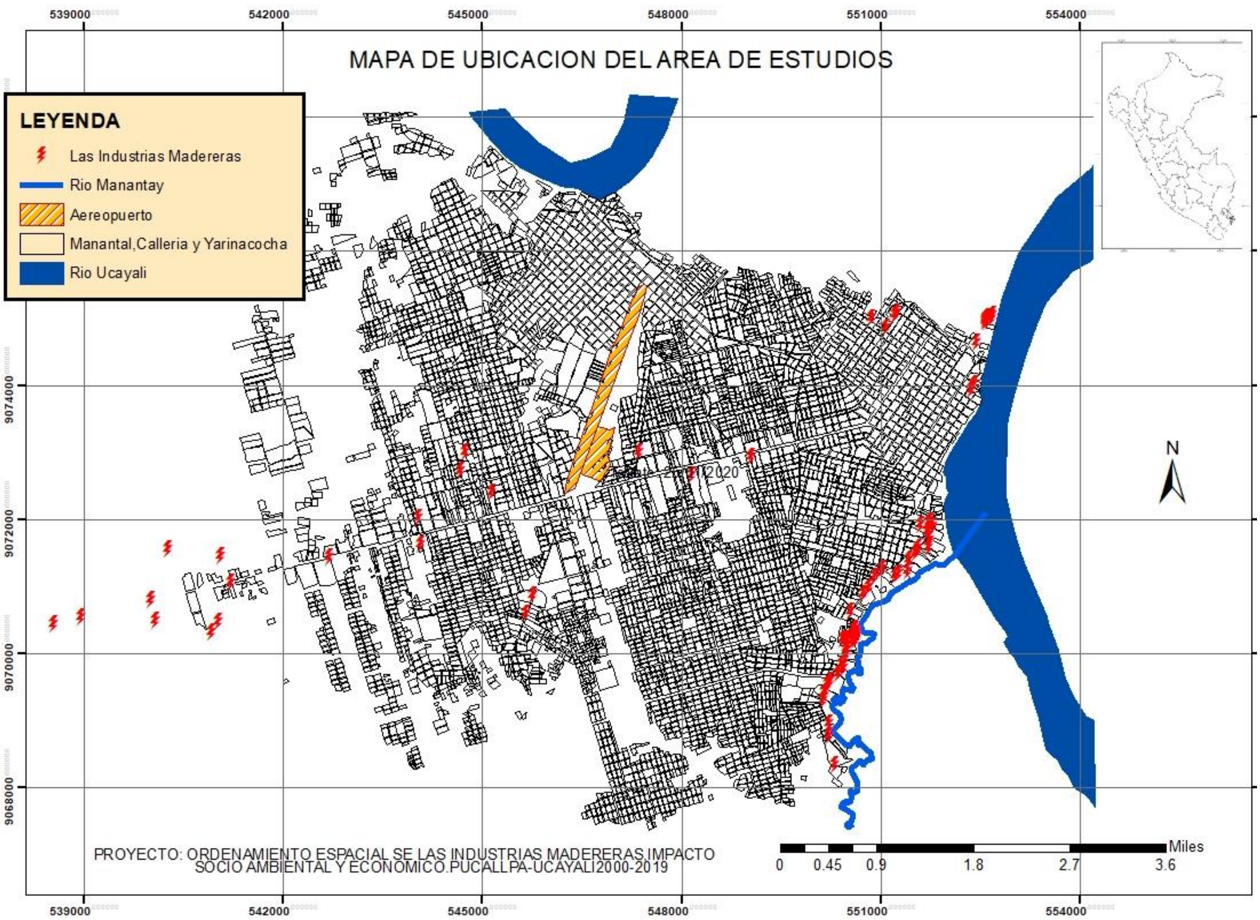
The timber industry uses renewable natural resources – the Ucayali regions timber trees – which are felled and transported mainly by river and dirt roads and discharged in the adjacent ports, as shown in Photos 1, 2 and 3. This is corroborated by the specific activities, at the district level, there are 669 timber companies dedicated to sawing and wood brushing representing 59%, 24.5% wood leaf factory, other products 14% and parts and pieces of carpentry 2.5%; also taking into account that in 2010 there were 131 companies engaged in primary timber processing, while by 2018 it was approximately 393 companies; at the study area level, in 2011 there were 35 companies and in 2018, 51 companies, which are substantial increases [10].They are then processed in the facilities to obtain planks, sleepers, plywood, etc., (Photos 3 and 4) and wood waste, such as wood shavings and sawdust. This is the basis of the company's relationship with the environment when it comes to determining a suitable location and dealing with issues generated by this timber industry activity (Meza 2010) [11].

4 Methodology

The study area consists of the urban areas of Pucallpa, Yarinacocha and Manantay, and the Ucayali region where the timber industries are mainly located (Map 1).

In order to illustrate the issues raised, spatial analysis was performed using cartographic modelling and the buffer tool to determine the zones of influence. The quantitative inductive method was also used to collect information using GPS; thus a buffering database was structured, zoned with the distances of 50, 100, 150, and 200 meters with respect to georeferenced industrial enterprises and their very high, high, medium, low and very low corresponding affectation levels respectively in order to identify the criteria with the pollutant indicators and complete the information in the database and matrix. This will allow to monitor the effects in the areas mentioned in order to have an orderly occupation of the space points, to cross-check with preliminary maps and pre-established surveys;

MAP **1**



Source: IGN. Municipalities of Calleria, Manantay and Yarinacocha. Regional Govt. Ucayali. Production Management. Authors' own compilation, UNMSM [12], [13], [14], [15], [16].

pollution was also monitored. The qualitative deductive method was used for the in-depth interviews with the inhabitants of the houses. Using cartographic modelling, the industries, urban areas, wetlands, etc., were georeferenced, and the relationship with the environmental management system and the influences of these timber industries was established through the following activities:

In the pre-field phase, the bibliographic, statistical, cartographic and related projects were reviewed; the matrix, surveys and interviews were prepared, as well as the measuring instruments and the preliminary thematic maps based on photographs and satellite images; then cartographic digitisation was carried out with its attribute and integration of the thematic maps. In order to meet the project goals, the influences and consequences of the timber industry were established using cartographic modelling and the buffer tool; samples were taken from between the company and the houses located at a distance of 50, 100, 150 and 200 linear metres with GPS recordings: Based on Matrix 1 with very high, high, medium and low levels, as well as the variables (diseases, environment, dumping of waste, vegetation cover and socioeconomic state), the key concepts of the variables used were defined as follows:

- C*artographic modelling using the buffer tool*: it consists of unifying cartographic and tabular information, establishing zones through the buffer command and then establishing criteria with the attribute and its respective variables and levels in order to collect information.
- *Diseases:* the effects of wood processing by the sawmills, the machinery and the lorries that drive on unpaved roads, which produce dust and noise associated with respiratory and ear diseases.
- *Environment*: a balanced set of elements encompassing nature, life, man-made elements, society and culture existing in a given space and time.
- *Dumping of waste*: material residues such as sawdust, dust, particles, chemical residues and waste dumped in the streets, streams, flood plains and the river.
- *Vegetation cover*: natural plants of the lowland rainforest; i.e. flood forest or adapted plants.
- *Socioeconomic state*: based on the materials used in the construction of houses located in the study area.

The instrument was then formulated and implemented in the field.

Information was collected during the field phase, including: surveys, interviews and GPS point surveys to complement the database of the timber companies surrounding the rivers and the urban area; based on cartographic modelling using the buffer tool of the influences at 50, 100, 150 and 200 linear metres from the companies to the homes, with GPS points, interviews, surveys and the observation of the impacts.

In the workshop, the data was explored and described and the information interpreted and analysed to complement the digital cartography and the presentation of the results.

MATRIX 1

LEVEL CRITERIA	VERY HIGH	HIGH	AVERAGE	LOW
EAR AND RESPIRATORY DISORDERS	Very frequent	Frequent	Rare	Non-frequent
NATURAL ENVIRONMENT	Very high value	High value	Average value	Zero value
DUMPING OF WASTE	Very high impact	High impact	Low impact	Zero impact
LOWLAND RAINFOREST VEGETATION COVER	Very high vegetation cover	High vegetation cover	Vegetation cover	Low or zero vegetation cover
SOCIOECONOMIC STATUS OF HOUSING CONSTRUCTION	Masonry with rendering	Masonry without rendering	Wood and cement	Wood

Source. Authors’ own compilation 2019 research, UNMSM.

5 Results

Through the application of cartographic modelling, the industry's zones of influence were determined using the buffer tool. The first step was to georeference the industrial companies and then a matrix was applied through surveys, interviews and observation at the georeferenced points 50, 100, 150 and 200 metres from the industries to the homes already georeferenced. As a result, the following levels of respiratory and ear diseases were discovered: very high (26%, 50 metres), high (42%,100 metres), medium (21%,150 metres), and low (11%, 200 metres). In terms of environmental management: very high (37%, 50 metres), high (47%, 100 metres), medium (11%, 150 metres), low (5%, 200 metres). Dumping of waste: very high 37% (50 metres), high 47% (100 metres), medium 11% (150 metres), low 5% (200 metres). Regarding vegetation cover: very high (5%, 50 metres), high (32%,100 metres), medium (63%, 150 metres), low (00%, 200 metres). Socioeconomic state: very high (00%, 50 metres), high (16%, 100 metres), medium (79%, 150 metres), low (5%,200 metres). (see Table 3 and Maps 2).

These results are related to the research we conducted previously, where particle contamination was 179,615 µg/m3 , exceeding the permissible limit of 150 µg/m3 [6] [11]. This data shows the impacts reported in the survey table and interviews with the residents located near the timber companies (Table 3, Map 2).

On the other hand, the growth of timber and charcoal companies, as well as urban expansion and population densification, is increasing, as observed in the 2007 population density data: Calleria 13.28 inhab/km^2, Manantay 107.20 inhab/km^2, Yarinacocha 432.76 inhab/km^2 with an average of 26.30 inhab/km^2; and in 2017, Calleria 14.03 inhab/km^2, Manantay 129.62 inhab/km^2, Yarinacocha 500.90 inhab/km^2 and an average of 29.53 inhab/km^2, with an increase in the three districts of 3.23 inhab/km^2. In addition, the productive activity of the timber industries grew from 35 companies in 2011 to 86 companies in 2019 with an approximate increase of 51 companies, as some shut down and others open, according to data from the Regional Production Office of the Regional Government of Ucayali (2019). The number of

URBAN POPULATION PER DISTRICTS: CALLERIA, MANANTAY AND YARINACOCHA 2007-2017

TABLE 1: 2007

DISTRICTS	URBAN POPULATION (Inhab)	AREA (km^2)	DENSITY (2007) Inhab/km^2
CALLERÍA	13,6478	10,277.67	13.28
MANANTAY	70,745	659.93	107.20
YARINACOCHA	85,605	197.81	432.76
TOTAL	292.828	11,135.41	26.30

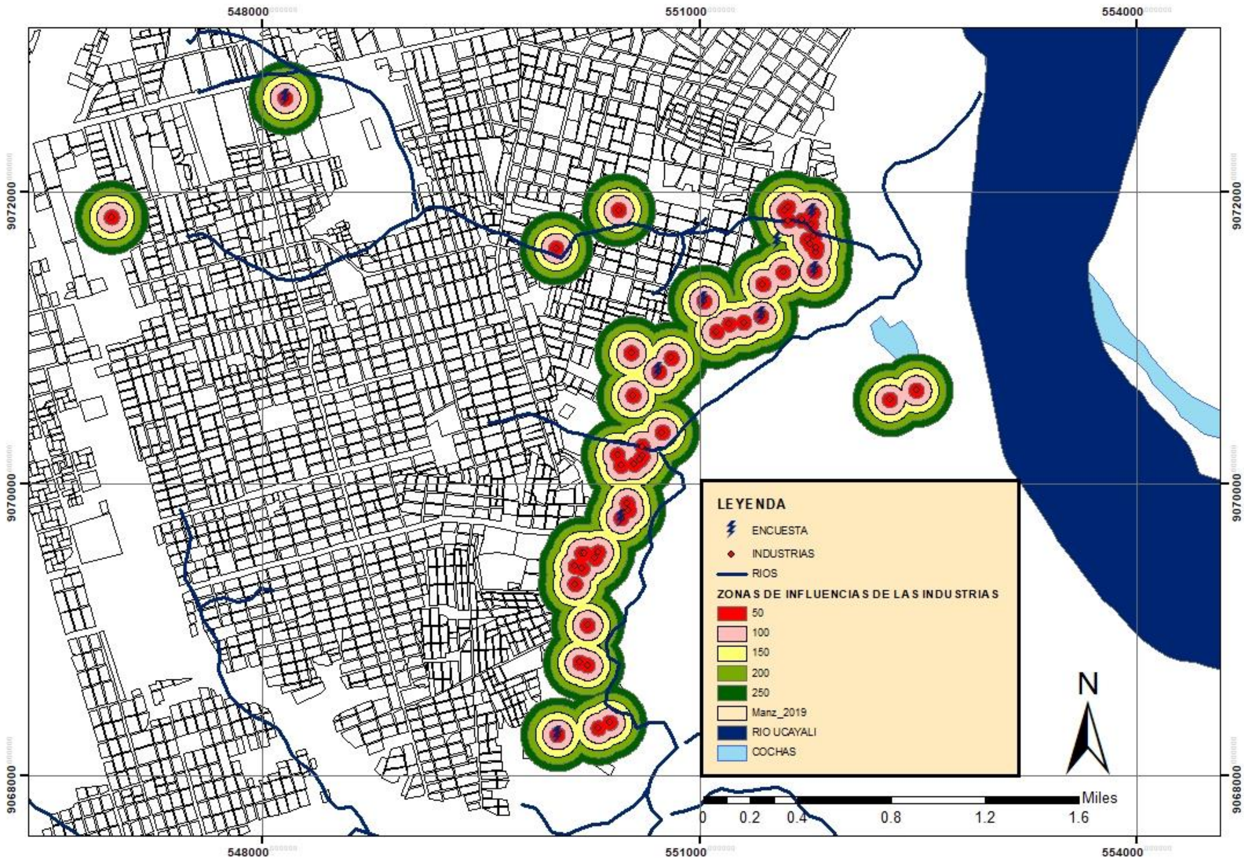
Source: 2007 INEI Census.

TABLE 2: 2017

DISTRICTS	URBAN POPULATION (Inhab)	AREA (km^2)	DENSITY (2017) Inhab/km^2
CALLERÍA	144,207	10,277.67	14.03
MANANTAY	85,540	659.93	129.62
YARINACOCHA	99,084	197.81	500.90
TOTAL	32,8831	11,135.41	29.53

Source: 2017 INEI Census.

MAP **2**



Source: IGN. Municipalities of Calleria, Manantay and Yarinacocha. Regional Govt. Ucayali. Production Management. Authors' own compilation, UNMSM, 2019 [12], [13], [14], [15], [16].

TABLE **3**

TABULATED SAMPLE RESULTS

LEVELS	DISEASES (%) FREQUENCY	ENVIRONMENT (%) POLLUTION LEVEL	DUMPING OF WASTE (%) QUANTITY MATERIAL SPILED	VEGETATION COVER (%) AREA WITH VEGETATION	SOCIOECONOMIC STATE (%) HOUSING MATERIAL
VERY HIGH	42	47	47	63	79
HIGH	26	37	37	32	16
AVERAGE	21	11	11	5	5
LOW	11	5	5	00	00
TOTAL	100	100	100	100	100

Source: Regional Govt. Ucayali. Production Management. Authors' own from field work, 2019, UNMSM.

charcoal producers is also increasing, although this leads to overcrowding and disorder in the use of the spaces, producing pollution and contamination. As a result, the areas they are located in become unsanitary due to polluted streams and flood plains and the increase in dumps, as shown in the data matrix, Thematic Map 1 of the timber industry and Photos 1 and 2. These pipes and lowials in relation to companies; show unhealthy areas with sewage waters that are in the buffering areas.

Lastly, the number of timber companies is on the rise (Map 1), and the highest proportion can be found in the district of Manantay, followed by Calleria and Yarinacocha. The spatial distribution of the industries has no established order – the sites are spatially dispersed – but municipalities are drawing up zoning plans. These companies are acclimatising to a certain extent; on the other hand, charcoal-kiln workers, when interviewed, stated that they are forming associations and the sites are already located at a distance from the urban population. It is important to mention that the timber companies are selling the waste from the sawmills for the manufacturing of chipboard, and any other waste goes to the charcoal kilns.

A lack of control in the wetlands and streams has been observed through the presence of sewage and land clearance, as can be seen in Photos 1 and 2 and in Table 3. The conservation of wetlands and streams is important for the oxygenation of the natural environment.

6 Discussion

The urban population and density, as well as urban sprawl, is increasing in all three districts. Green zones are decreasing, the streams are affected by wastewater and sewage as shown by Map 1, Photos 1 and 2, and Table 3 of the survey, where a summary is given of the levels and indicators of disease, environment, dumping of waste, vegetation cover and the socioeconomic status of the population.

In accordance with the background information and the theoretical framework, cartographic modelling was applied, using the buffering tool with linear distances of 50, 100, 150 and 200 metres. The layers were built: location map, map of urban districts and georeferenced industrial companies. It was then taken to the field to obtain samples at random, by means of a survey at the points, according to the intervals established by the GPS and completed with the final mapping. The most relevant information was taken to obtain the following results:

Respiratory diseases are between a very high level (26%, 50 metres) and a high level (42%, 100 metres). Environment: very high (37%, 50 metres) and high (47%,100 metres). Dumping of waste: very high (37%, 50 metres) and high (47%,100 metres). Vegetation cover: very high (5%, 50 metres) and high (32%, 100 metres). The socioeconomic status of the houses was based on construction materials. It was observed that regarding construction, the medium level prevails (cement, wood) (79%, 150 metres); as seen in Table 1 and Maps 2 and 2-A. This leads us to a final result, which is the spatial model of socioeconomic and environmental impact of Map 3, where the results are represented with environmental impacts at distances of 50, 100, 150 and 200 metres from the timber industries.

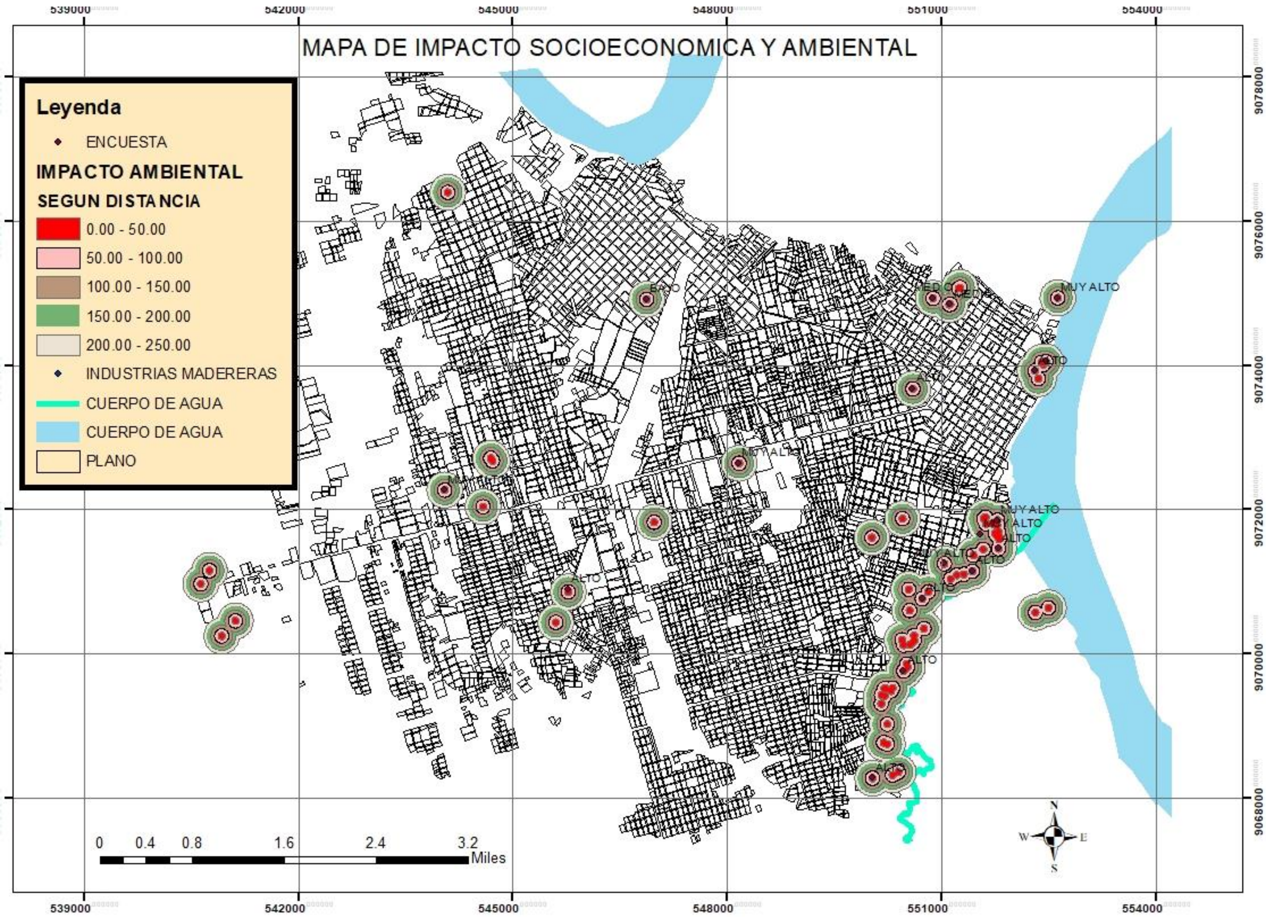
MAP **1**
POLLUTED STREAM

Source: Project fieldwork, 2019, UNMSM.

MAP **2**
A SAMPLE SAWMILL

Source. Field work from project, 2019, UNMSM.

MAP **3**



Source: IGN. Municipalities of Callería, Manantay and Yarinacocha. Regional Govt. Ucayali. Production Management. Authors' own compilation, UNMSM, 2019 [12], [13], [14], [15], [16].

7 Conclusions

(a) The measures taken regarding the spatial planning of the timber industry and the social-environmental and economic impact in 2000-2019 period have not allowed permissible limits to be exceeded in order to improve the quality of life and the environment, as can be observed in the results of Table 3 and the spatial model on socioeconomic environmental impact (Map 3), which shows the levels and indicators of diseases, environment, dumping of waste, vegetation cover and the socioeconomic status of the population.

(b) The timber industry is located in the vicinity of the Rivers Ucayali and Manantay and in the urban areas; all the timber companies have been georeferenced; they have no established order and are not located outside

(c) The levels of pollutants in the study area have not exceeded the permissible limits, because according to Matrix 3 of the variables and the levels and indicators, they are in the “very high” to “high” range (Table 3) with regard to data on particulate pollutants, which is 179 615 µg/m3 , exceeding the permissible limit of 150 µg/m3 [11].

(d) The socio-environmental and economic conditions have not improved, as shown in the results and Table 3, because it clearly shows that they are at a “very high” to “high” level.

(e) The legal standards implemented in the interest of the environment and the planning of the timber industry and its surroundings have had no effect, as can be seen in the table below (Table 3). However, we must highlight the relocation of the charcoal kilns and their organisation – they are located at a distance from the timber industry and the urban population. They used to be located very close to the timber companies, producing agglomeration, outbreaks of infection and contamination caused by wood-burning processes involved in producing charcoal.

Recommendations

(a) It is recommended to authorities, business owners and the local population to implement land-use and environmental-planning measures for the timber industry in the three urban districts in order to foster socioeconomic and environmental development.

(b) Local and regional authorities and environment, manufacturing, agriculture and health ministers, etc., should monitor the relevant areas to obtain reliable data on the permissible limits of air, water, soil, health, etc., and take the necessary precautions.

Gratitude

The authors thank the Universidad Nacional Mayor de San Marcos, the Vice – Rectorate for Research and Posgraduate Studies of Lima-Peru, for the financing to develop this project.

References

[1] Andrade, A. *Ordenamiento territorial. Una aproximación metodológica y conceptual*, IGAC, 1994. Bogotá-Colombia.

[2] Junjie Liu, Danlin Cai, Daxin Zhu, Siyu, Siyu Huang. A Regional Industry Intelligence Business Platfform based on Adaptive Clustering. *International Jounal of Circuits, Systems and Signal, Processing* Volume 14, 2020. China.

[3] Isard, Walter. *Location and space-economy; a general theory relating to industrial location, market areas, land use, trade, and urban structure.* Published jointly by the technology press of Massachusetts Institute of Technology and Wiley, 1956. Cambridge.

[4] Instituto Nacional de Desarrollo Urbano. *El Plan Director de la Ciudad de Pucallpa.* INADUR, 2006. Lima-Peru.

[5] Instituto Nacional de Estadística e Informática. *Censos Nacionales: XII de Población, VII de Vivienda y III de Comunidades Indígenas*. INEI, 2017. Lima-Peru.

[6] Meza Arquiñigo, C. *Análisis espacial de las industrias madereras y su impacto ambiental. Región Ucayali*. IIHS, 2011. Lima-Peru.

[7] Meza Arquiñigo, C. *Aplicación del SIG en el crecimiento urbano de la ciudad de Pucallpa para su gestión y ordenamiento ambiental. Pucallpa, Región Ucayali*. IIHS/26, 2018. Lima-Peru.

[8] Información Estación Meteorológico Climática, UNU 2006.

[9] Meza Arquiñigo, C. *La deforestación en la Región Ucayali y su influencia en el cambio climático*. IIHS, 2006. Lima-Peru.

[10] Meza Arquiñigo, C. *Modelamiento SIG para identificar los cambios del río Ucayali y su influencia ambiental. Caso Pucallpa*. 2006. Lima-Peru.

[11] Meza Arquiñigo, C. *Modelo de localización de las industrias madereras y su impacto*

ambiental. Pucallpa-Región Ucayali. IIHS, 2014. Lima-Peru.

[12] Instituto Geográfico Nacional. *Cartas Nacionales. Perú*. IGN, 1989. Lima-Peru.

[13] Gobierno Regional Ucayali. *Informes de los datos de las industrias madereras*. Dirección Regional de Producción, 2019. Lima.

[14] Municipalidad de Callería, Ucayali. *Informe cartográfico.* Dirección de Desarrollo Urbano, 2019. Lima-Perú.

[15] Municipalidad de Manantay. *Informe cartográfico*. Dirección de Desarrollo Urbano, 2019. Lima-Perú.

[16] Municipalidad de Yarinacocha. *Informe cartográfico*, Dirección de Desarrollo urbano, 2019. Lima-Peru.

Contribution of individual authors to the creation of a scientific article (ghostwriting policy)

Carlos Meza Arquiñigo developed the research project, participated in the field work, data analysis and image design. He wrote the report and prepared the manuscript.

Alida Diaz Encinas participated in the field work, analysis and interpretation of data.

Nestor Montalvo Arquiñigo was responsible for the analysis of tables and the matrix of the cartographic model.