Book Chapter

Methodological Planning Strategy for the Development of the Ceramist Production Chain in the Amazon

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Bioeconomic Potential of Amazonian Biodiversity

The Amazon has about a third of the world's tropical rain forests, forming a mosaic of ecosystems covering an area of approximately 6 million km² [1]. The extensive variety of microorganisms, richness of fauna and flora point to indicators that the region has the greatest biodiversity on the planet, placing it under favorable conditions for the sustainable use of its potential [2,3]. Supply of inputs and raw materials for the production of bioproducts, biofuels, energy generation and herbal solutions are examples of the bioeconomic potential in the Amazon. Paradoxically, socioeconomic dynamics and anthropic pressures in certain market segments have promoted pressures that have challenged the support capacity of ecosystem services. The intense pattern of consumption of natural resources in relation to the time needed to recompose the goods and services provided by nature compromises the provision, maintenance of life and human well-being [4-7].

It is noticed that the vast territorial extension, associated with the geological, topographical, hydrological and climatic patterns of the region, hinder the process of governance and sustainable management of natural resources.

The challenge in a globalized market is to meet the assumptions of the Organization for Economic Cooperation and Development (OECD) in productive sectors in the Amazon region, as the expansion of industrial activities to meet national and international markets usually results in the loss of biodiversity and, consequently, in the impairment of ecosystem services [7].

Biodiversity or biological diversity acts at all levels and forms of biological organization present in ecosystems, the species that compose it and the genes that make up these species [8,9]. Although it has already been considerably reduced, with extinctions and reductions in the population size of certain species, biodiversity still has significant diversity and abundant variability [10].

The state of Amazonas, as it holds the largest land parcel, corresponding to 30% of the Amazon, still maintains an expressive biodiversity. However, attention is turned to productive activities, carried out from the exploitation of biological resources, as they must be carried out in a sustainable manner and with the perspective of natural recomposition.

From a geographical, socioeconomic and environmental point of view, Amazonas is in a prominent position in the region, with an area of 1,559,146,876 km², an estimated population of 4,269,995 inhabitants [11] and a wide variety of productive sectors, integrated to the capital, Manaus, which concentrates the main economic activities of the state. As an urban and commercial center, Manaus is ranked the largest city in the North Region and the 7th in Brazil, reaching a GDP of R$ 105.7 billion in 2020 [12] and an estimated population of 2,255,903 inhabitants [11], forming the epicenter of the local economy.

In addition to its strategic importance for regional development, the capital of Amazonas is home to a relevant industrial center, which was conceived in the development model that seeks to meet socioeconomic and environmental aspects [13]. The Manaus Industrial Center is considered the support base of the Manaus Free Trade Zone (ZFM), with approximately 500 industries and a turnover of US$ 22,819 billion in 2020, generating more than half a million direct and indirect jobs, mainly in the segments of electronics, two-wheelers and chemical [14].

In addition to these industrial segments, agroindustry, tourism, fish farming and an important ceramist center located in the municipality of Iranduba, bordering the city of Manaus, also stand out. The ceramics center has strategic relevance for the economic development of the city of Manaus, as it absorbs around 95% of all pottery-ceramic production in Iranduba's ceramic industries.

Iranduba Ceramist Pole, Amazonas, Brazil

The Ceramista Pole of Iranduba (CPI) comprises a conglomerate of 18 industries located on the right bank of the Rio Negro, opposite the city of Manaus (Figure 1), with access to and flow of production carried out via the Rio Negro bridge.

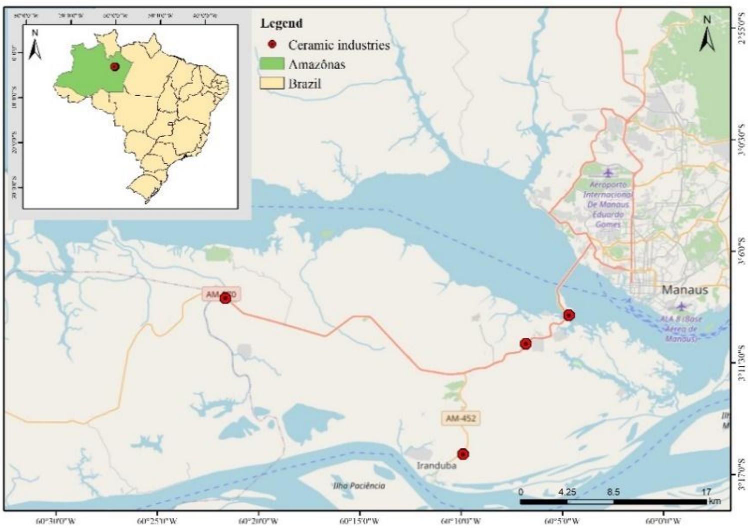

Figure 1: Localization of the ceramic industry production center of Iranduba, Amazonas.

The CPI area is part of the Metropolitan Region of Manaus (RMM), consisting of extensive diversity and geological potential with an estimated mineable reserve of 35,993 x 10^3 ton, used in the production of red ceramics [15]. It is located under alluvial and residual deposits of the Alter do Chão Formation, which is formed by sedimentary rocks from Phanerozoic ages, such as: sandstones and claystones, including kaolins [16].

The low choice of innovative solutions and the limited technological resources of the CPI have conditioned companies to use native firewood as a raw material in the process of burning of ceramic artifacts. Research carried out in the geographic area of Iranduba indicates that woody residue is still the main energy product and the manufacturing base for the production of ceramic artifacts in the locality [17-20]. The firewood used in the factories comes from primary or secondary forest areas, making the municipality of Iranduba one of the largest industrial consumers of native firewood in the state of Amazonas [21,22].

The aggravation of environmental problems and pressures on the forest at a global level resulted in the creation of several legal instruments for the protection of wood components [23,24]. These measures aim to prevent deforestation and ensure that the transport of inputs that involve wood (firewood), including that intended for burning of bricks in potteries, is carried out with documentation that attests to the origin of this raw material. The DOF-System (Forestry Origin Document) is the mechanism that has been used to ensure that the entire process relating to transactions with wood in its most diverse forms is controlled by the Environmental Inspection Agency, from harvesting to marketing.

The DOF-System was developed and implemented in order to make mandatory the presentation of information on the origin, transport and storage of forest products or by-products of native origin. However, the implementation of this environmental control mechanism further aggravated the scarcity of energy resources for the burning of ceramic artifacts by CPI industries. Some ceramist industries have been submitting to underhanded methods of extracting clay and firewood and, therefore, subjecting themselves to the constant risk of fines imposed by environmental inspection bodies.

Another factor related to the manufacture of ceramic artifacts affects the process of obtaining the raw material. Despite the extraction of natural clay being one of the most important links in the production chain, due to the nature of the activity, its operation generates significant impacts on the environment, with siltation of water courses and expulsion of native fauna. In the municipality of Iranduba, the obtainment of raw material is carried out in marshy areas, with the use of mechanized equipment, mainly mechanical shovel [7]. It is noteworthy that the use and management of natural resources (forests, rivers, soils, fauna and flora) have been recurrent themes in political and academic debates, with a view to outlining a path of economic and sustainable growth [25].

This panorama shows that ceramic activity on an industrial scale in the Amazon must be carefully planned, anchored in the pillars of sustainability and grounded in public policies that favor the recovery of impacted or degraded areas.

Methodological Systematization of Research

The methodological systematization of the research was structured based on the main elements of the CPI production chain, delimited into 7 variables shown in an illustrative figure in the shape of a mandala.

To identify the spatial variability of climatic conditions in the study area, a cut was made in the georeferenced database that integrate the studies by Martorano *et al*. [26], based on the adaptation of the Köppen methodology (1900) proposed by Martorano *et al*. [27], spatially identifying the municipality of Iranduba. The climate database includes data from the National Institute of Meteorology (INMET) and the National Water Agency (ANA), in addition to matrix data from the global platform WorldClim Global Climate Data, with data interpolated at a spatial resolution of 1 km [28], similarly to the assumptions of information extraction carried out by Tourne *et al*. [29], Martorano *et al*. [30] and Martorano *et al*. [26].

To assess the soil variables and the potential of clay contents in the geographic area of the study, with a view to establishing sustainability scenarios, information from the base of SoilGrids [31] was used, whose maps are publicly available under the CC-BY 4.0 license. SoilGrids is a global automated digital soil mapping system, with spatial resolutions of 1 km, based on advanced spatial prediction methods.

In the bibliographical survey on the subject, primary and secondary sources were used, based, above all, on studies that focused on the dynamics involving the ceramic sector in Iranduba. From the bibliographical survey and the elaboration of the state of the art, the research was structured showing the main elements and influences studied in the Iranduba ceramist production chain (Figure 2).

This procedure was performed in three steps:

- Initially, relevant elements that characterize links or interactions related to the production chain were systematized, in the context of the studied object. This cognitive mapping was elaborated from a methodological script, considering strictly necessary variables to carry out the research. Later, these variables were delimited in specific approaches that would be evidenced in a playful and illustrative figure, in the shape of a mandala.
- In the second stage, the preliminary design (mandala) was sliced into seven fragments, subdivided into three layers, in order to demonstrate all the elements covered in the research. Objectively, the fragments or slices of the mandala were defined as the historical aspects; variables related to the origin of the raw material (soil characteristics and energy sources); climatic variables; economic-financial variables; database on the ceramist pole; and business sustainability from an environmental, social and economic perspective.
- In the third stage, more subjective aspects were outlined, aiming to identify and analyze factors that could be adequate and/or adjusted to the model designed in the previous stage. Finally, the different perceptions and opinions of other researchers were captured in order to evaluate and improve the mandala model.

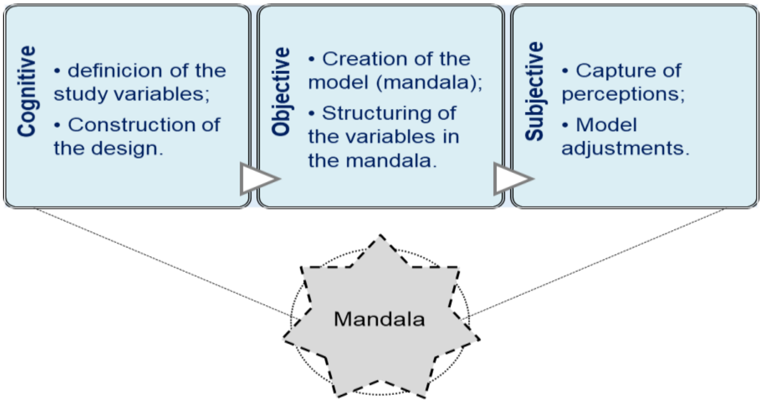

Figure 2: Methodological diagram indicating the steps used in the construction of the mandala

Overview of Iranduba's Ceramic Production Chain

The structuring of scientific research is one of the most important steps in the methodological process and in scientific investigation itself. Thus, based on the state of the art and the systematization of the variables that interrelate with the CPI production chain, the research elements were structured in a logical diagram in mandala format, considering different areas, perceptions and tacit knowledge.

In Figure 3, it is possible to observe that the methodological structure based on mandala brought elements capable of tracing the script and systematization of the spatial-temporal dynamics of the CPI production chain.

Figure 3: Integrating Mandala of Research Methodological Planning at the CPI

The fragment *historical aspects* shown in the mandala contemplate the main events related to the ceramist pole since its inception until the year 2020; the fragment of *soil variables* involves the pedology, geology and clay composition of the Iranduba ceramist pole; the *energy sources* fragment includes non-wood residues, agroforestry biomass and firewood used in the process of burning ceramic artifacts; the *climatic variables* fragment addresses the relative air humidity, temperatures and rainfall at the research site; the *financial variables* fragment deals with production volume, operating costs and revenues; the *database* fragment deals with public policies, legislation and stakeholders in the ceramic sector; and the *sustainability* fragment addresses the bioeconomic, environmental and social aspects highlighted in the ceramist pole.

From a practical point of view, it was found that the construction of the mandala is a dynamic and interpretive process through which external information is interpreted and reinterpreted as a function of an explanatory model, which can become increasingly complex and abstract [32]. It is a tool that has the potential to provide objective and subjective results, identifying the position, intervention strategies and changes that may occur in the research design [33].

The mandala is an ancient element that makes it possible to establish bridges and create interdependencies with various areas of knowledge, regardless of their interpretations, having in its scope the triad investigation, education and action [34-36]. It is over 2000 years old and is one of the richest works created by circular designs, intricate patterns or symbols [37]. Although mandalas have been used since the dawn of humanity as traditionally religious tools and psychotherapeutic strategies in different population groups [38-40], the instrument can be used also to characterize the structure and fragmentation of knowledge in research methods that focus on the dynamism of sustainability.

Integration of Physical and Biophysical Variables of the Mandala

The methodological systematization of the research with the help of the mandala evidenced the fragmentation and reintegration of knowledge through active imagination, providing a technical-scientific view of the research roadmap. The mandala projected the main biophysical and socioeconomic variables of the CPI, outlining the fundamental elements of the production chain. The diagram can also serve as a guide for other researchers interested in synthesizing the various biochemical, biomolecular and biocomputational fragments towards the completeness or totality of the process.

At the same time, the mandala represents a type of map guiding researchers on their journey to new insights connecting all parts of the process [41]. Furthermore, when constructed in groups, mandalas arise from the dialectic between the subject, the group and the problem that one seeks to understand, acting through systemic and open processes, allowing the development of non-linear approaches to the complex situations to be studied [42].

This line of scientific thought in the form of a mandala has strong adherence to the fundamentals of the circular economy, demonstrating how processes are managed, self-regulated and work harmoniously in a cyclical manner, contrasting with the current linear model [43]. When there is an imbalance in certain ecological niches, important ecosystem services are compromised. This implies the need to change the linear model that allowed an unusual form of economic growth beyond the planet's support capacity [44]. The adoption of a structured system similar to the circular economy system that considers ecological processes, industrial ecology, blue economy, among others, tends to collaborate in the construction of a structural model capable of contemplating social strengthening with the addition of economic value and conservation of natural resources in the Amazon. The mandala expresses a diagnosis of the process, tracing an analysis of biophysical and socioeconomic variables to support sustainable planning strategies at the Iranduba ceramist pole.

Another aspect observed is that mandalas act as open works of art and do not enclose their possibilities, but open them up so that different subjects can choose their conditions, sequences or forms, problems, answers and reflections as spaces for dialogue and construction [45,46].

The axes that rotate the mandala represent the stages and/or links in the production chain, creating interdependencies and connecting various areas of technical-scientific knowledge. It presents a central point that interconnects with the other elements in an interdependent way, incorporating different knowledge, experiences and learning [47]. The logical diagram follows constructivist methodological assumptions, integrating knowledge, social and cultural levels that dialogue in an integrated, dynamic and playful way [48].

From the perspective of cognitive development, the construction of the mandala results from several steps that can be improved throughout the process, supporting the idea that learning is something social, cultural and plural, built through the interaction between previously acquired knowledge and new learning experiences. The center of the mandala represents its essence and the other elements in general represent the elements linked to this point and somehow depend on it [35].

Spatio-Temporal Dynamics of the Iranduba Ceramist Pole Production Chain

The production chain structure allows for an integrated view of all the links or elements, including the potential and vulnerabilities of the sector, enabling interventions in inefficient points or the maximum exploitation of competitive resources.

Historical Aspects of CPI

In the municipality of Iranduba, archaeological research has already shown that the region was densely inhabited by indigenous populations for nearly six centuries, where its inhabitants mainly developed agriculture and the production of ceramic artifacts [49,50].

The main factors that contributed to the installation and strengthening of the ceramic-pottery center in this region of the state of Amazonas were: a) the existence of extensive deposits of clay raw material; b) proximity to the main consumer center, connected through the Manoel Urbano – AM-070 highway; and c) high supply of unskilled and low-paid labor [51].

Until the 70s (twentieth century), only two ceramic industries were installed in the municipality of Iranduba, producing bricks with two, four and eight holes, in addition to solid bricks, combogó (cast elements), "channel" and " Marseille” roof tiles, ceramic tubes of varying inches in diameter and connections intended exclusively for constructing buildings [52,53]. However, with the entry of asbestos sheets, plastic tubes and imported artifacts, the sector's diversity was drastically reduced, restricting almost exclusively the production of eight-hole bricks for construction industry [51].

From the 80's (twentieth century), several companies in the pottery-ceramic sector migrated from the city of Manaus to the right bank of the Rio Negro, as a result of urban expansion. The companies established themselves in the geographical area of the district of Cacau-Pirêra, municipality of Iranduba, playing a preponderant role in the economic activity and social life of the Amazonian population [19,20,53,54]. On the other hand, with the intense urban pressure in recent decades, there has been an increase in population growth in the region, characterized by disorderly occupation in certain locations [55]. These changes, typical of economic factors of the current pattern of production and consumption, contributed to the stagnation of the ceramic sector in Amazonas, even aside from technological advances that exist in other regions of the country.

The creation of the Metropolitan Region of Manaus (MRM) in 2007 brought greater dynamism between the CPI and the host city Manaus, with a positive impact on the economy of the municipality of Iranduba [56].

It is estimated that at the height of real estate expansion in Brazil, between 2008 and 2013, the annual production of the Amazonas ceramics center reached the order of 100 to 128 million pieces, of which around 90% were ceramic blocks [7,20,51]. Even amidst the technological obstacles and limitations faced by the sector, surveys reveal that between 2009 and 2010 the ceramic industries in Amazonas generated between 3.5 and 4000 direct and indirect jobs, with the municipalities of Iranduba and Manacapuru as the main red ceramic producers. The municipality of Iranduba alone was responsible for about 75% to 88% of all brick and roof tile production in the State [7,57,58].

In Brazil, the main products of the red ceramics sector are: blocks, bricks, tiles, hollow elements, slabs, red tiles, tubes, light aggregates, in addition to products for other purposes such as expanded pyro clays, ornamental objects and household utensils, having common clay as the main source of raw material.

In 2009, the state government recognized the municipality of Iranduba, together with the municipality of Manacapuru, as the main ceramic centers in Amazonas. However, it detected several difficulties in the production chain, due to environmental problems, inadequate infrastructure and inefficiency of the kilns used to burn bricks, causing low productivity and a rise in the price of the final product.

Characterization of the Raw Material and Potential of Thermal Energy Sources

The CPI geographical area has a great potential and geological diversity of clays in the 15 cm, 30 cm and 60 cm layers, whose exploration has been ongoing for the last 40 years [7]. It presents variations in clay contents with a gradual increase in the soil profile. In the 15 cm layer, there is the smallest percentage of clay contents, prevailing classes with 31 to 40% and less than 30% clay in the soil. However, in the 60 cm layer, clay contents predominate in a large part of the municipality, with clay values above 40% (Figure 4).

The CPI industries have a high potential for absorbing solid waste as a source of thermal energy during the cooking process (burn) of productive artifacts [59]. Of the 18 industries located in the CPI, 8 companies already use, on a small scale, waste of different categories and species in their production process, including non-recycled paper, wood construction waste, sawdust and açaí seeds (*Euterpe precatória* Mart.).

This waste incineration practice minimally meets the operational needs of companies, however, new strategies must be implemented in order to reduce the impact of deforestation, since native firewood is the main source of thermal energy used by CPI industries [20-22].

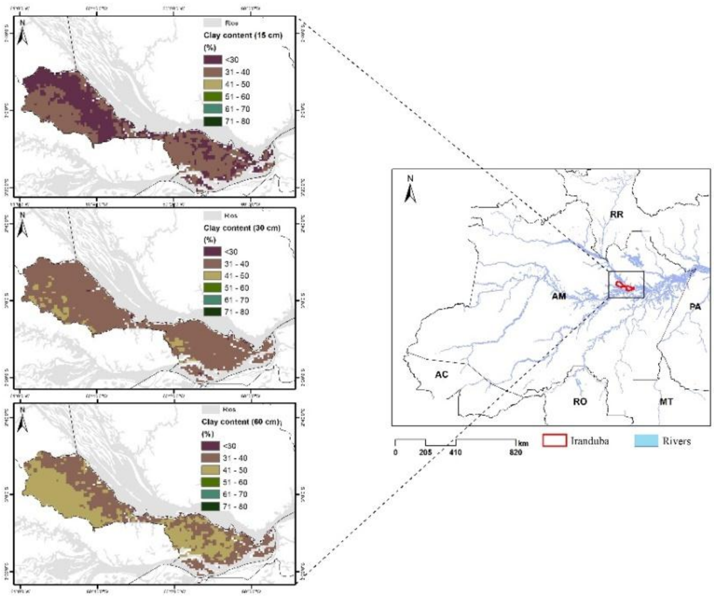

Figure 4: Soil clay contents at 15 cm, 30 cm and 60 cm in the municipality of Iranduba, Amazonas.

Climatological Influences on Production Units

The predominant climatic typology in the research area is Am3, mainly in the northwest region of the municipality, in transition with the Af3 which predominates in other locations (Figure 5), with total rainfall below 65 mm in the least rainy month, which is August of historic series. It is noteworthy that the annual rainfall varies between 2000 to 2300 mm, annual average air temperature above 27 ºC and relative humidity ranging from 80 to 85%.

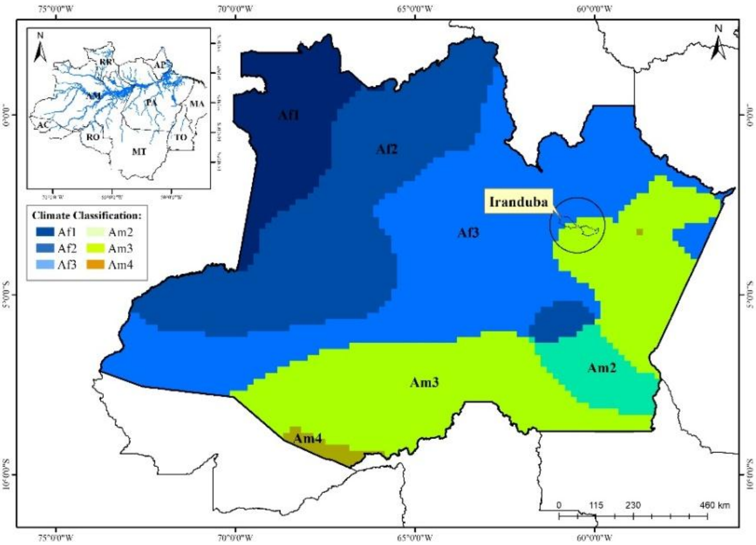

Figure 5: The Legal Amazon and the climate classification of Iranduba, Amazonas.

In order to support possible improvement strategies in the production system of the CPI industries, infrared thermography was used to analyze the thermographic patterns of the production units. The use of infrared thermography as a management resource in production units for ceramic artifacts is something innovative. When properly used, infrared thermography enables the diagnosis of thermal conditions related to human physiology and environment, in order to support the decision-making process regarding the adoption of improvements in thermal comfort.

Thermographic image captures were carried out in internal and external areas of a productive unit of the CPI. The internal targets evaluated were the chambers used for cooling the ceramic artifacts produced, the coverage of the industry shed, the kilns used in the brick burning process and the vegetation surrounding the industry. To obtain the temperature of the evaluated components, thermal patterns identified by the typical colors of thermographic images were adopted. In each treated image, 3 to 5 points were traced for each temperature standard.

By analyzing the thermographic pattern, high temperatures were identified in all imaged targets. In the innermost area of the work environment (Figure 6A), it was found that the maximum, minimum and average temperatures had values of 46.5°C, 29.7 °C and 37.8 °C, respectively. These same average temperatures were observed in the produced ceramic artifacts (bricks), stored in an internal cooling chamber, awaiting the packaging and marketing process.

The products transported by the employee, as well as the equipment used in the transport (cart) had maximum, minimum and average temperatures of 37.5 °C, 36.3 °C and 36.8 °C, respectively. The highest temperatures were concentrated in the most internal environment, decreasing as the heat exchange with the external environment occurred (t1 > t2). The specific temperatures of the roof, including the tiles and metallic structures of the industrial shed (Figure 6B), had slightly higher temperatures, with maximum, minimum and average temperatures of 58.6 °C, 31.4 °C and 47.4 °C, respectively.

The area of the kilns where the products are burned (Figure 6C) indicated a higher concentration of heat sources, as it had a maximum ambient temperature above 160 °C, a minimum of 51.9 °C and an average of 117.5 °C. The peripheral areas (borders) of the kilns had mild temperatures, with a maximum of 79.2 °C, a minimum of 50.9 °C and an average of 61.9 °C. However, it was observed that employees (kiln operators) who work directly in the brick burning process are subjected to a higher rate of unhealthy conditions, due to high temperatures and humidity, aggravated by the inhalation of soot in their work environment. The maximum, minimum and average temperatures detected in this workstation had values above 160°C, 110°C and 138.2°C, respectively.

The temperatures of the vegetation surrounding the ceramic industry had maximum, minimum and average of 41.3 °C, 26.2 °C and 34.2 °C, respectively (Figure 6D). The presence of vegetation favors environmental temperature control, through shading and energy consumption by evapotranspiration on the leaf surface, making the maintenance of green areas of paramount importance to mitigate thermal discomfort in the Production Unit [60,61].

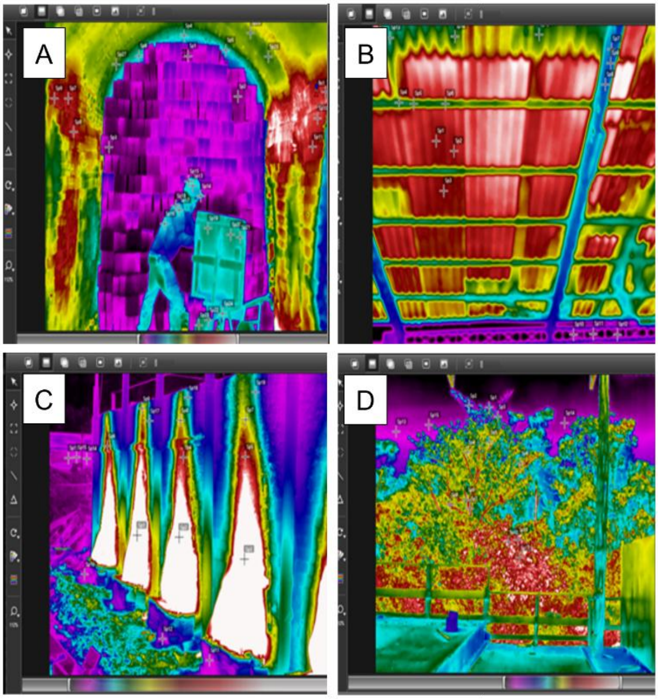

Figure 6: Environmental thermographic patterns diagnosed in the CPI area.

Economic and Market Variables of the Ceramic Sector

The Brazilian ceramic sector is the main supplier of materials for masonry and roofing for residential and commercial use, comprising 6,903 ceramic and pottery industries spread across the country, with an estimated production of 63.6 billion pieces.year^{-1} of ceramics and approximately 140 million tons of clay, considering the average mass of 2.0 kg.piece^{-1} [62,63].

The ceramic segment in Brazil is quite diversified, consisting of artifacts ranging from small household utensils and ornaments to products and tableware used on a large scale in construction industry.

Red ceramics (structural ceramics) are responsible for an annual turnover of R$ 18 billion, generating 293,000 direct jobs and 900,000 indirect jobs [61,62]. However, the ceramic industries have a great deficiency in statistical data and performance indicators, despite the significant amount of jobs generated. The absence of such data makes systematic monitoring and the development of indispensable strategies for improving production processes and competitiveness unfeasible.

In CPI and throughout the state of Amazonas, the ceramic sector is concentrated in the production of structural ceramics (red), with solid bricks and 8-hole bricks being the main products manufactured [7].

In the CPI productive units, a structure consisting mostly of family businesses classified as small and medium-sized companies prevails. The quantity of pieces produced in each pottery depends on several market factors, mainly the demand of the construction industry chain. The CPI industries, considered operationally small, produce between 10,000 and 15,000 parts.day^{-1}. Medium and large companies produce between 30,000 and 40,000 pieces.day^{-1}.

The transformation industries of Amazonas, which include the ceramic industries, registered a GDP of R$ 23.1 million in 2019 and R$ 23.6 million in 2021 [12]. The 2.57% variation may be related to fluctuations in the prices of ceramic products, which in CPI increased by about 18% between 2018 and 2020. CPI's monthly sales revenue is estimated at between R$ 1,600,000 .00 to R$ 1,980,000.00, with operating costs for each industry ranging from 65% to 75% of total gross revenue.

Public Policies and Sustainability Indicators

In the context of modernity, one of humanity's most urgent challenges is to find a fair and balanced measure that enables sustainable development, considering economic, environmental and social aspects, based on institutionalized public policies [64].

In the geopolitical context, the municipality of Iranduba has undergone major socio-spatial transformations in the last 20 years, mainly with the implementation of macro-projects, defended as public policies, directly interconnected with the locality. The four major projects with environmental, economic and social impacts implemented in the region of Iranduba were: the Coari-Manaus gas pipeline; creation of the Metropolitan Region of Manaus; the construction of the Rio Negro bridge; and the implementation of the Cidade Universitária (neghborhood). The Cidade Universitária project is currently at a standstill.

Difficulties and Challenges of the Iranduba Ceramist Pole

The developmental logic and the repositioning of the global capitalist economy are causing the emergence of new productive agglomerations, as well as the refunctionalization of traditional productive agglomerations, especially those that emerged during the fordist period of development, in the second half of the 20th century [65]. The natural tendency is for large companies to incorporate restrictive policies to curb the production and sale of unsustainable products in all their modalities and industrial categories.

The introduction of technological innovations in order to overcome rivals and obtain greater market share is something absolutely necessary for a company to be able to remain active in the market. However, productive efficiency and competition are not sufficient characteristics to guarantee the sustainability of a business. It is necessary that companies seek or conquer new markets under the logic of what Kim & Mauborgne [66] call blue oceans.

For the authors, these oceans represent unexplored market models or spaces that can create or capture new demands. From this perspective, the authors believe that most blue oceans have not yet been mapped, meaning that CPI industries may still be rooted in red ocean strategies, where scarlet waters are defined by the current economic structure of the sector, represented by the absence of solid and systematic principles of risk management and innovation.

The social, environmental and economic dynamics of the Iranduba ceramics center is quite complex and challenging. To assess the different interfaces of the production chain of the ceramist pole, it was proposed to structure a mandala containing the main research variables. The study showed that the current scenario of the pottery-ceramic industry in Iranduba has low production capacity and basically serves a consumer market concentrated in the city of Manaus. There are extensive areas of clay raw material and abundant employment of unskilled labor. The main source of thermal energy for burning ceramic artifacts is still native firewood and underused agroforestry residues at the Manaus Industrial Pole.

From the point of view of innovation, Florentino *et al*. [7] understand that the adoption of a production system based on new business models, having as a parameter the bioeconomy and sustainability, must occur in an integrated manner, with market orientation and active participation of research institutions, agro-extractivist communities and pottery industries.

For the authors, a bioeconomic-based production chain requires knowledge and technologies to incorporate by-products (biomass) that result in the manufacture of ecological products (bioproducts) and sustainable business models.

Blockchain resources are seen as a decisive technological factor for the development of sustainable production chains in the region, as companies have a set of operating activities that are very favorable to transforming natural resources into reference bioproducts for the entire Amazon. On the other hand, the materialization of structural changes in the production chain with an increase in biotechnology and the supply of sustainable products requires the formulation of specific policies. Local macroeconomic variables should be considered, as well as a careful analysis of the potential and vulnerabilities that involve the ceramic sector in the region [7].

Faced with this arid scenario, added to the political instability in the country, it is essential that the ceramics industries centers adapt and discover new alternatives in dynamic economic environments, evaluating all sectorial, organizational and strategic variables that favor the creation and navigation in blue oceans [67].

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