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Gender and sand extraction in the Usumacinta River basin

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1. Introduction

Sand and gravel, collectively referred to as aggregates, are the world’s most extracted natural resources by volume after water. Each year, ca. 50 billion tons of these materials are extracted to meet societal demands for housing, industry, and transportation (UNEPA, 2019). According to estimates by OECD (2018), the current extraction levels will double in the next few decades. In many regions, rivers are particularly affected by intense sand mining (UNEPA, 2022), as they contain easily accessible deposits that appear to be renewable. However, the expansion and intensification of river sand mining over the last century has caused serious environmental and social impacts (Torres et al., 2017).

Recent perspectives on sand sustainability called for an improved understanding of mining systems and their larger supply networks as a series of multiple, interconnected coupled human-natural systems (Torres et al., 2021). These networks and their embedded natural and social systems evolve over time in response to disruptions (e.g., regulations, technological development) as complex adaptive systems (Levin, 2003). Numerous studies have documented how the extraction of river sand alters environmental systems (e.g., Hackney et al., 2020; Koehnken et al., 2020). However, achieving sustainable outcomes also requires a deep understanding of the forces shaping social systems within the sand-supply networks (Torres et al., 2021). This entails accounting for the pattern of complex interactions between the actors in the system, many of which might be underpinned by evolving gender norms.

The importance of a gender lens in the management of natural resources is well recognized (Kawarazuka et al., 2017; Meinzen-Dick et al., 2014). In mining research and policy, gender issues have taken center stage (Lahiri-Dutt, 2022), particularly in the artisanal and small-scale mining sector as reports indicate that women comprise about 10–50% of the workforce, with the highest percentages being found in Africa (Hinton et al., 2003). Research over the last decades have shed light on the dominant hegemonic masculinities within mining environments and communities and the acute gendered division of labor (Connell and Messerschmidt, 2005; Lahiri-Dutt, 2022), with women depicted as both heroines and victims (Rutherford, 2020). Several studies have examined how mining expansion and mechanization affect gender roles and identities, and the factors that support or hinder the transformation of these roles and women’s involvement in decision-making and political power (Großmann and Gullo, 2022; Hinton et al., 2003; Muthuri et al., 2022). These factors include gender norms and cultural beliefs. For
example, in certain cultures, women are prohibited from entering mines during their menstrual periods because they anger the gods, bring bad luck, or pollute mines (Hinton et al., 2003), while in others menstrual blood is associated with good luck (Priandhita and Lahiri-Dutt, 2023). Rather than studying men and women as separate categories with distinct roles, many researchers recognize the importance of understanding the diverse experiences of both genders within and around mining operations, whether they are involved in mining activities or completely excluded. Danielsen and Hinton (2020) emphasize the concept of social relations of gender, which looks at the social relationships through which genders are constituted as unequal social categories, affecting the access and control over resources and decision-making processes (Cislaghi and Heise, 2020). Adopting a gender relations perspective involves recognizing that social hierarchies are shaped by the interplay of gender, class, age, and ethnicity, along rural-urban gradients (Kabeer, 1994), and provides a dynamic interpretation of women and men’s lives in mining sites. Interventions to improve the management of natural resources and gender equality needs to be anchored in such knowledge (Buss and Rutherford, 2020).

Most research on mining and gender issues has focused on high-value minerals such as gold, coal, or diamonds. However, the social systems and gender relations within sand mining contexts are poorly understood (Marschke and Rousseau, 2022). The figures regarding the female workforce are highly uncertain (e.g., 4–7% in the development minerals sector in Fiji and Benin, 12-88% in Uganda; (ACP-EU, 2018; Djihouessi et al., 2017; ACP-EU 2018)), and the documented roles are diverse, including digging, classifying aggregates, cleaning, selling food and water, doing laundry or getting involved in sex work at the periphery of mining sites (Haghgo and Amimo, 2017; Daghar, 2022; Jambiya et al., 1997; Sigsworth, 2022). Regarding impacts, the women who live in riverine communities seem disproportionately affected by sand mining, facing increased flooding risks and having to travel longer distances for basic resources like water, medicinal plants, and wood fuel due to deforestation and the lowering of the water table (Du et al., 2019; Haghgo, 2020; Nguru, 2007; Athukorala and Navaratne, 2008). These impacts add to their domestic burden and may limit their income-generating activities.

Here, we aimed to advance the understanding of practices and gender relations in sand mining at male and female spaces. Specifically, we ask whether river sand mining contributes to construct, reinforce, or challenge gender relations. We focus on the mining communities on the basin of the Usumacinta River, Mesoamerica’s longest river. We combined a review of legal instruments and mining concessions in the area with fieldwork carried out between 2018 and 2022 to grasp the range of practices and environments associated with the mining settings. Through direct observation, interviews, and workshops, we explored whether mining is affected by gender norms, and examined men’s and women’s participation, their perceptions, and expectations in mining communities, including their roles and working conditions. In doing so, this paper aims to provide insights into the interplay of factors that shape gender outcomes and could redress unequal power relations. This knowledge is essential to improve governance and achieve Sustainable Development Goals, such as the one on promoting gender equality (SDG5). This research is part of an interdisciplinary and international project (VAL-USES) focused on providing a holistic view of the sediments in the Usumacinta River basin through a systems integration perspective and bringing together experts across disciplines such as ecology, law, geography, political science, engineering, archeology, anthropology, and agroecology, with relevant stakeholders. This project provided a good basis for approaching the coupled human and natural systems in mining contexts, including the influence of the river and sediment dynamics on local communities and their ability to adapt to changing environmental conditions.

2. Methods

2.1. Conceptual framework

Following Cislaghi and Heise (2020), we conceptualize the gender system as a social system that organizes hierarchies and privileges based on a binary division of masculine and feminine spheres. Gender norms are one of the components of the gender system that also includes gender roles, socialization processes and power relations. Specifically, gender norms are presented as “the social rules and expectations that keep the gender system intact” (Cislaghi and Heise, 2020). They are social norms defining acceptable and appropriate actions for women and men within a particular social order and timeframe, which serve to legitimize and reinforce the existing gender relations. Gender norms are socially and culturally constructed in specific contexts and result from socialization processes and social interactions, and as gender relations they are dynamic, subject to change and context specific. They are embedded in and expressed through institutions, activities, beliefs, and practices. Men and women comply and adhere to those expectations and beliefs, and through their actions contribute to reproducing gender norms and expressing inequitable power relations (Connell, 2014; Lazar, 2005).

2.2. Study area

The transboundary Usumacinta River basin, spanning 73,200 km² and home to Mesoamerica’s longest (at 1100 km) and most powerful river, encompasses parts of Guatemala, Belize, and Mexico (Kauffer, 2019). The river runs from Guatemala’s highlands (upper basin) through the Mexican states of Chiapas, Campeche, and Tabasco (middle and lower basin) before flowing into the Gulf of Mexico (Fig. 1) (Mendoza...
through the Mexican transparency system. In total, we obtained information of 10 citizen complaints about sand mining operations in the area from 2000 to 2022. In total, we found 21 mining concessions for aggregates. We reviewed and examined the information provided in the concession documents, which included details on the geographical locations of mining sites, access to the mining sites, prior mining activities, perceived environmental risks, restoration processes, forms of organization, types of equipment and methods of extraction, environmental and local regulations, informal practices, and key stakeholders. When available, the accompanying environmental impact assessments and other authorizations that are required to obtain each mining concession were also analyzed for additional information.

Furthermore, we obtained data on complaints, fines, and closures of mining sites carried out by the Mexican Federal Attorney for Environmental Protection (PROFEPA) to gain insight into local dynamics. The data was accessed from the federal institution after four requests through the Mexican transparency system. In total, we obtained information of 10 citizen complaints about sand mining operations in the state of Tabasco and none from Chiapas. Some of those complaints led to fines and shutting down operations.

2.3. Review of mining concessions and formal complaints

We first conducted a review of aggregate extraction permits along the Usumacinta River and its tributaries to identify target locations for fieldwork (Fig. 2). In river systems, the Mexican National Water Law defines mining rights for aggregate extraction as concession titles, granted through the National Water Commission (CONAGUA) and registered in the Public Registry of Water Rights (REPDUA). We requested information about concession titles to extract aggregate resources in the area from 2000 to 2022. In total, we found 21 mining concessions for aggregates. We reviewed and examined the information provided in the concession documents, which included details on the geographical locations of mining sites, access to the mining sites, prior mining activities, perceived environmental risks, restoration processes, forms of organization, types of equipment and methods of extraction, environmental and local regulations, informal practices, and key stakeholders. When available, the accompanying environmental impact assessments and other authorizations that are required to obtain each mining concession were also analyzed for additional information.

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2.4. Fieldwork activities

Fieldwork was conducted between 2018 and 2022, with a break from mid-March 2020 to December 2021 due to the COVID-19 pandemic. We used the reviewed information to organize the first fieldwork campaign to the study area, which targeted the 21 mining concessions that were supposed to be active in 2018. The contents of the reviewed documents and mining concessions were contrasted through in situ observation and semi-structured interviews with members of the local communities and relevant stakeholders. To identify new extractions sites, we used snowball sampling (Atkinson and Flint, 2001) following the indications and suggestions of local stakeholders, members of riverine communities, and other researchers. Fieldwork was carried out in 79 locations along the Usumacinta River and 8 tributaries, 6 of them in Mexico, 2 in Guatemala. To examine cross-border dynamics, we visited 6 locations near the border in Guatemala (within 25 km from the border). It was not possible to conduct more in-depth and prolonged fieldwork in Guatemala due to security concerns and limited funding.

The recorded locations were grouped into 54 mining sites according to their collective organizational structure, each mining site containing one to several extractive locations on sandy beaches, islands, and in-stream deposits. The types of collective organizations involved in sand mining included cooperatives, unions, ejidos, and private companies. Cooperatives are formal organizations of at least 5 people who join to extract and sell river aggregates. They are established by registering with a notary, local authority, or judge. Joining the cooperative requires payment of a fee, but the cost of changing registration documents is often too high for sand miners, resulting in the frequent informal entry of new members. Unlike other countries, the Mexican government does not actively promote cooperatives. The existing cooperatives have emerged organically through grassroots efforts, inspired by successful fishermen’s cooperatives in the region. Unions are formal organizations made up of workers primarily involved in aggregate transportation, but...
also including extraction in some sites, and are affiliated with large, historically established trade union confederations linked to political parties. Ejidos are a collective land tenure regime that establishes joint ownership of lands and are mainly destined for agriculture and forest management. They were created during the Mexican Revolution to give land parcels to landless peasants and have evolved into the main rural form of social organization in the 20th century, prior to the privatization of land ownership in 1994. Although their role as collective forms of organization has changed, they continue to hold significant power in regulating sand extraction in the Usumacinta River basin, especially in rural areas. Private companies are organizations established using private capital and officially registered as business entities. They tend to originate from major urban centers such as federated states’ capitals. These companies are often contracted by governments to undertake public infrastructure projects such as the construction of roads, railways, and bridges, which require the highly mechanized extraction of aggregates. We considered that multiple extractive locations belonged to the same mining site when they were in hands of the same organizational structure and were managed by the same leaders.

Data was collected through a variety of methods, including 42 semi-structured interviews, 13 collective interviews with groups consisting of 2 to 15 individuals, 28 informal interviews, direct observation on active and abandoned extractive locations, two workshops with local sand miners and villagers, and 5 meetings with organizations and governmental institutions. The questions and observations focused on understanding various topics, including livelihoods, resource management, working conditions, social relations, gender roles, labor division, and the involvement of women in mining activities and organizations, along with the reasons behind their participation or lack thereof. The local population was willing to collaborate, but accessing mining sites of private companies was challenging and potentially dangerous. In June 2019, one of the earliest sand miners who had turned into a conservationist was murdered (REFORMA, 2019) while we were conducting fieldwork.

Of the 54 identified target sites, 3 were removed due to the lack of ongoing mining activities and 10 were excluded because of a lack of data on collective organization and local regulation, particularly in reference to industrial sites that were not operating in accordance with the law and in which the interviewed stakeholders were not involved, resulting in a final sample of 41 mining sites. These sites were then catalogued in a database by mining types, stakeholders involved, forms of organization, site characteristics, regulations, informal practices, phases of the extractive process, conflicts, and women’s participation in extractive activities. We recorded indigenous population in 24 sites, but the percentages varied greatly across sites, from 1.6% of local population to 100%, with three sites being entirely managed by indigenous people (Fig. 3). Almost all these sites (23 out of 24) were in Chiapas.

Finally, we identified three relevant cases of female participation in sand extraction, which we describe in detail and analyze regarding their core role for this activity.

3. Results

3.1. Gender norms and labor division at mining spaces

The process of extracting aggregates in the Usumacinta River and its tributaries can be broken down into four distinct phases: 1) the extraction phase, which involves the collection of sand, gravel, and pebbles and their subsequent stockpiling and classification by sizes, typically near riverbanks in flood-safe areas; 2) the temporary storage phase on flood-safe areas or nearby locations, where the aggregates are kept for the miners’ own needs during the rainy season (when direct extraction is hindered by the river’s high level and flow) or for sale at a later time when prices are higher; 3) the supplying phase, which mostly corresponds to the selling phase, but can also include exchange or donation; and 4) the transportation phase, which involves moving the materials from the storage location to the consumption site (e.g., construction zone). In addition, there are organizational tasks that encompass managing shifts, handling legal permits, conducting sales, and agreeing on sale prices. These administrative tasks are sometimes developed at offices in town, i.e., outside the geography of the mining site.

We found a significant gendered division of labor. At the extraction and storage phase, adult men constitute all the labor force at 68.29% of the sites (n = 28 sites). Young men (10–17 years old) are present at 14.63% of sites (n = 6 sites), adult women at 9.76% of sites (n = 4 sites), and young women (12–17 years old) at 7.32% of sites (n = 3 sites). All four classes are only present in 2 mining sites. Most miners at artisanal mining sites are members of riverine communities with an agricultural and fisheries background, whose dwellings are close to mining sites (within ~5 km) on the riverbanks or a little further away as a protection against flooding.

Men participate in all phases of the supply-chain across all sites, whereas women only participate in organization, selling and storing tasks in 19.5% (n = 8 sites), 9.8% (n = 4 sites), and 2.4% (n = 1 site) of the sites, respectively (Fig. 4). All the truck drivers were men, and no women participated in activities that involved mechanized extraction.

Across the sites, we heard about gender norms, particularly in rural communities, which assign women the primary role of housewives, with few exceptions. Therefore, their main responsibilities revolve around housekeeping and childcare in the domestic sphere. Both men and women shared that women’s main responsibilities lie in attending to the needs of their husbands and relatives. This includes having their meals prepared when they finish the workday or take a break. Women are economically dependent of men, regardless of whether men engage in mining, fishing, or farming livelihoods. They do not consider engaging in paid work outside of the home and lack control over the household finances. While men contribute a portion of their income towards household expenses, men ultimately decide how the majority of the income is spent. During interviews conducted in the homes of participants, women were typically present and sometimes listening but primarily engaged in cooking, childcare, and serving drinks, without interrupting the conversation unless they played a significant role in an organization or were the focus of the interview (see case 2 in Section 3.2).

Gender norms also restricted the mobility of women in rural areas...
Fig. 4. Percentage of mining sites (n = 41) in the Usumacinta River and its tributaries with regular men and women participation by type of activity based on fieldwork developed on 2018–2022. Note that selling includes other less common supply streams such as exchanges and donations.

and their participation in public and political local affairs. Specially, married women experience strict and unquestioned control over their mobility. They rarely now how to drive, generally only leave the house to visit family members, attend church, or buy groceries, and scarcely go out from their villages. In one case, a miner who has a wife and two young mistresses, said that he locks the door of one of the latter when he leaves her house, and he justifies it saying that “she prefers to stay at home”. While young girls have received better education than their mothers, pursuing higher education beyond secondary school requires traveling to the town and even further for the university, which is less accepted and frowned upon for young women compared to young men. Girls as young as 14 or 15 sometimes become early mothers, dropping out of school, and entering marital life at a very young age, which further reinforces gender roles within the domestic sphere. These circumstances are more pronounced in indigenous communities or when riverine communities are located in remote areas. In contrast, urban areas tend to exhibit relatively more relaxed gender norms. Indeed, women from rural areas who wish to earn their own income express that they would have to relocate to urban areas, and once they make this transition, they rarely return to their rural communities.

As an expression of gender norms, the river space is deeply divided by genders, with men primarily occupying the mining spaces with their machinery, creating a strong masculine atmosphere, whereas women are confined to household chores on the sandy beach, such as extracting and carrying water, washing, and sporadically auxiliary tasks in mining activities and recreational activities. In the morning, the river is mainly used for men’s activities such as fishing and sand extraction, while in the evening, when sand mining has finished, women are more present for family activities with their children. Nevertheless, in Guatemala where local population faces a shortage of water services, the riverbanks are used in the morning for both sand mining and the washing and grooming activities of women and children, but the places are spatially separated and sometimes marked.

3.1. Male spaces: The sand miners of the Usumacinta

Men are the ones primarily in charge of the extraction phase (Fig. 4). They often expressed that the work at the mining sites was not for women, as they see it as too physically demanding and unbecoming for them: “it is not a space for women, it is a space for men” (in Spanish: “No es un espacio de mujeres, es un espacio de hombres”). Usumacinta’s sand miners (known as “areneros” in Spanish) can be grouped into four categories according to the target sand deposits and their methods of operation (Table 1, Fig. 5): (1) the sand divers (known as “buceadores” in Spanish), who extract the sand at the riverbed beneath the surface of the water, at depths of 3–9 m; (2) the sand fishermen (known as “pescaadores” in Spanish), who extract the sand from in-stream sandbanks in waist-deep waters and employ a cable and pulley system (imitating a fishing rod) to carry the sand from the river to the storage site; (3) the sand harvesters, who collect sand from deposits found on the river banks or sandy beaches exposed during the dry season; and (4) private companies who carry out highly mechanized sand extraction involving the use of dredgers, bulldozers and backhoes. In this setting, workers are primarily dredger and machinery operators, and drivers. The range of sand mining practices depicts different forms of organization and is influenced by both the mechanization of the activity and the conditions of access to the river resources.

The majority of the 41 mining sites analyzed use a combination of artisanal tools and machines for extracting sand. Specifically, 73.17% employs artisanal tools, 58.54% have bulldozers and backhoes, and 19.51% use dredgers, which are only found at industrial mining sites. Additionally, 7.31% of sites use local adaptations of extraction technology such as pulley systems (see section 3.2.1). Sand miners usually work from 3 to 4 am until 12 pm or from 7 am until 4 to 5 pm, when they go home for a late lunch. Mining is mostly a temporary activity conditioned by the demand (e.g., construction projects) and the seasonality of the river, although it was done year-round in 16.7% of the sites, coinciding with dredging operations of private companies. Because of that, artisanal sand mining is generally a livelihood diversification activity that is considered to provide a good income. This activity is typically combined with seasonal agriculture, such as growing corn, rubber, lemon, oil palm, banana, but also raising cattle, fishing, producing wood charcoal, or working in town in the commerce sector, carpentry, masonry, or handicrafting.

Sand divers and fishermen use boats such as dugout canoes, pirogues, or fishing boats to extract sand in-stream through artisanal methods in all the sampled locations (Fig. 5). Divers use equipment such as buckets and baskets to collect sand from the riverbed and steel rods, commonly used in the construction industry, to anchor the boat and assist in descending to the river’s bottom. Sometimes, they work naked early in the morning to avoid accidents with their clothes and because of the heat. In contrast to the divers who hand carry the extracted sand,

Table 1

<table>
<thead>
<tr>
<th>Categories of sand miners and their approach</th>
<th>Divers (4 sites)</th>
<th>Fishermen (2 Sites)</th>
<th>Harvesters (28 sites)</th>
<th>Private companies (7 sites)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-stream (deep waters)</td>
<td></td>
<td>Riverbanks (shallow waters and beaches)</td>
<td>In-stream (deep waters)</td>
<td></td>
</tr>
<tr>
<td><strong>Tools</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Artisanal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand barges</td>
<td></td>
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<tr>
<td>Shovels</td>
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<tr>
<td>Barrows</td>
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<tr>
<td>Baskets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel rods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semi-mechanized</td>
<td>None</td>
<td>Pulley system with engine</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Mechanized</td>
<td>None</td>
<td>Bulldozers Backhoes</td>
<td>Bulldozers Backhoes Dredgers</td>
<td></td>
</tr>
</tbody>
</table>

The Extractive Industries and Society 15 (2023) 101277
Fishermen employ a pulley system with wires (known as “cables” in Spanish) to carry the sand from the river to the storage site. Divers and fishermen are the most skilled members of local communities, as this activity is dangerous and physically demanding. They hire shovelers to pile or bring the sand to the shore and load trucks, frequently including their sons, grandsons, nephews, or brothers-in-law, sometimes under the age of 18. Sand harvesters perform mostly dry activities, which can be either artisanal or mechanized using bulldozers or backhoes, depending on their organizations and their individual and collective economic capabilities. When the activity is artisanal, men use shovels. Shovelers are considered to have a lower status in local social hierarchies than machine operators, divers, and fishermen. The group of sand harvesters is more heterogeneous than that of sand divers and fishermen due to the high participation of members of local communities who also extract aggregates for their own needs (e.g., for replacing earthen floors or wooden walls with materials made of aggregates).

In the transportation phase, after extracting and piling the sand, carriers use 6–7 m³ trucks for selling. For fulfilling the needs of families, they use individual cars or pick-ups. When the mining is done by sand divers and fishermen, transport is arranged by the customer who hires transportation unions, which have their own trucks. When sand harvesters also work as union drivers, they oversee the entire process. The concentration of large quantities of sand in certain areas leads to a gathering of extraction teams competing for resources, which can result in tensions and conflicts, particularly when private companies enter a site that has been historically exploited artisanally.

Throughout the different phases of extraction, the sand mining space is a male-dominated sphere. It serves as a platform for socializing around a hegemonic masculinity, with many conversations revolving around sex and women, as witnessed by our male colleagues in field observations. Knowledge about mining practices is transmitted from grandfathers and fathers to their sons and grandsons. However, there is also certain social mobility, with some individuals transitioning from mining to jobs such as truck driving, farming through the Sembrando Vida government agriculture scheme, or they open their own shops to sell materials, with their fathers not necessarily expecting or insisting their sons to follow in their footsteps.

During interviews and group discussions, miners often cited the physically demanding nature of sand mining and beliefs about women’s weakness and vulnerability as the reasons for women exclusion from mining. Tasks such as diving, harvesting, and shoveling require considerable strength and expose workers to intense heat and sunlight. They described the labor as strenuous and too dangerous for women, referring to the wounds in their hands, injuries, and the risk of drowning. Furthermore, divers and fishermen mentioned the hazards associated with the dynamic nature and rapid changes of the river flow and the presence of debris (wood and waste materials), as well as women’s lack of swimming skills. The challenging conditions also dissuade young men from pursuing careers as sand divers and fishermen, as expressed by themselves or by their parents and uncles. They often prefer pursuing education or employment opportunities in urban areas.

Fig. 5. Typology of sand miners of the Usumacinta River. A) Sand diver in the morning at wintertime (December). B) The pulley system of sand fishermen (imitating a fishing rod) to bring the sand from the shore to the flood-safe area. C) Sand harvesting on the river shore. D) Sand dredging site of a private company. Credit: Edith Kauffer.
3.2. Female spaces: Women’s contribution to sand mining

Women directly contributed to mining-related activities in 8 of the 41 mining sites examined (19.51%) and were completely absent in the remaining sites. In half of the locations, women were physically present at the mining site during extraction and storage phases, mostly in sites managed by cooperatives. As we ventured further into rural and remote areas, we found a notable decline in the presence of women at the mining sites. In fact, women were completely absent in mining sites managed by indigenous communities. However, women were also absent from mining sites operated by private companies. In the remaining four locations, women performed administrative tasks at the offices of private companies or unions in urban areas, where they usually live.

A strict division of labor prevailed in the rural villages located along the Usumacinta River and its tributaries. Most women assume the role of housewives, with their daily activities involving cooking, childcare, washing, cleaning, and tending to their orchard or vegetable garden in the backyard for self-consumption. Women rarely engage in other income-generating activities while men are mining. Occasionally, they operate a small home-based shop selling a small range of beverages, snacks, and basic personal hygiene products, or they manage an economic canteen.

During interviews, women expressed their reluctance to engage in sand mining activities because they agreed with the male perspective that it was too dangerous, and their husbands did not agree with them doing it. When they did engage in mining-related activities, women normally got involved through family connections (i.e., husbands, fathers, and brothers) to perform activities that are described by men as “minor tasks” or “help”. The few women who participate mostly live close to the mining site and can operate near or from their backyard. Those women are often tasked with manually picking and sorting pebbles from the stockpiles of sand and gravel at riverbanks or in storage areas. In the areas where this was the case, men participating in group discussions explained that these activities were easy, required patience – seen as a “feminine trait” – and did not require women to move away from their garden. The separated pebbles are sold for landscaping and decorative purposes in the Yucatán Peninsula. By engaging in this task, women could earn a small amount of money, referred to as “un dinerito” in Spanish. However, it is the male intermediary who purchases the pebbles from the women and resells them who profits the most. During conversations, a few cases where described in which women had assume a bigger role in mining sites when their husbands and sons had migrated seasonally to the US or the Maya Riviera. However, women’s involvement was limited to administrating the family business and representing their husbands or sons during cooperative meetings.

Engaging in more physically intense activities such as shoveling was highly exceptional (Fig. 6) and coincided with peaks of demand. That was the case in 2022 due to the Maya Train tracks building, when some women also shoveled sand in the barges to fill out the buckets to speed up extractive activities and increase sales, ultimately benefiting the family’s overall finances. When it happened, women’s contributions were frequently disregarded or undervalued by male miners. In such situations, women were usually accompanying their husbands, and if other men noticed this, the husband was often mocked for not being

Fig. 6. Although women have a primary peripheral role in sand mining activities, they are sometimes seen providing “support” (as expressed by miners) for physical activities such as unloading sand barges (A), starting the engine of a motorbike to transfer the buckets of sand to stockpiles (B), picking and classifying pebbles for selling them as decorative stones (C), and even loading trucks (D). Credit: Víctor A. Gallardo Zavaleta and Edith Kauffer.
‘manly enough’ and his heterosexuality was questioned. Rarely the women engaging in physical activities were remunerated for their work as it was seen as auxiliary work, which contrasts with the women performing office work at urban areas, who are remunerated. If the mining site is located far away from home, women do not travel to participate into the mining activities as expressed by miners during the interviews. They normally avoid traveling along the river with dugouts and barges to collect sand or using machines to dredge or load materials (but see case 1 below). Indeed, women only enter the river for crossing to the opposite riverbank or travelling when it is closer and cheaper than by road. During our visits to mining sites, we invited young boys and girls to accompany the principal investigator – a woman – on the dugout. However, it was impossible to convince the young girls to join, while boys (5–6 years old) were eager to participate. Both genders believed that the presence of women contributes to slow down operations and makes mining less efficient.

We identified three examples of women’s participation in diverse activities associated with organisations of sand extraction that we describe below, and which allowed us to question the invisibility and subalternity of women’s work in the Usumacinta River basin.

Case 1. The teenage girl and the motorcycle

In one of the oldest extraction sites with the biggest cooperative for sand extraction dedicated to sand fishing, a teenage girl starts the engine of a motorcycle to bring the sand from the shore to the storage area. The engine activates a pulley system that lifts metal buckets of sand and gravel from the riverside to a stockpile located several metres above the water flow, where materials are later classified. This young girl ‘helps’ (as put by the cooperative members) her grandfather, father, and brother to manage this part of the storage area. She is attentive to the indications of the men, who shout out when she must start the bike. She stops the bike after the bucket empties its contents on top of the stockpile, where materials are later classified. This young girl ‘helps’ (as put by the cooperative members) her grandfather, father, and brother to manage this part of the storage area. She is attentive to the indications of the men, who shout out when she must start the bike. She stops the bike after the bucket empties its contents on top of the stockpile when it reaches the end of the pulley system and is sunk back into the boat by gravity. Before the invention of the pulley system, the sand was moved on the backs of men and thereafter by horses, representing a heavy phase of the process. During our first visit, the teenage girl was distrustful towards foreigners. While we talked with her grandfather, father, and brother, she stood behind them without directly interacting with us. After subsequent visits, her demeanor changed significantly. She was confident and had a pleasant smile, no longer requiring her family protection. Throughout the mining operations, the teenage girl is frequently present, sitting on the motorcycle. Boys as young as 9 years old, along with other women participate in running the motorcycle.

Case 2. María, the invisible head of the cooperative

One of the oldest cooperatives of the Usumacinta River basin was created 40 years ago by 8 members of a riverine community to extract sand from the river, store it, and selling it year-round. Although the founding members were all men and the current miners (divers) are exclusively male, women have actively participated in other cooperative activities. At one point, the cooperative had a total of 11 members, including four women, and women continue to play a role in the organization. Following the death of the cooperative’s president in 2009, his wife, who was already a member along with their daughter, assumed the presidency due to her kinship. Her contributions to the management of the cooperative were significant and she even shovelled sand from the dugout to the truck when there was a high workload. After her son’s passing, it was hard for her to lead the organization and keep up with the administrative workload, so she resigned in 2015. María – a pseudonym to preserve her confidentiality – lives in poverty. Despite her resignation, the cooperative continues to use her electronic signature to issue invoices, which worries her due to her inability to travel to the state capital to complete the deregistration of her electronic signature with the tax authorities. Although she served as the cooperative’s president for 6 years, her presidency was and is scarcely recognised. After conducting numerous interviews with miners and the cooperative’s main leader (identified by the miners), María’s role was discovered. When we interviewed María at her home, one of the miners also attended the conversation without saying anything. When we asked her about the current president, María said that this man was the president. The stated leader according to the sand miners was the treasurer, who was one of the cooperative’s founders and had been our main source of information for over a year. After interviewing María, the treasurer refused to allow further visits to his home, as he concealed information regarding María’s past presidency. Today, the cooperative has only 4 members, one of whom is a woman. She and her husband bought the memberships from another member and became the newest members. They employ shovellers and divers who carry out the mining activities and she only participates in selling sand on the beach near her husband. We requested an interview with her, but she declined to speak. However, one of the members of the research team informally spoke with her husband. The cooperative organizes individual sales based on demand, and during their assigned shifts, her husband told us that he takes the main role in serving clients.

Case 3. Women in unions to fill quotas

According to Mexican law, transportation unions that control both sand extraction and transportation by trucks in certain sites require 22 members to establish a section. One of the unions of the Usumacinta River basin was founded in 1996, when the construction of a road started and the demand for construction aggregates rose. The general secretary of this union explained in an interview: “My wife is a member of the union, but in reality, it’s only the men who are responsible for the handling of materials. I take care of everything” (in Spanish “Aquí mi mujer está metida en el sindicato pero ahora sí, los puros hombres nos encargamos del manejo de los materiales. Yo me hago cargo de todo”; Interview, December 14, 2022). In several unions, women appear as formal members but in practice they do not participate in extractive, administrative nor management activities. They were signed up as members to fill the required quota to create a section, but they remained as housewives and had little knowledge about the organization of the unions. The union’s members who were interviewed were mainly organized around kinship relationship, with the father holding a leadership position and his sons, daughters, and wife being formal members. The men typically work as drivers and sometimes as harvesters, except for when they attend university classes or work in an urban area. Larger unions that are based in the capital of municipalities sometimes employ women as secretaries in their offices, but they are not union’s members.

4. Discussion

River sand mining provides opportunities for diversifying the household’s livelihood strategy of the riverine communities of the Usumacinta basin. Many people rely on the river for their livelihoods as farming entails considerable risks due to frequent and seasonal flooding, and working at ranches, plantations or in the city requires longer travelling times or having to migrate seasonally (Pischke et al., 2018). The mining sector presents a complex picture, with sites worked predominantly by hand coexisting with others that are highly mechanized. Within this context, our research reveals that there is a significant imbalance between men and women’s spaces in the mining communities. Men contribute to the whole production process across contexts and organizations, whereas women’s participation is almost anecdotal and restricted to certain locations mostly managed by cooperatives, neither too rural nor too mechanized. Consequently, our description reflects the situation of both separated and opposite spaces: the male spaces well-structured and organized, and the female spaces being un-systematic, peripheral, and characterized by individual participation rather than collective involvement. The division of labor and spaces result in an uneven distribution of the benefits and risks of river sand mining, with most women being unpaid and men earning income and receiving training for the use of technology and mining practices, thus...
reinforcing gender inequalities. There was however an important divide between rural and urban communities regarding roles and labor conditions of women.

4.1. Factors that limit women participation

We conclude that a combination of physically demanding work conditions and deeply ingrained gender norms in rural communities have led to a strict sexual division of labor and space in the Usumacinta River basin, resulting in limited female engagement in sand mining and associated organizations. The strenuous nature of the work (also discouraging young men to engage in mining activities) and perceptions of women’s weakness hinder their participation, while gender norms expressed through societal expectations and divisions of labor reinforce the disparities. Sand diving, fishing, or dredging are physically demanding or technical activities that in the area are culturally intended for men, who are represented as undertaking dangerous and skilled work, as in other artisanal mining contexts (e.g., Danielsen and Hinton, 2020; Rutherford, 2020). Interestingly, similar diving approaches for sand extraction have been reported in countries like Sri Lanka (Piyawadani, 2016; Talbert, 2012) and India (Rege, 2016; Srivastava, 2017), and they were also fully executed by men.

Our research confirms that gender norms in the rural areas of the Usumacinta River basin follow the domestic and the male breadwinner models (Romano and Papastefanaki, 2020), with men being the principal wage earners and women having a pivotal role in reproduction, housekeeping, and care work. Moreover, through mobility restrictions, these norms undermine women’s ability to engage in activities that take them away from their homes. We found evidence that women’s participation in sand mining was strongly modulated by dependency relationships. When women get to participate in mining-related activities, they make it through their family connections (e.g., marriage, inheritance). These gender relations keep women on limiting gender roles and on the margins, performing tasks that are considered minor, which contributes to their invisibility. Even when performing physical tasks, working at the office, or assuming leadership positions, their contributions are frequently disregarded by their colleagues and employees, as shown by the case of Maria. As highlighted by Rutherford (2020), the family unit plays a crucial role in of gendered moral politics lying at the heart of labor mobilization in artisanal mining in rural contexts. Male labor in sand mining is mobilized through socialization, kinship, and generational ties, whereas female labor is mobilized through moral obligations and subjected to dependency relations, enabling her husband or other male relatives to harness her labor for their economic interests.

Gender norms were also expressed through gender-specific connections to river resources and riverscapes that influence mining spaces. Previous research in the Usamacinta River basin has shown that the activities undertaken by men and women along the river’s edge are highly distinct (Kauffer, 2022), which aligns with our own observations. Women had limited access to the river and its resources, especially in rural indigenous communities, making the riverscape primarily a male domain, organized around specific gender-specific activities and schedules. For example, only 1% of the committees managing water resources in Chiapas have female representation (Kauffer and García, 2003). This pattern might extend beyond the Usamacinta River, as numerous studies on water governance from around the world have shown that irrigation, hydropower, and water policies are often biased against women (Romano and Papastefanaki, 2020 and references within). However, sand mining practices in the Usumacinta River date back to the 1950s, in conjunction with infrastructure expansion and changing preferences for building materials. As a result, the context and regulation development significantly differs from areas with a long-standing mining tradition, such as those portrayed by Romano and Papastefanaki (2020).

To summarize, when women participate in sand mining, they tend to contribute to activities that 1) can be developed close to their home, 2) require no formal education or technical skills, and 3) are performed under the direction of men or near a male relative both in extraction sites and at organizations. At present, gender norms make inconceivable for both genders to envision women playing an active role in sand mining and challenging the prevailing gender system.

4.2. Gender relations and roles in sand mining

Our research shows that river sand mining in the Usumacinta has contributed to perpetuate traditional gender norms and has not significantly disrupted gender relations. Women’s economic dependence on men in rural communities was by no means exclusive of the mining sector. Moreover, gender norms were already expressed in the area through the separation of the river space and labor division (Kauffer and García, 2003), which has been extrapolated to the mining space.

The strict gender division found in this study is consistent with findings from other river sand mining areas worldwide, where dominant hegemonic masculinities prevail. However, there is a wide diversity of cases (Bendixen et al., 2021), which range from unpaid to paid work, and from complete absence (Marschke et al., 2021) to participation in classification, storage, loading, and supporting tasks (ACP-EU, 2018; ACP-EU 2018; Djihouessi et al., 2017; Cathogho, 2020; Cathogho and Amino, 2017; Jambiya et al., 1997; Siggsworth, 2022), extractive tasks (Bikkinda and Tejo Shrayya, 2017; WACA, 2017), or leadership positions in governance (Daghhar, 2022; Du et al., 2019), and protests against the over-exploitation of river resources (Athukorala and Navaratne, 2008). Such heterogeneity illustrates how the influence of factors determining gender relations is susceptible to change depending on the dynamics of sand-supply networks and its embedded social systems. Disruptions such as rapid changes in demand, opportunities for alternative livelihoods (e.g., mining of high-value minerals, industry), mechanization and technological development, human flows (e.g., rural-urban migration), rampant illicit activity, government programs, or formalisation efforts, have the potential to modify gender relations in the mining systems (Buss et al., 2017; Hinton et al., 2003; Romano and Papastefanaki, 2020). For instance, if the mechanization of the mining process in the Usamacinta River basin intensifies and becomes more prevalent, this could lead to a further masculinization of the workplace and mining process, as discussed by Romano and Papastefanaki (2020). In other regions like Andhra Pradesh (India), government policies are trying to promote the feminization of the sector by providing sand mining rights to women’s self-help groups to curb illicit mining (Bikkinda and Tejo Shrayya, 2017). Migration is another well-known factor that alters gender relations and labor division in households and rural areas of left-behind family members (Kelley et al., 2020). In China, the men migration from rural to urban areas has disrupted traditional gender
roles on sand mining, leading to a shift in decision-making and governance responsibilities towards the women who remain in rural areas (Du et al., 2019). We also observed women assuming representation and administrative roles within the cooperatives along the Usumacinta River when their male relatives travelled or migrated for seasonal employment.

Furthermore, Grosman and Gullo (2022) describes how the temporary displacement of men to work at mines is changing gender roles and duties leading to women’s increasing involvement in the public sphere in Indonesia. However, all authors highlight that it is important to avoid overemphasizing the degree to which these changes challenge deeply entrenched gender hierarchies.

The application of a gender analytical lens to the sand mining sector in the Usumacinta River basin has shed light on the intricate relationship between gender, power dynamics, and mining practices. Therefore, this approach has paved the way to uncover underlying causes and identify workable solutions for addressing gender power imbalances within the sector. Further research is needed to gain knowledge on when and how women leadership and integration emerge, and to identify systemic changes needed to alter gender dynamics in sand-supply systems. This knowledge will help to make progress towards meeting SDG 5 and achieving gender equality in the mining industry.

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