

Living on water and land: Challenges and opportunities for the development of Amphibious Communities in the Peruvian Amazon Rainforest**Gabriela P. Vildosola^{a,b,d}, Jorge Alarcon^{a,b}, Leann Andrews^{a,c}**^a*Centro de Investigaciones Tecnológicas Biomédicas y Medioambientales, Peru*^b*University of Washington,*^c*Pennsylvania State University*^d*Universidad Científica del Perú***Abstract**

Loreto, the largest Amazonian region in Peru, is home to more than 200,000 inhabitants that live in traditional riverside rural communities adapted to an amphibious lifestyle, with houses that rise or float on the river in times of flooding and perch on the dried riverbed in low water times. Nevertheless, these amphibious communities are not exclusive to rural areas. Iquitos, the largest city of Loreto, is surrounded by alluvial plains, where more than 90,000 people live on the water and bring a rich social, cultural, and environmental vibrancy to the regions. However, poor infrastructure conditions and limited resources in these communities affect the ecosystem and the population's health. The objective of this qualitative study was to understand the physical, sociocultural, and environmental conditions in which these amphibious communities live and identify the political, legal, and cultural barriers that prevent their healthy urban development. Data collection was conducted through semi-structured interviews, surveys, and observation of physical and environmental conditions. The results suggest conflicts in the formalization processes of these informal communities, from administrative and legal aspects to a limited definition of habitable territory. We identified the benefits of the current urban-architectural conditions of these communities, whose housing typologies, adapted to the seasonal change of the rivers, may provide an alternative model to adapt with resilience to the impacts of climate change and sea level rise. We also identified challenges in sanitation, accessibility, public space, and strength of community networks, as well as challenges in the response of the government whose proposals for relocation of the amphibious communities have not fully considered these communities' economic, social, and cultural values.

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Keywords*Built environment; Urban Resilience; Amphibious Communities; Peruvian Amazon.***1. Introduction**

In addition to the recent global pandemic and climate emergencies, main challenges of the 21st century include coping with population growth in cities, the increase in slums and informal settlements, and providing adequate and affordable housing and infrastructure with accessible urban services for vulnerable population (UN-HABITAT, 2022, 2016). According to the United Nations update on Sustainable Development Goal #11, Sustainable Cities and Communities, by 2030 more than 60% of people worldwide are expected to live in cities, almost one quarter of the global population (over 1 billion people) currently are living in slum conditions lacking tenure, safe utilities or living space, and three times that many (or more than 3 billion people) are in need of adequate and affordable

housing worldwide (UNSD, 2019). Acknowledging that adequate housing is a basic human right because of its impact on health and safety, equity and inclusion, and livelihood opportunities, the UN calls for increased efforts to address policy barriers and built environment investments to address this global emergency that likely has only intensified with the recent global pandemic and climate change (UNSD, 2019).

Peru's urban development and built environment conditions reflect these challenges. According to the 2017 census, 43.7% of the population lives in slums, informal settlements, or inadequate housing (INEI, 2018) and this number is expected to grow in the coming decade. The main cities of the Peruvian Amazon, including Iquitos, have additionally unique challenges with rapid Indigenous migration from the jungle leading to mass development of amphibious slums communities built within the urban floodplains. These communities contain wooden houses that float on the river or rest on stilts high above the floodplain. These designs, adapted from traditional houses design in rural Amazonian areas where many residents have migrated from, adapt to the seasonal dynamics of the rivers in times of flooding or dry spells, characteristics that may promote resilience to climate change and sea level rise. However, these communities also suffer from poor infrastructure conditions and limited resources that affect ecosystem and human health.

This article presents an overview summary of preliminary research findings on amphibian communities settled on the alluvial banks of Iquitos, the most populous city in the Peruvian Amazon and capital of the department of Loreto, the largest geographical region in Peru.

Objective: The study's objective was to understand the physical, social, cultural, and environmental conditions in which amphibious communities live and identify the political, legal, and cultural barriers that prevented their healthy urban development.

Methodology: This study had a qualitative approach. Data collection was through semi-structured interviews, surveys, and observation of physical and environmental conditions during the months of May to November 2021. The team conducted 42 semi-structured interviews with officials, academics, and inhabitants of the amphibian communities. The team also conducted an open online survey with 23 multiple-choice questions about perception and conditions of amphibious communities, and received 147 responses from the general population living in the non-flood-prone highlands of Iquitos. Lastly, observations of physical and environmental conditions was carried out over five days in five different amphibious communities around the city.

2. The Context

Loreto, located in northwestern Peru, is part of the Amazon ecosystem and occupies almost a third of the Peruvian territory (CEPLAN, 2019). Despite this large area, its population represents only 3.37% of the country's total and is predominantly urban with 68.7%, concentrated in the capitals of the provinces, and with Iquitos being the most populated. However, in four of its provinces, more than 61% of the population is rural, where more than 200,000 riverside inhabitants live in traditional rural communities adapted to an amphibious lifestyle, with houses that rise or float on the river in times of flood and perch on the riverbed in times of low water (INEI, 2018; Desmaison, Espinoza, Jaime and Gallardo, 2019).

According to the classification made by Jorge Burga (2018, p.116-117), traditional Amazonian housing can be: (1) Settled on the ground, located in high areas that are not subject to flooding; (2) floating, based on wooden logs and (3) elevated on stilts. The last two adapt to the changing water level of the rivers in the summer and winter seasons. Wood predominates as a material for the structure and partitions and irapay leaves for the covers. He also indicates that these houses are the ones that have had little influence from other cultures, maintaining over time most of their original traditional characteristics. Currently, with increase urban influences, some of the houses' materials are being changed, such as Irapay leaves to metal or plastic corrugated sheets for roof coverage.

Amphibian communities are not only found in rural areas. More than 90,000 people live on the outskirts of the city of Iquitos, on the alluvial plains whose landscape varies with the seasonal change in the water level of the rivers surrounding the city. To adapt to this situation, the people build their houses in the likeness of rural and traditional houses, floating or on stilts. Elevated wooden paths, made by the community, connect the houses during the river's rising season. In other situations, residents have raised the level of their streets with fill material, gaining ground

from the river. When built properly, many of these homes are resilient and can cope with extreme fluctuations in water including the increasingly severe impacts of climate change. However, poor environmental conditions and lack of infrastructure including water and sewer services have a negative impact on the health of these communities and the ecosystems they live within. (Alarcón, et al, 2018).



Figure 1 Rural Yanamono Community, Indiana, Peru

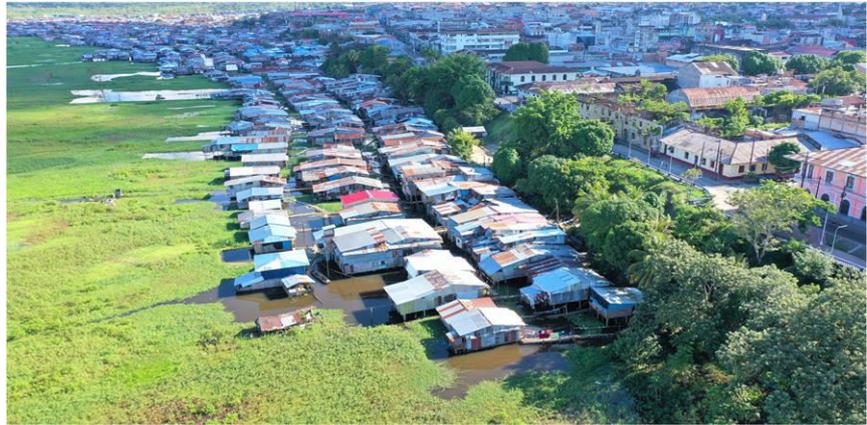


Figure 2 Salaverry urban amphibious slum in Iquitos

3. Key findings

3.1 Physical conditions

Architectural typologies

Most amphibian communities use traditional architectural typologies, traditional construction approaches and traditional materials. The houses are floating or rest on stilts. Their structures and partitions are made of wood. Although, the traditional irapay sheet is still used, the materials and constructions systems are changing with urban influences, and many roofs are zinc calamine, like the rest of the city. The neighbors express these changes: *“Previously, the roof was made of irapay leaves, almost most of the houses, and before the 2000s, the houses were made of rafts, floating. Almost all the houses were floating because that's how they started.”*

Currently, there is a gradual change towards contemporary materials and construction techniques, such as concrete columns, beams, and brick walls. Residentes express that they make these changes respond to maintenance and time costs, durability and as a symbol of progress: *“The house is emerging little by little. Previously, the columns were made of horcones, that is, of sticks. And little by little, they are being built of concrete, column after column that has required a long time. It is not finished yet. Because as we know, water grows in the area, so it means that the horcones do not last long due to humidity”.*

There are some variants in houses on stilts. In stilted houses the first level is used for a warehouse, garage or shop during the river's low season. In the high river season, the warehouse moves to another place, and the shops go up to the second level. Some houses may also have an additional level for bedrooms.

Accessibility and mobility

Accessibility and mobility within amphibious neighborhoods are conditioned by the dynamics of the rivers. In times of low water, when the riverbed dries up, residents may move between houses without inconvenience, either in smaller vehicles or on foot albeit they may need to climb down long stairs to reach the ground if they live in stilted houses. The most mobility difficulty is experienced in times of flood, when the water rises since it is necessary to build floating or stilted wooden bridges to access the houses. In the past, the local governments has supported some communities with materials for this bridges. However, for several years now, the local government supported only access bridges to educational and health facilities, not personal residences. A resident reveals: *“the handmade bridges that are built when the water rises... the years began to pass and, the construction of the bridges was stopped, that is, they only built up to a certain point, up to the school...”*. In the Belén amphibious area of Iquitos, you have the alternative of using canoes to get around when the river rises, however, it demands an additional cost,

harming the household budget that could support food, water, healthcare or other living expenses. A resident of the AAHH Sachachorro states *"the biggest problem is the issue of fares... you must have your [own] canoe or your [own] boat so that you can move, if you do not have it, you have to pay, so, I will carry (canoe)..."*

Public space

Public spaces exist during the river's low season. Soccer fields and recreation spaces are improvised in the dry riverbed and become vibrant communities places. A resident describes: *"...when the river goes down... their activities are carried out at ground level, there are spaces where they set up their sports fields, or suddenly there are some [community] meetings, we have a slab that is exactly where it is going to be. the boardwalk, where they also hold their meetings"*. The drawbacks to these successful public spaces occur when the water level rises. These spaces disappear and the most affected are children and adolescents. As stated by a resident: *"...children begin to swim in the water... and young people and adults begin to look for sports spaces, for example, visit [other] communities that have a space that is not subject to flooding and start playing sports, Normally the school field is used..."*

Access to public services

In amphibious neighborhoods, the electricity service is communal and may be installed precariously above water level. Usually, community organization pay for a connection on highlands and they extend cords to the households living on the floodplain. In some cases, electric companies will install direct connections to the household when electric post can be secure and communities have some preliminary land tenure documentation. There are problems accessing clean running water the supply either lasts for only a few hours and may have contamination issues, or is lacking entirely and residents need to purchase water from a neighbor. A resident states: *"The neighbor supplies us with little water... she has acquired her little water, I think she has bought the water line."* There is a discourse that the service is achieved equitably because residents describe that they "fight for it", as indicated by the daughter of a villager: *"If we have water... not all of them, for example, in my case, my father was the first to have water, as always when they seek to improve him, there are only a few..."*. Few have sewage drains. The property title, or lack of it, impacts access to services, and, in most cases, a sanitation system. There are also problems with the municipal collection of solid waste and trash in the communities, especially in times of rising rivers. The neighbors reported that some of the options for waste management are burning trash, hiring local transportation to send it to areas where the municipal service is more reliable.

3.2 Sociocultural conditions

Worked

Most of the inhabitants of the amphibious neighborhoods dedicate their lives to fishing, agriculture and trade, transport, and construction. The type of work may vary depending on the season when the river is low or high. There is a strong link between the river and employment and so families seek to live on the riverbank, with most of amphibious communities living in the lower area of Belén, which allows them to access the Belén market where residents may have a stall, work at the port, or in related businesses. As a resident expressed: *"This settlement, the lower area of Belén, drives the city of Iquitos, it is the driving force... because everything comes from Belén, from the market... the market is so big, they all come from San Juan or Punchana... because of the things at lower prices. That is what attracts people..."*. Another neighbor confirms *"My dad came to live here [in the floodplain], because it is accessible to the Market, because they are from the daily bread, they work here in the port, and from here we make a living, and with which he has educated us."*

Cultural

Life in the water parallels the traditional Amazonian culture of rural areas because the initial settlers of amphibious communities comes from the riverside communities in the jungle. These communities have adapted to live in different ways depending on the season and the dynamics of the rivers. Likewise, their ways of living are more communal. To most residents living in a flood zone is not always conceived as wrong or risky, rather it is traditional. *"...and in that Amazonian world, water, the forest and the rain, are an essential part... which implies the abundance of resources and creativity, in times of drought it is planting, it is living the forest, the land, they are*

new sources of food. It is landscape beauty; In times of flood, water is an extraordinary source of life, water is pleasure for the Amazon, it is an enormous pleasure."

Organizational Structure

Amphibious communities have representatives who are elected in community assemblies. These representatives manage solutions to social and physical problems, and contact elected representatives such as congressmen, mayors, and governors, depending on the issue. As a representative says, *"We have recently met with the high-level commission of the presidency of the current president... that until December they must build the educational and health buildings... and we are also coordinating with the Ministry Housing..."*.

Independently of what is the organization structure, community organize mingas (collaborative work practices) to address community needs, such as cleaning the landscape of trash and weeds, dealing with citizen insecurity and crime, and solving built environment problems such as the construction of access bridges, elevation of grades, and water services. As one member of the community expressed *"I did my things as an authority, I managed to have communal electricity, water with the neighbor, and so on..."*

Interpersonal networks

The neighbors that were interviewed highlighted that community structure and collaborative work are fundamental for neighborhood, community and families development. Mingas are developed to improve and clean the place and build wooden bridges but there are other dynamics to provide interpersonal supports. For example, neighborhoods always collectively save funds to support community projects. As a neighbor said, *"We all collaborate with two soles, three soles, five soles. We have made a little bag to build our bridges, so as not to be bothering our authorities, we collaborate among neighbors ..."*

Likewise, groups of young activists have been formed in the Belén neighborhood in Iquitos to carry out activities in favor of the community, environment, education, and culture. One of its members said, *"...since 2016 [they have] been working in an articulated manner with the population [that gathers to form] community mingas, based on cultural festivals [and] participation among young people, that is why now you are currently seeing committed young people."* However, according to residents, in some cases, interpersonal relationships are affected during the time of rising rivers. Living in confined spaces and limited access to public spaces for recreation may promote acts of domestic violence, *"...but because of that (non-existence of public spaces) there are many problems. Of course, the level of violence in the houses increases, the stress in the family, because it is a closed space."*

3.3 Environmental conditions

The changes that are taking place in the houses, such as the change of materials or construction systems, were observed to not be very adaptive to the Amazonian climate. Corrugated sheets for roof coverage, without a ceiling, generate great heat and poor air circulation in an already hot location. Traditionally the houses have been open and spacious with leaf roofs to face the heat. On the other hand, if this houses are built too high, they are negatively impacted by winds, with climate change making weather events more intense, more frequent, and more difficult to predict with certainty. These urbanization techniques avoid being able to prevent, adapt and plan with confidence.

The neighbors also report that the flood usually brings snakes, and there are problems when water accumulates and stagnates for long periods of time because the puddles become breeding grounds for mosquitoes. Without formal utility infrastructure, the contamination of rivers by dumping sewage and solid waste is a problem, affecting not only people but also the animal population and the ecological environment (wetlands, flora, and fauna).

3.4 Barriers in the formalization process

According to the interviews in this study, it was identified some of the reasons why the population settles in risky or non-authorized areas are the lack of a housing policy, the lack of urban planning, and the lack of urban land. "I imagine that what leads people to settle in these areas is the need for housing. It has not been adequately addressed by the government". Likewise, the lack of a territorial approach that considers traditional Amazonian lifestyles adapted to the Amazonian floodplain and its rivers does not allow exploring urban-architectural alternatives to

improve the habitat in Amazonian amphibian neighborhoods. An interviewee states, "The laws are made from a mentality that does not reflect the lifestyle of the people. So, there is a large gap between what the laws say and what people do."

This also critically means that the communities settled in the alluvial plain cannot be formalized because the law qualifies this territory as a "non-mitigate risk zone" due to the flooding caused by the increase in its waters during the Amazon winter season. Despite great efforts, many communities remain informal preventing or limiting public investment in services and infrastructure in amphibious neighborhoods.

Because of all these challenges, the State's proposal is to relocate these communities to high ground that is not prone to flooding along the Iquitos – Nauta highway, more than 14 km (or one hour by bus) from the amphibious neighborhoods. While well intentioned, this solution has not been optimal. Of the four relocated experiences reviewed within this investigation, it was identified that three of these neighborhoods do not have physical sanitation, water or property title. Only one have electricity. In other case, housing modules with light materials were included but not electricity hooked up. One resident of these relocated communities explains, "We have proof of possession, not title. There is a problem of overlapping land that is not solved. Because of the slowness of the regional government office and the passivity of the president of urban empowerment".

The most recent development plans carried out by the Ministry of Housing failed to relocate 2,600 families to the so-called New City of Belen. After six years, the Ministry has only managed to relocate 397 families. And it still does not have water and sewer services or equipment. One of the problems reported by residents is the distance to their work centers related to the Belen market and the river since it requires more time and money. "I do not work, because I cannot work as the market is far from me, the [bus] ticket, coming and going, now if you have mobility, gasoline has risen in price, you have to invest fifteen soles in gasoline and, all that remains for us is a little awkward for us...". Another problem is housing, whose concrete and small living corridors has not considered the climate or culture of the families living within them.

Over the last decade, in order not to be relocated, some amphibious communities have asked the authorities to raise the level of the streets to access formalization and water and sewer and sanitation services. This avenue is not regulated but is fairly accepted by the entity that performs the formalization process. Some interviewees, mainly academics, do not believe that ground elevation is an adequate solution since it affects environmental health and causes ecological damage. While, most municipal officials interviewed do not agree with this practice, they sometimes accept it because they cannot think of another alternative, some residents demand these approach since they see the opportunity to access the benefits of formalization, such as access to the property title, services, and equipment.

Another barrier identified in the formalization processes of amphibious communities is the physical sanitation of the land because they are privately owned land or in the process of being reverted to the State. Therefore, these processes usually last more than ten years.

4. Conclusions

The urban and architectural typologies of amphibious communities adapting to seasonal changes in floodplains can be strategies for the development of resilient housing and neighborhoods adapted to climate change. However, the lack of a territorial approach that incorporates the traditional and urbanizing Amazonian ways of inhabiting, added to the relocation processes as the only currently proposed alternative solution for these communities, limits the exploration of technical alternatives to improve the living conditions of the amphibious communities.

Different barriers were identified in the formalization processes of the amphibian communities. Which include the qualification as a non-mitigate risk area and, limiting the definition of habitable land. Other obstacles are administrative processes, existing owners, and jurisdiction of floodplains. However, the communities have found some strategies to access formalization themselves, such as raising the street level.

City planning must incorporate proposals for the sustainable and healthy development of amphibious and slums communities, as these communities continue to grow and expand cities. For this, it is necessary to consider the

challenges identified in this research, such as water and drainage sanitation, accessibility and mobility, public space and recreation, improvement of construction systems, strengthening of community networks and cultural values, preservation of ecological resources and environmental responsiveness.

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