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RESEARCH ARTICLE

What is a bad flood? Local perspectives of extreme floods in the Peruvian Amazon

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Abstract The annual flood cycle is integral to rural life and livelihoods in riparian Amazonia. Livelihoods are built around the flood cycle, which facilitates transportation and affects soil fertility and fish migrations. Flood extremes, however, can have devastating impacts for riverine populations, yet there is minimal understanding of what distinguishes a 'normal' flood from a 'bad' flood, or flooding as integral to riverine settlement from flooding as environmental hazard. We address this limitation by drawing upon hydrograph data and field data collected in a riverine village in the Peruvian Amazon. We define four extreme flood types based on height, duration, and timing of onset, and illustrate how they each create a unique combination of negative and positive implications. We discuss the integral role of fishing to floodplain livelihoods during the flood season, and the implications of flood extremes for health, safety, and food provision. The article proposes a more nuanced conceptualization of flooding in riverine Amazonia to better inform policies and practices aimed at supporting local populations during extreme floods.

Keywords Amazon · Climate change · Extreme floods · Floodplain livelihoods · Local knowledge · Peru

INTRODUCTION

Riverine areas in Amazonia have attracted human settlement since prehistory (Denevan 1996). The combination of favorable soils for agriculture, access to water and wildlife resources (especially fish), and the prospects for fluvial transportation and mobility have been used to explain riverine settlement patterns (e.g., Lathrap 1970; Denevan 1996), and to draw attention to the floodplain (*várzea*) as an alternative to upland development (Denevan 1984; Barrow 1985; Sternberg 1995; Padoch et al. 1999; Smith 1999; Pinedo-Vasquez et al. 2011). Although seasonal flooding is an inherent property of large river floodplains, the risk of flooding, especially to extreme flood events, creates significant challenges for human occupation and use of floodplain resources (Goulding et al. 1996; Denevan 1996). Extreme floods and droughts experienced throughout the basin in recent years (Espinoza et al. 2011; Marengo et al. 2011; Camacho Guerreiro et al. 2016; Barichivich et al. 2018; Bauer et al. 2018) and climate change projections that point to more frequent higher and longer floods in western Amazonia (Sorribas et al. 2016: Ronchail et al. 2018) raise important concerns about the implications of increased flood hazard exposure for Amazonian riverine populations and their livelihoods.

The importance of flooding for economic livelihoods and life in the Amazon floodplain is well-documented. When addressing floods, studies typically distinguish seasonal water level fluctuations from extreme flood events (e.g., Hiraoka 1985; Goulding et al. 1996; Sherman et al. 2016). In the floodplain, the annual rhythm of floods—the flood pulse—is considered a given or 'normal', a property that defines the floodplain landscape and ecology (Junk et al. 1989), and to which riverine populations and their livelihoods must adjust (Denevan 1984; Harris 1998; Gram et al. 2001; Pinedo-Vasquez et al. 2002). Although the flood season does impose significant challenges for floodplain dwellers (Goulding et al. 1996; Harris 1998), the literature suggests many benefits associated with the flood pulse, and that livelihoods are well adapted to it (Denevan 1984; Gram et al. 2001). Specifically, houses are built on stilts, people build bridges to cross creeks, and households have developed diverse livelihood portfolios that are in tune with the flood cycle. Such portfolios are based on a combination of different activities (e.g., agriculture, fishing and extraction), annual and perennial crops (including flood resistant varieties), agricultural zonation and intricate land management systems, use of multiple biotopes, and building food reserves like manioc flour (*fariña*), accompanied with flexible institutions governing land tenure and resource use (Bergman 1980; Hiraoka 1985; Padoch et al. 1999; Arce-Nazario 2011; Pinedo-Vasquez et al. 2011). In contrast, extreme floods, which are less predictable, are treated as disruptions that have profoundly negative implications for those exposed, who often struggle to cope (Hofmeijer et al. 2013; Sherman et al. 2016). Extreme floods are known to drown crops, affect food security and income, destroy houses, and drive people to seek refuge in or support from relatives in upland areas (Hiraoka 1985; Tournon 1988, 2002; Denevan 1996; Coomes 2010; Takasaki et al. 2010; Sherman et al. 2016; Bauer et al. 2018).

This literature has made important contributions to our understanding of riverine livelihoods and flood vulnerability in Amazonia but is limited in two important ways. First, until recently, studies on the impacts of extreme floods focused on the height of the flood waters, given that unusually high floods would inundate houses, and even the highest land on the floodplain, where staple crops are grown (e.g., Denevan 1984; Tournon 2002); they also pay considerably less attention to the effects of flood timing, variability and duration, which also affect people, although perhaps in distinct ways (Coomes 2010; Coomes et al. 2010, 2016a; Sherman et al. 2015; List and Coomes 2017; Ronchail et al. 2018); as a result, our understanding of the impacts of different types of extreme floods remains incipient. Second, floods tend to be characterized as a hazard, using terms such as 'big', 'severe', 'major', or 'extreme' without explicitly defining what makes a particular flood event bad (e.g., Denevan 1996; Lima et al. 2015; Pinho et al. 2015; Marengo and Espinoza 2016; Sherman et al. 2016), often ignoring that extreme floods may also have positive implications for people (White et al. 2001). Riverine dwellers' reports of plentiful harvests and abundant and tasty fish following a big flood (Tournon 1988; Sternberg 1995) provide evidence of this, as do recent reports of increased abundance of fish and aquatic fauna (Bodmer et al. 2018). Clearly, a more nuanced understanding of floods, not simply as a hazard, is needed in Amazonian livelihoods research; one that acknowledges that different types of floods can have different implications for riverine populations, some of which can be more harmful than others, and that even extreme floods are not inherently or purely bad. Such a nuanced understanding is particularly critical to assess the fate of riparian people given the unprecedented unpredictability, severity, and variability in flooding in the region in the context of anthropogenic climate change.

This paper seeks to contribute to that goal, reporting on a study of the implications of different types of flood extremes in a riverine community in the Peruvian Amazon. Although flood reversals during the flood recession period (*repiquetes*) are considered an important source of agricultural risk, especially for rice production (Coomes et al. 2016a; List and Coomes 2017; Ronchail et al. 2018), our focus is specifically on the high-water season. We purposely examine extreme floods defined in terms of flood height, duration and timing to gain further insight on the potential implications of each type of flood, although we acknowledge that specific flood events may be considered extreme along more than one dimension (e.g., high, long and early flood). Specifically, we capture the relative severity of floods. To provide a more balanced account of the implications of extreme floods, we consider negative as well as positive impacts of different types of extreme floods. Finally, in response to calls to ground environmental knowledge in experiential and local knowledge (Brondizio and Moran 2008; Boillat and Berkes 2013; McNamara and Buggy 2016; Vogt et al. 2016; Coles and Quintero-Angel 2018), we document extreme flood implications as understood by riverine populations along the Ucayali River to gain further insight on the important linkages between floods and riverine livelihoods in western Amazonia, where settlement is still centered along rivers, livelihoods are dependent on natural resources, and poverty persists (Coomes et al. 2016b).

MATERIALS AND METHODS

Study area

Our study site, Éxito, is a small village situated along the Ucayali River, upstream from Pucallpa—a dynamic economic center and the second largest city in the Peruvian Amazon (Fig. 1). Like most riverine settlements in the region, Éxito is inaccessible by road, thus village residents must rely on fluvial transportation (Abizaid 2005; Salonen et al. 2012; Webster et al. 2016), taking up to three hours to get to Pucallpa during the low-water season. Founded in the early 1900s, at the confluence of the Ucayali with the Mashangay Creek, Éxito is the oldest village in Mashangay and its residents maintain important social networks with kin and friends in nearby communities (Abizaid et al. 2018), through barter and trade, visits, and participation in intercommunity sports and social events. Most residents in Éxito also have relatives and friends in Pucallpa and travel to the city regularly to visit, sell produce, buy goods, or seek medical assistance. People from Éxito are known as

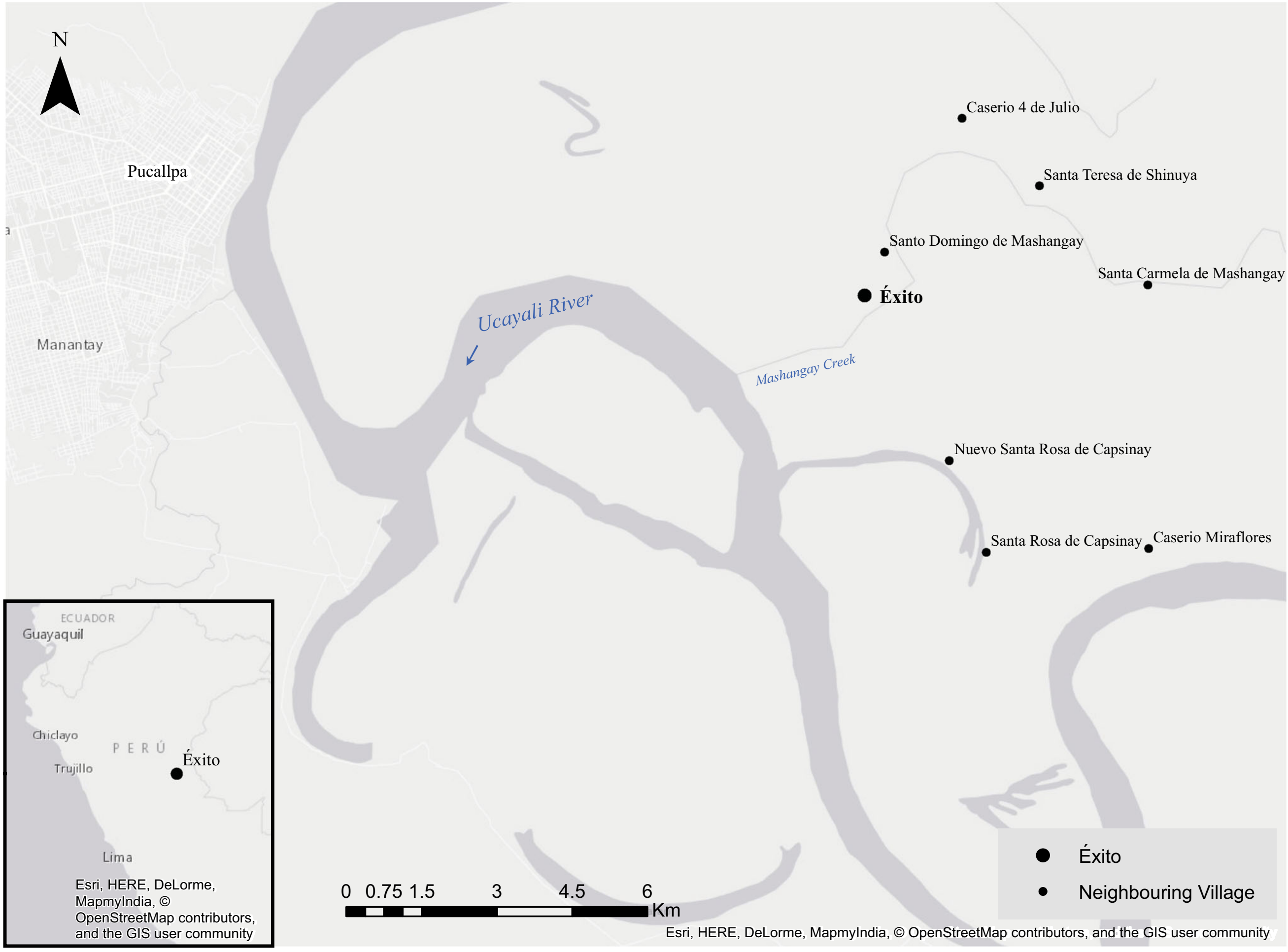

Fig. 1 Location of study site (Éxito), on the Ucayali River floodplain

ribereños, a quasi-ethnic group composed of Spanish-speaking mixed descendants of Europeans and Amerindians (Padoch 1988; Chibnik 1991), which comprise about 50% of the population of the Peruvian Amazon (Coomes et al. 2016b). They make a living primarily from flood recession farming and fishing—both for subsistence and cash income—and agricultural wage labor (Langill 2018). Crops and fish are typically sold in Pucallpa, though fish is also shared or sold locally. A minority of residents also engage in hunting, timber extraction, or seasonal wage work, and three families own shops. With a mean annual income of $7385 USD, most households live barely above the poverty line.

Removed from the *terra firme*, Éxito has direct access to land on alluvial terraces within the floodplain only, which are generally fertile but are susceptible to various degrees of flooding in terms of water depth and duration, depending on their elevation. At the time of study, land in the community was composed primarily of *bajiales*, low-lying depressions and terraces that flood for several months every year, and low levees that also flood annually, though for shorter periods of time. High levees (areas that flood only every few years) and mudflats were common at different moments in the past, and residents recall times in which everyone had plantain (*Musa spp.*) orchards and rice was an important cash crop locally (Abizaid 2007; Coomes et al. 2009). Today, small swaths of high levee persist around the community, but mudflats have disappeared due to river dynamics. With local migration rates as high as 750 m/year at some bends and 42 meander cutoffs between 1985 and 2015 (Schwenk et al. 2017), the Ucayali is one of the most active meandering rivers in the world. The village is located in a segment of the river that has been particularly dynamic in recent decades. Found on the outer bank of a meander, the village has retreated 3 times due to riverbank erosion; older residents estimate that the current village site would be about 2 h by foot from its location in the 1950s (Abizaid 2007), and multitemporal Landsat Imagery shows it 1.86 km NE from where it was in 1993. The most recent relocation occurred following the Masisea cutoff in 1997, a meander cutoff upstream from Éxito that accelerated river migration (riverbank erosion), widened the river channel, and increased flood levels (Coomes et al. 2009; Schwenk and Foufoula-Georgiou 2016), driving many village residents to permanently migrate to Pucallpa or to areas upstream from the cutoff (Abizaid 2007). Since then, the river has migrated back and forth and two chute cutoffs (in 2002 and 2013) have left Éxito more than 2 km away from the river's edge, leaving behind ephemeral mudflats and sandbars (Schwenk and Foufoula-Georgiou 2016). Also resulting from such dynamics is a complex mosaic of ox-bow lakes, side channels, and swales that serve as important fishing grounds for local residents. At the time of the study, maize (*Zea mays*) was the dominant crop, with 76% of households surveyed in 2017 growing it with credit obtained primarily from the Agrarian Bank or informal lenders in Pucallpa. Manioc (*Manioc esculenta*), watermelons (*Citrullus lanatus*), cucumbers (*Cucumis sativus*), sweet peppers (*Capsicum spp*.), and cilantro (*Eryngium foetidum*) were also planted in small fields; plantains, an important staple, citrus (*Citrus spp.)*, the signature crop of the Mashangay basin, and other fruit trees were grown on the highest terrain of the community. Residents in Éxito fish nearby year-round, changing fishing grounds depending on fish availability.

Livelihoods, fluvial transport, and the rhythm of life are closely tied to the Ucayali River's annual flood cycle (Figs. 2 and 3). Flood waters at Pucallpa typically peak in late February-early March, approximately 9 m higher than the low stage (Fig. 2). The flood provides new fertile sediments for agriculture (Ohly and Junk 1999; Hiraoka 1985), defines the local agricultural calendar (Langill 2018), and influences fish population dynamics (Castello et al. 2015); during the flood season, boats can dock right at the community and travel routes are easier and faster (Tenkanen et al. 2015). Éxito residents have adopted several innovative strategies to reduce impacts of severe floods and actively benefit from the annual flood. Particularly noteworthy are the grafting of citrus trees above the flood line to create flood-resistant trunks, the clearing of vegetation along certain paths to create *caminos* (waterways) for fish before the onset of the flood, where they can set their gillnets once the land is submerged, and in recent years, the construction of higher houses and bridges due to rising flood levels.

Data collection

Primary fieldwork was conducted by the first author in Éxito between June and September, 2017. Data was collected using participant observation, semi-structured interviews, and a household survey. Based on informal reports about a bad flood in 2014, we defined our study population in terms of residence in the community that

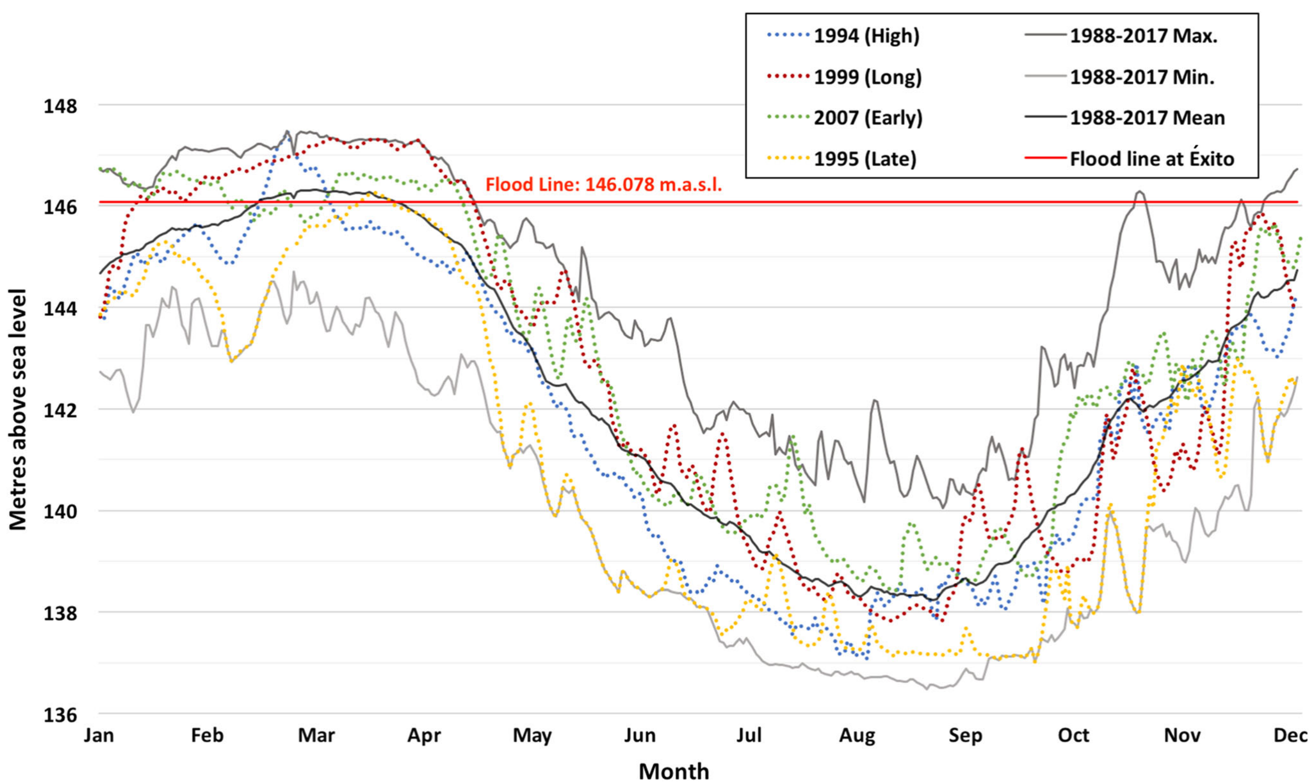

Fig. 2 Ucayali River levels at Pucallpa, based on daily records from the Dirección General de Transporte Acuático-Ucayali, Ministerio de Transportes y Comunicaciones (DGTAU-MTC). Dotted lines represent the most extreme flood year of each flood type (see Table 1)

Fig. 3 Éxito, a floodplain community along the Ucayali River during low water season (top) and high water season (bottom). (Top photo by J. Langill in 2017 and bottom photo by C. Abizaid in 2018)

year. Of the 44 households present at the time of data collection, 33 were eligible to participate, of which 31 willingly consented. Household heads were given the option to participate in an interview and/or a household survey; in total we completed 24 interviews and 25 surveys. Participants were asked about personal and collective flood experiences, perceptions of flood vulnerability and resilience, as well as demographic and household contextual information. Both male and female heads of households participated (44 individuals across 31 households). Data collection was conducted in Spanish, with the help of a local field assistant. Interviews lasted approximately 45 min and surveys took about 2.5 h. Interview data were transcribed verbatim and, along with qualitative survey data, were imported to NVivo^{TM} software for data organization and coding (Saldaña 2013). A brief follow-up visit was also made by the second author in early March 2018 to identify local markers in relation to daily river level measurements taken by the Dirección General de Transporte Acuático-Ucayali, Ministerio de Transportes y Comunicaciones (DGTAU-MTC) at the Pucallpa gauging station, and to observe conditions during the flood season. Insights derived from seven fieldwork visits to the village by the second author since 2002 serve to contextualize our findings.

RESULTS

Identifying flood extremes

We defined different extreme flood types based on information obtained from participants during early stages of fieldwork regarding the most relevant types of floods for people in Éxito; they identified high, long, early and late floods as the most salient. We relied on local qualitative descriptions to compare normal and extreme floods and combined them with river level data obtained from DGTAU-MTC. During the 2018 visit, participants reported that the main street in the village was submerged on February 25th, when hydrograph records at Pucallpa showed the Ucayali at 146.078 m.a.s.l. As houses are generally built on the highest available ground, we assume that agricultural lands are lower and thus were already flooded on that date (Labarta et al. 2007). This water level thus serves as a reference point for when Éxito is flooded.

When referencing high floods, the most common indicator was that the flood inundates peoples' homes. Since houses are typically raised on stilts approximately 50–70 cm, we define a conservative estimate of a high flood at 147.078 m.a.s.l. or above (i.e., 1 m above the line defined earlier). For long floods, most participants described them as lasting longer than 2 months. We thus conservatively define long floods as any flood that remains at or above 146.078 m.a.s.l. for at least 70 consecutive days. Participants reported that the village typically inundates at some point in late January or February. To define early and late floods, we use the first date of inundation, considering an early flood as any flood year that reaches 146.078 m.a.s.l. on/before January 15th and a late flood as any year that water levels touch the same level on/after March 1st. Table 1 shows the occurrence of each extreme flood type between 1988 and 2017. All four flood extremes occurred multiple times during this period, most notably since the Masisea cutoff in 1997 (Abizaid 2005; Coomes et al. 2009). High floods and long floods occurred about every 4 years, early floods about every 3 years, and late floods about every 5–6 years.

Absolute and relative flood severity

Participants' ranking of each flood's severity on a Likert scale (from zero to five) allows us to asses local views on the severity of different types of floods (Fig. 4). Long floods were identified as the most severe (mean score = 4.33), followed by early (mean score = 4.08), and high floods (mean score = 4.04); all three types qualified as near-devastating. Late floods were ranked considerably lower in severity but were still viewed negatively (mean score = 2.26). Overall, these results suggest that bad floods may come in different forms.

Respondents were also asked to rank floods in relative terms (worst, second worst, and third worst flood type) based on their impacts. Results are generally consistent with the Likert-scale rankings, with early and long floods most commonly ranked as the worst flood types, followed by high floods; late floods appear less significant in relative terms (Fig. 5). Triangulation of these findings with interview data rendered very similar results. These rankings are

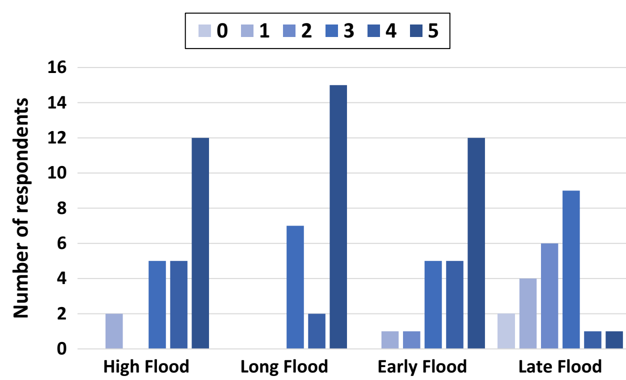

Fig. 4 Respondent absolute rankings of how negative extreme floods are, by flood type. Level of impact is indicated by number (and colour intensity), ranging from 0 (no impact) to 5 (devastating) (n = 24)

Table 1 Extreme flood events on the central Ucayali River, by flood type (1988–2017)

Flood type	Description	Years	Mean probability of occurrence	Most notable flood year
High flood	Water level > 147.078 m.a.s.l.	1994, 1999, 2000, 2001, 2002, 2008, 2011, 2012	~ Every 4 years	1994: water level reached 147.476 m.a.s.l.
Long flood	Water level > 146.078 m.a.s.l. for 70 days or more	1999, 2000, 2001, 2003, 2006, 2008, 2011	~ Every 4 years	1999: inundated for 101 days consecutively
Early flood	Water level reached 146.078 m.a.s.l. on or before January 15th	1998, 1999, 2001, 2003, 2004, 2006, 2007, 2008, 2013	~ Every 3 years	2007: inundated on November 12th, 2006 (preceding calendar year)
Late flood	Water level reached 146.078 m.a.s.l. on or after March 1st	1989, 1991, 1993, 1995, 2005	Every 5–6 years	1995: did not inundate until March 21st, 1995

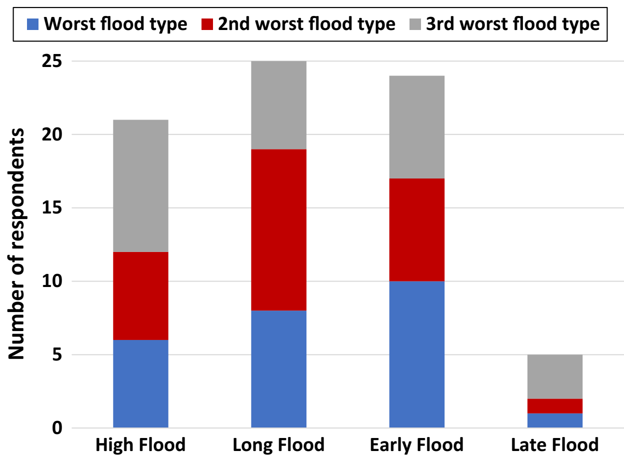

Fig. 5 Respondent relative ranking of extreme floods (n = 25)

attributed to the unique impacts of each flood type, to be discussed in the following section.

Impacts of four extreme flood types

Although extreme floods are generally regarded as bad, as discussed above, we found that people in Éxito identify a series of positive effects of each type of flood as well. Indeed, each flood type has unique consequences for riverine dwellers, and usually creates both negative and positive implications, that are experienced differently within the village. Below, we present a summary of the most common negative and positive impacts of different types of floods (high, long, early and late) (Tables 2 and 3).

High floods

Referring to negative implications of high floods, some participants stated that they are detrimental for fishing, as fish can swim over their nets and go too far inland away from the village. Many participants also discussed that high floods destroy crops and can kill fruit trees that provide sustenance and income (maize, manioc, plantain, citrus, papaya). For households that have not harvested before the flood arrives, high floods make it difficult if not impossible to harvest maize, with respondents citing stories of harvesting from canoes or waist-deep in water, as observed by the second author in 2003. Most houses also get inundated during high floods and it is difficult, if not impossible, to preserve food and seed reserves and care for livestock. Participants reported having to raise all household items onto rafts or build platforms (Fig. 6). Finally, participants expressed concerns about children spending too much time in the water—some sharing devastating stories of children drowning—and of dangerous animals (snakes, eels) near or inside houses.

Table 2 Summary of positive and negative implications of extreme flood types. The number of signs indicates the number of positive (+) or negative (−) implications that emerged from interviews and surveys conducted in 2017, Éxito, Peru

	Extreme flood type			
	High flood	Long flood	Early flood	Late flood
Agriculture	− − −	− − −	− − −	+/−
Fishing	+++/−	++	+/−	−
Food provision	+/− −	+/−	−	
Health	− − −	− −	− −	−
Transport	+/− −	+/−	−	−
Animal care	− − −	− − −	− −	+/−

Conversely, other participants noted important benefits from high floods, notably for fishing and transportation. Specifically, they reported that fish are abundant during high floods, and that they are able to catch and sell fish directly from their homes. According to them, increased fish availability is an important source of food and allows them to make cash to buy food and staples from the city to make up for agricultural losses. High floods also mean that boats can reach individual houses and facilitate transport to the market.

Long floods

Prolonged floods can take an important toll on agriculture and food security. Manioc and plantains, the main staple crops, can only withstand flooding for short periods; long floods were also reported to cause delays in the subsequent planting season, affecting food supplies and income. While there is more fish to eat in the village, most households run out of other food stocks, such as plantain, manioc, rice, and animal feed, creating great stress. Long floods often cause significant boredom for people, as social life (mobility, sport events, social gatherings) is extremely limited during such floods; for individuals more oriented towards agriculture, long floods also mean several months without work.

The most salient benefit of long floods for people is the lengthening of the local fishing season. A longer season implies more time to fish, which translates into more fish to eat and more money from fish sales, at a time in which fish prices are high. Many people described a great sense of happiness in the village during long floods thanks to increased fishing opportunities; though some, like an elder woman we talked to, are unable to secure sufficient food because she is too old to fish.

Table 3 Representative comments from participants on the positive and negative impacts of extreme floods, by flood type; field data collected in 2017, Éxito, Peru

	Negative	Positive		Negative	Positive
High flood	"It affects us more than anything. Most of all the children, if the water rises higher it brings every illness" "We're all accustomed to eating plantains. So, when the water is too high, it kills the *platanales* and affects us" "It passes the floor of the house, and where can we go? You have to find a way to move to another place until the water recedes" "It kills plantain trunks, yuca, fruit trees"	"Convenient for fluvial transportation, boats can come all the way to the houses" "When there is a big [high] flood, it benefits me because there are so many fish" "When there is more water, there is more fish" "More fish so more food"	Early flood	"If the water comes in November, my produce will not be harvested. It would take everything away from me, no hope for anything" "It would also affect us greatly because it does not give us time to prepare. I mean, to harvest our plants. It does not give us time anymore" "Sometimes there is nowhere to dry the *fariña*, because the flood rises, rises, rises, and everything is wet" "Maize has a specific time to harvest, so if water comes early it ruins this" "It surprises us. For example, my canoe right now is broken. If the flood came right now, it wouldn't be good to use. I need to have another one made first"	"If it comes quickly then fish come faster" "When it comes fast, it leaves fast, you are planting your seeds faster"
Long flood	"Everyone is bored. You want to work. Where are you going to work when everything is water? Just wait. How do they say? From eating to sleeping, from eating to sleeping, what can you do? … People are bored" "When the flood lasts [a long] time, there are no plants that resist. In 15 days plantains begin to fall. The oranges die, even the lemons die … it kills the plants almost in their majority" "The worry is that you cannot have anything anymore. I mean that more famine comes to you. Because it lasts longer … you have to wait. This is the desperation that one has sometimes, how to provide for the children more than anything … you do not even have anything to feed your animals. The food for the animals is finished, for yourself too. Sometimes you do not have anything to sell. You have to sell what you have to eat. This is the biggest, biggest famine. That from which the water lasts"	"More food, more fish, more money from fishing" "When we are two, three months under water, there are so many fish, and that is why the people say they do not want it [the river] to recede, to continue even if it keeps rising they say, so that they can continue to catch their fish so they can continue to sell"	Late flood	"There is nothing to sell, we have to wait" "Less fishing when it [the flood] comes late"	"Less time surviving the flood" "It does not affect us because it gives us time to harvest our products, all of them" "We can prepare a raft [for our animals]"

Fig. 6 A raft-type floating floor added to a house built in order to maintain a living space and protect belongings above the water line during the 2011 flood, which was both a high and long flood event. Note the height of the elevated floor, relative to the roof thatch; the logs below would allow the floor to adjust to changes in water elevation. (Photo taken by C. Abizaid in 2011)

Early floods

Early floods were viewed negatively in terms of catching people unprepared, most notably in agriculture. Nearly all participants mentioned losing maize and manioc because they could not harvest them in time. Given the importance of agriculture for annual incomes in Éxito, and particularly selling maize, the severity of losing entire crop harvests cannot be understated.

This is exacerbated by the fact that most households take cash loans to grow maize and are expected to repay their loan from the revenue. As with high floods, early floods create labor bottlenecks because everyone needs to harvest quickly. Participants also reported not having enough time to build a canoe, roast their *fariña*, or prepare fishing nets, houses, and chicken coups, in years when the flood comes early. While seldom discussed, some participants mentioned that early floods can negatively impact fishing, as the flood is out of season for fish migrations, and that mobility is limited at first because the land is too wet for land transport and the water is not deep enough yet to travel by boat.

More commonly, early floods were viewed as favourable for fishing. Participants reported that during early floods, they are able to start fishing and earning money from fish sooner; as put by many of them "fish follow the water". Moreover, one participant also noted that if a flood comes early it is more likely to leave early, which he deemed beneficial for the next agricultural cycle.

Late floods

Of the four types of floods, late floods were associated with the fewest number of implications, negative or positive. Late floods were not reported to kill crops or trees, but participants associated them with delays in planting during the following agricultural cycle if waters also recede late. There have been some years that the flood is so late that villagers plant thinking it may not arrive, only to have their young plants destroyed and their labour and inputs wasted. Late floods were also associated with fewer fish, or at least late arrival of fish, which creates a gap with no significant economic activity, once harvests are completed but before people can actively turn to fishing. Late floods were also associated with similar mobility problems to those caused by early floods, but unlike them, late floods were deemed positive in the sense that they provided enough time for people to prepare fully for the flood season.

All flood types

Importantly, all floods—extreme or not—have negative and positive implications for riverine populations, some of which have not yet been mentioned. Among the negative impacts, participants reported floods in general are associated with health problems, namely influenza, diarrhea, fever, and rheumatism. Children and the elderly were identified as the most vulnerable. According to some participants, the impacts on health are exacerbated by the fact that the medical post is often unattended during the flood season. Extreme floods over the last decade have damaged or killed orange and lemon trees on several occasions, affecting citrus production, for which Mashangay is known for in the Ucayali region.

In terms of benefits of floods, the most commonly reported were for fishing, boat transportation, and agriculture. As noted above, fishing (for food and income), particularly during the flood, was described as one of the main reasons for living on the floodplain. Participants reported that during a good flood season it is possible to make over $1000 USD from fishing. According to fisherfolk from Éxito, with their small *peque–peque* boats they can fish farther away, check their nets more frequently, and transport the fish to market; either fresh or preserved in iceboxes. Similarly, it is not uncommon for former residents to go to Éxito to fish during the flood season. High water levels were also reported to shorten routes and travel time by boat and to enhance access to the community from the Ucayali. Beyond the flood season, participants also highlighted the benefit of the flood for floodplain agriculture, as the annual flood acts as a natural fertilizer for the soils.

DISCUSSION

This study illustrates that the variability in flood height, duration, and timing greatly shapes lived experiences with flooding among riverine people in Amazonia. It offers the first integrated analysis of both the negative and positive impacts of extreme floods in Amazonia, and represents an important step in generating a more comprehensive understanding of environmental hazards more broadly (White et al. 2001). Using a combination of interview, survey, and river level data, we defined four flood types (high, long, early, and late floods) and analyzed their occurrence over the past 30 years along the Ucayali River. Building on that and drawing upon the experiences and perspectives of local peoples, this study offers four important insights on the role of extreme floods in shaping riverine livelihoods in the region.

First, our analyses indicate that it is not only the height of the flood waters that makes a flood event *extreme* or *bad*, as implied in the literature (Denevan 1984; Tournon 2002). Specifically, while high floods are common, long and early flood events occur as frequently ($\sim$ every 3–4 years) and tend to have more severe negative implications for people, yet are less acknowledged in the literature. Overall, we found that each of the four flood extremes acts a hazard though with varying impacts; high/long/early floods were regarded as near-devastating and late floods having lesser though still negative effects. This means that extreme floods can take on different forms, providing additional evidence corroborating the varied impacts of flooding (Sherman et al. 2015; Coomes et al. 2016a; List and Coomes 2017). Beyond the four flood types presented here, which may be abstract, participants mentioned variations within each of the categories and the possibility of a single flood as extreme along more than one dimension, like the 2011 flood (which was both long and high) (Table 1). Fully understanding the multiplicity of flood types, and their unique implications, creates obvious logistical challenges for research, yet the consequences of not accounting for variation in flood patterns are too great. The results of this study demonstrate the importance of understanding flood variations and their relevant impacts for riverine dwellers.

Second, although extreme floods are generally seen in negative light, this study provides evidence that they can simultaneously have negative and positive implications for people. As shown, different types of extreme floods were associated with varying impacts for agriculture, fishing, food provision, health, transport and animal care; many of them are negative, but some are quite positive. An extreme flood can be bad for agriculture and health, but good for fishing and transport. This is consistent with patterns associated with the annual flood pulse (Goulding et al. 1996) but has not been fully acknowledged for extreme floods.

Third, our results call for a broader conceptualization of fishing and its role in riverine livelihoods, especially in relation to extreme floods. We found that local residents regard improved fishing opportunities as an inherent benefit of flooding (to different extents depending on flood type), and that fishing is more widely practiced during the annual flood than has been previously acknowledged. The literature tends to assume that fishing is of lesser importance during the flood season due to the fish dispersing through the floodplain (e.g., Hiraoka 1985; Harris 1998), however, our results are consistent with other studies that document fishing during the flood season (Coomes et al. 2009, 2010; Takasaki et al. 2010). Moreover, our results indicate that we need to broaden our understanding of the multiple roles that fishing occupies during the flood season. While existing literature recognizes fishing is a common and important coping strategy to deal with high floods (Coomes et al. 2010; Takasaki et al. 2010), this study shows that fishing may also serve as a response to flooding in normal flood years, and an anticipated activity that is actually enabled by the annual flood, at least in some places. As such, during irregular floods, fishing may be a response exercised to the flood hazard, but it is also a depended-upon livelihood activity that is simultaneously affected by flooding. Perhaps it is not the annual flood that determines fishing opportunities, but instead the *variability* of flooding. Acknowledging this may not only help us to reconcile the different interpretations of fishing observed in the literature, but it also points to how deeply embedded fishing is in the flood experience, and the various ways that agro-fishing livelihoods may be impacted by flood hazards. Recognizing the importance of fishing for rural livelihoods is timely, given the increased pressure on fisheries due to the growth of urban demand, and a city-based commercial fleet that is better equipped to catch fish with sophisticated nets, motors, ice, and salt.

Finally, our results underscore the severe impacts of flood extremes for health, safety, and food security. Health issues were found to be associated with floods regardless of flood type, safety concerns with high floods, and food provision problems with long floods. Health, safety, and food security issues are recognized in the literature (e.g., Hiraoka 1985; Harris 1998; Espinosa 2010; Espinoza et al. 2011; Hofmeijer et al. 2013; Sherman et al. 2015, 2016), but remain poorly understood. In this study, youth and elderly emerged as particularly vulnerable to health and safety concerns. Given that in this context women are responsible to care for children and the ill, it is likely that they would also carry the burden of caring for ill household members during floods. Extreme floods were also found to create problems with food security, though famine was only explicitly mentioned by one respondent, notably a single mother. These results provide additional evidence of how lived experiences with hazards—in this case floods in the Peruvian Amazon—vary and are socially differentiated (Watts 1983; Wisner et al. 2004) and reiterate the need for further understanding that is grounded in experiential realities of those most affected.

CONCLUSION

Our findings reiterate how a single environmental hazard—flooding—can manifest in many forms. Extreme floods, whether high, long, early or late, were all found to cause negative implications on health, safety and food provision. However, each flood type also has positive impacts, therefore challenging perceptions of environmental hazards as all-negative. Overall, while each of the flood types considered here deviates from the typical annual flood curve in Amazonia, all four of them were found to create a unique set of impacts for livelihoods. Specifically, fishing was found to be not only a response or a safety net for floodplain dwellers, but also a necessary livelihood activity that is enabled by the annual flood, especially during extreme flood events.

In the Amazonian context, these findings raise important academic and policy implications. While flood extremes do have significant negative implications for people, we argue that referring to them as *bad* may be harmful for local populations, as it discounts their experiences of the unique combination of negative *and* positive impacts from floods, and furthermore prevents productive planning for floods by government officials and relief organizations and dealing with flooding to ensure safety and security for all people. Furthermore, such an understanding is helpful to situate *ribereños* ability to live with floods and seize opportunities derived from them. We recognize that individual experience with floods is socially differentiated (Comfort et al. 1999; Wisner et al. 2004) and is shaped by changes in the political economy in the region (Santos-Granero and Barclay 2000). We conjecture that livelihood orientation and increased monetization of the economy are shaping flood experience in the Peruvian Amazon, but there are likely other intersecting variables of importance. These differences, and how they shape people's ability to face extreme floods, is a critical area of inquiry that warrants further study.

The increased frequency and magnitude of hydrological hazards along the Amazon and other large rivers underscores the need to better understand the lived realities of flooding and other environmental hazards. The type of nuanced perspective on flooding and livelihoods that we portray here could be applied to other large tropical and subtropical river floodplains like the Congo, Ganges–Brahmaputra, or the Mekong, which are home to hundreds of thousands or millions of people whose livelihoods are closely connected to flooding. The need for such understanding is particularly pressing given hydrological changes due to climate change and the current trend in dam construction worldwide (Best 2019). By examining local perspectives on flooding in a riverine community in the Peruvian Amazon, this paper provides a unique contribution to understanding floods, not only as an environmental hazard but also as integral to people's lives and livelihoods in the region, founded upon the complex relationship between the negative and positive dimensions of flooding.

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