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Household recovery from disaster: insights from Vietnam's fish kill

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ABSTRACT

In April 2016, toxic chemicals leaked into the ocean in central Vietnam during a trial of a waste discharge system for a newly built steel plant. This resulted in a significant fish kill that impacted coastal livelihoods and the seafood sector across four provinces. We surveyed 520 households to understand how people experienced this environmental disaster, and their recovery strategies. On average people stopped all fishing-related activities for over nine months: this was a period of precarity for most households. Fish farming households suffered the greatest financial losses. Fishing households, while having a lower income, recovered more quickly than fish farming households since the mobility of boats and fishing grounds afforded flexibility and adaptability. In the longer term, relatively significant financial compensation from the company responsible for the spill made a difference to household recovery and their perceptions of the disaster. We argue that this toxic spill was a major stressor for coastal households in central Vietnam, and contribute to the precarity and the livelihood resilience literatures by offering a multi-dimensional perspective to understanding household recovery strategies. This study also draws attention to the importance of better understanding financial compensation as an aspect of recovery from human-induced disasters.

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1. Introduction

In April 2016, an environmental disaster resulted from a leak of an unknown amount of chemical effluent into the coastal waters of central Vietnam. Dead fish and other aquatic life washed ashore, and over 100 tonnes of fish carcasses were collected in the first month after the spill (Hoang et al., 2019). Official numbers placed the fish kill at over 300 tonnes, including wild fish (115 tons), farmed fish (100 tons) and clams (67 tons) (National Steering Committee, 2018). These numbers do not account for the loss of shrimp, cuttle fish, squid, and other aquatic species, nor do they explain how the chemical leak impacted household livelihoods. People further reported incidents of food poisoning from eating contaminated fish, and urban protestors took to the streets since

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no one took accountability for the leak (Hookway, 2016; Martinez Cantera, 2017). Campaigners in Taiwan joined in this cause, pushing for financial compensations for spill victims, since the parent company was Taiwanese-owned (Bui, 2019).

The Vietnamese government initially thought the fish kill was linked to an algae bloom (Paddock, 2018), although by late June 2016 the Formosa Ha Tinh Steel Corporation – a subsidiary of the Taiwanese conglomerate Formosa Plastics Groups – was held responsible. The company had illegally discharged toxic waste, emitted during a wastewater discharge system trial for their newly built steel plant situated at the edge of a deep water port (Hoang et al., 2019). The released waste water contained phenol, cyanide and iron hydroxides, which forms into a colloidal iron complex denser than seawater. This complex contaminates or kills exposed species, particularly bottom feeding fish (National Steering Committee, 2018). The Formosa Ha Tinh Steel Corporation settled with the Vietnamese government for a remedial compensation package of 500 million USD (Hoang et al., 2019): eventually 65 percent of these compensation funds were transferred to impacted coastal households (Vietnam Ministry of Finance 2018).

Fishing was banned within 20 nautical miles of the shores along the four impacted provinces and consumers were advised not to eat seafood from this area. Thus, near-shore fishing stopped, with 4,000 non-motorised boats grounded and nearly 17,600 low capacity motorised boats no longer operating (Ha Tinh CPC, 2018; Quang Binh CPC, 2018; Quang Tri CPC, 2018; Thua Thien Hue CPC, 2018). Off-shore fishers, fishing outside the 20 nautical mile zone, found it difficult to sell their fish products as consumers panicked about the health implications of contaminated seafood. More than 510,000 people in 130,000 households across the four provinces were impacted (National Steering Committee, 2018), including fishers, fish farmers, local businesses and tourism operators.

This was not the first time, however, that households in central Vietnam had experienced an environmental disaster. Annual tropical monsoons with typhoons, floods and flash floods have caused extensive economic and physical damage over the years (Shaw, 2006). Central Vietnam's 1999 flood, for example, resulted in over $190 million USD in repairs to homes and infrastructure (Nguyen, 2007); typhoon Ketsana's damage to central Vietnam in 2009 was evaluated at $785 million USD (Razafindrabe et al., 2014). These environmental disasters resulted in increasing debt levels as households struggled to rebuild their homes and repair damaged infrastructure. For decades, households have had to be resourceful to sustain themselves (Marschke & Betcherman, 2016). Even so, the 2016 toxic spill from the Formosa Ha Tinh Steel Corporation's plant was among the worst environmental disasters that central Vietnam has experienced (Chau & Sun, 2016): unlike other environmental disasters, the impacts of this disaster were immediately felt and could be pin pointed to human negligence.

Our paper seeks to understand how coastal households who rely on fishery resources responded to the massive fish kill in what we label as the Formosa incident. We begin this paper by highlighting key aspects of livelihood resilience and precarity in coastal communities. We then turn to an examination of households that were impacted by the Formosa incident, including how they adapted, and how they perceived the impacts of the Formosa incident two and a half years later. We argue that coastal livelihoods were precarious before the Formosa incident, and that people have managed such precarity by engaging in multiple livelihood strategies. This helped households rapidly shift livelihood strategies when the fish kill emerged. However, it was the unprecedented levels of

compensation that helped most households recover, at least from an economic perspective, in the longer term.

2. Livelihood resilience and precarity

We draw insights from the literature on livelihood resilience and precarity to help assess how people manage and, in some cases, recover from environmental disasters. We conceptualise livelihood strategies in response to precarious work conditions, and pay particular attention to how people make complex decisions in order to deal with their perceived risks and uncertainty. Livelihood resilience refers to people being able to 'sustain and improve their livelihood opportunities and well-being despite environmental, economic, social, and political disturbances' (Tanner et al., 2015, p. 23). The livelihood resilience literature focuses on people's perceptions of risks and choices of action in response to environmental incidents, and considers how livelihoods can be enhanced or become more resilient (Scoones, 2009; Tanner et al., 2015). In this literature, livelihood diversification in response to disturbances and shocks is viewed as an ability to build resilience. As an example, Belton et al. (2017) focus on how households move in, out, and in between livelihood activities over a period of time to better understand resilient livelihoods.

Even so, precarious work is a state of being that many resource-dependent communities in Asia endure (Cruz-Del Rosario & Rigg, 2019). When household livelihoods face a downward trajectory, and are not able to handle disturbances or shocks, the precarity literature offers additional insights since this literature pays careful attention to specific working conditions (Rogers, 1989). Precarity is the insecurity, instability, or uncertainty that workers assume in their work (Kalleberg & Hewison, 2013; Rogers, 1989). When workers face a series of insecurities, instabilities or uncertainties, feasible livelihood strategies become challenging. Workers are further impacted by policies and processes that, in promoting economic growth, produce disparate experiences. This includes fishers and fish farmers who face reduced yields and growing debt as they invest in new fish technologies or gear (Betcherman & Marschke, 2016). Environmental disasters have a tendency to further increase work precarity, particularly in places that are highly dependent on ecological resources (Marschke et al., 2020).

Livelihoods, as such, may need to transform rather than persist in the face of crises (Alexander, 2013). This area of literature presents some interesting insights into how household's might recover from disasters. Folke et al. (2010) distinguished coping, adapting, and transforming as three types of strategies in response to environmental hazards. Coping strategies are immediate responses after a disaster. Adapting strategies are adjustments to livelihoods to adapt to environmental change. And transforming strategies are long-term modifications of livelihood strategies. There are other ways to also consider how people respond to crises. For example, Johnson et al. (2014) present a series of indicators specific to fishers that include survival, social identity, diversification, getting by, and optimism. And, Thanh et al. (2020) argue that unpacking household adaptive cycles are key to understanding livelihood dynamics, and how households respond to livelihood challenges.

Fisheries-related work offers a source of livelihood and identity, which can foster community resilience through the social networks, collaboration, leadership, and outlook that such work brings (Berkes & Ross, 2013). Moreover, fisheries-related work enables households to determine their own work schedule, be outside or on the water, and relies on

community connections and relations. Simultaneously, relying only on fish work can increase precarity and path dependence for certain households, particularly those who face persistent poverty (Marschke & Betcherman, 2016). The World Bank (2012) estimates that the number of income-poor people in coastal communities in Vietnam is around 5.1 million, accounting for 30 percent of the country's national poverty figures. Many coastal households cannot sustain their livelihoods from fishing or fish farming activities alone, as such resource-based livelihoods are sensitive to climate shifts and over-fishing practices (Betcherman & Marschke, 2016). Coastal households often have little choice when it comes to considering alternative livelihood strategies (Andrachuk & Armitage, 2015; Tuyen et al., 2010), and migration of a household member(s) for work is increasingly common (Betcherman et al., 2019). Is this resilience in the face of adversity or a coping strategy in the face of chronic poverty? We draw from these tensions in the literature to examine the ability of coastal households in central Vietnam to respond in the short and longer-term to the Formosa incident.

3. The study area and methods

The 11-billion USD Formosa Ha Tinh Steel Corporation's plant is part of a trend towards Vietnam attracting Foreign Direct Investment (FDI). Such investment offers the potential for jobs, but it also presents new environmental risks. For example, in 2008, another FDI company, the Vedan Vietnam Enterprise Corporation Limited, polluted the Thi Vai River (Dung, 2019). And, Taiwan's Formosa Plastics, the main foreign investor in the Formosa Ha Tinh Steel Corporation's plant, was awarded the Black Planet Award in 2009 and is known as one of the top-10 polluters in Taiwan (Ethics & Economics Foundation, 2009). Beyond the 2016 fish kill, Taiwan Formosa Plastics has caused other environmental disasters in the region including a dust explosion in May 2017 and received a 25,000 USD fine for burying harmful solid waste in December 2017 (Lee, 2019). Vietnam has struggled with ineffective environmental regulatory programmes or insufficient enforcement capabilities to ensure adequate protection of the environment as Vietnam develops (Fortier, 2010). Environmental impact assessments (EIA), in general, are viewed as bureaucracy rather than as an important aspect of the development approval process (Wells-Dang et al., 2016).

While the Formosa Ha Tinh Steel Corporation's plant is located in Ha Tinh province, effects were felt across multiple provinces mainly to the south of the Formosa Ha Tinh Steel Corporation's plant, linked to seasonal ocean currents that flow **southwards (Vietnam Institute of Meteorology, Hydrology, and Environment, 2002). This study examines the livelihoods of coastal households within four provinces impacted by the toxic chemical leak. Reports from these four provinces found that 222,500 people or 56,000 households felt the impacts of the toxic chemical leak. We interviewed government officials from each province and reviewed government reports about the Formosa incident to guide our selection of four clusters of coastal communes that were highly reliant on fishing, fish farming and coastal service activities and were impacted by the Formosa incident. The coastal communes we selected included: Ky Khang commune in Ha Tinh province, Phu Thuan commune in Thua Thien Hue province, Ngu Thuy Bac commune in Quang Binh province, and Hai An commune in Quang Tri province (Figure 1).

Data collection took place between August and December 2018 in four coastal communes (one per province). A perceptions survey was administered with household

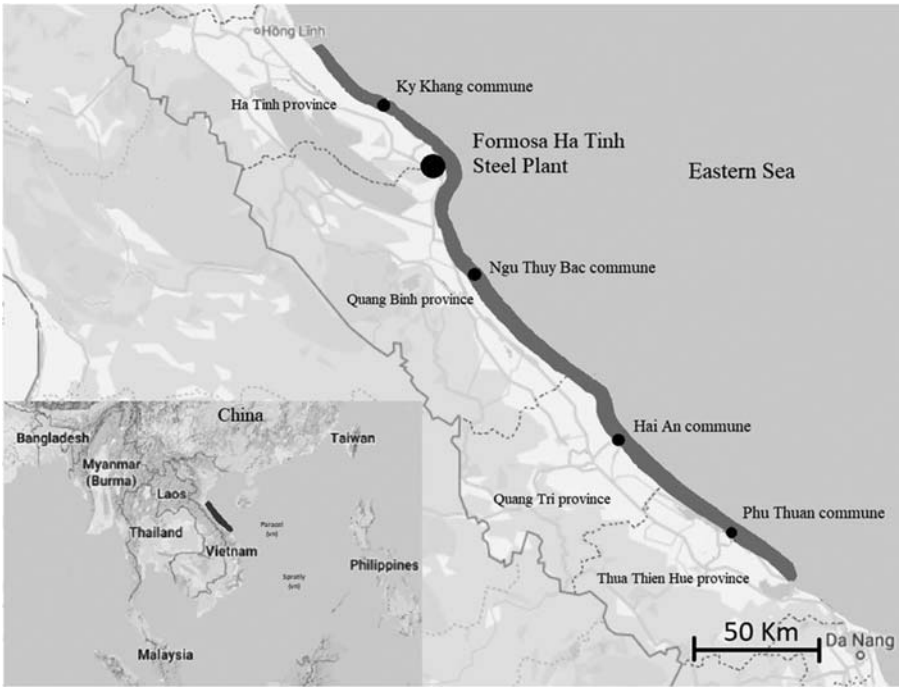

Figure 1. Map of study area impacted by the toxic chemical spill. Source: Google maps.

heads ($n = 520$, with 38 female headed), representing approximately 14 percent of households whose livelihoods were impacted by the toxic leak in each commune. The focus of the household perceptions survey was length of time out of work, impacts of the toxic leak on household livelihoods, recovery strategies, and government compensation. This survey was done by convenience sample, based on a list compiled by local government units to identify who required compensation; the research team then worked with local government staff to identify households in each of the three main livelihood categories impacted. Within these groups, households were randomly selected (fishers ($n = 200$), fish farmers ($n = 150$), coastal service households ($n = 170$)). Household head interviews took place at home, with other household members often being present (spouses, children and grandparents). The survey response rate was high as people were keen to discuss this topic. Key informant interviews ($n = 40$: 10 female; 30 male) shed further insights and nuance into how households responded to and recovered from the toxic leak. This combination of interview and survey datasets provided descriptive details about local perceptions of and household responses to the disaster. Provincial reports, websites, and local newspapers complemented these sources.

4. Results

4.1. Impacts of the Formosa incident on households

Fishers, fish farmers and fish venders were immediately impacted by the Formosa incident as toxic chemicals polluted the water and caused fish kills (Figure 2). People could not eat

local fish, dead fish washed ashore for months, and seafood markets collapsed. The fish kill had significant consequences for the households across our sample. Out of our 520 respondents, most respondents (over 92 percent) experienced an impact on at least two of their livelihood activities that depended on marine resources and could not work during the disaster. On average people stopped all fishing-related activities for over nine months: this was a period of precarity for most households. When households returned to their main livelihood activity, they did so with less intensity.

For fishing households, government regulations allowed for fishing to continue only from a 20-mile nautical zone from shore. Not all fishers had the boat or gear to enable them to fish so far from land. It took eighteen months before contamination levels (of oceanic water and in fish) were low enough that it was safe for nearshore fishing to continue (Figure 3). For fish farmers, fish farming activities took a year to resume since production cycles take months to get up and running. And, for fish sellers, it took time to return to fish vending, particularly at levels seen pre-toxic spill. According to one vender: ' … at that time, after the government announced that fishers could fish again, many consumers were not buying either sea or lagoon fish. Only in mid-2017 did a modest market for sea fish emerge'. Normally fresh fish is something consumers seek in Vietnam, so the nervousness around fresh fish presented a new dynamic for coastal households engaged in fisheries activities. The consumption of benthic fish (fish that live near the ocean bottom) was more affected than pelagic fish (fish that swim at mid-levels in the ocean).

Eventually, most households returned to their main livelihood activities. For those that could not or faced persistent economic losses, the reasons varied. In a few areas, the water environment remained polluted, particularly in the sea substrate, not returning to pre-Formosa incident quality. A few fishers commented how they no longer could catch bottom or benthic fish (via traps or drag nets) or that overall fish productivity was declining. Poor households struggled with work. As a widower explained: 'Normally I buy fish daily, and when the weather is bad and there is no fish, I work as a labourer. Then the leak occurred, and there was no fish to buy and there was no other work for me to do either'. And, the seafood market was uncertain for a long time after the toxic leak: fresh fish sales were down, consumer trust in seafood markets was low, and in larger

Figure 2. Dead fish washed up on the beach in central Vietnam, April 2016. Photo: Hoang Phuc.

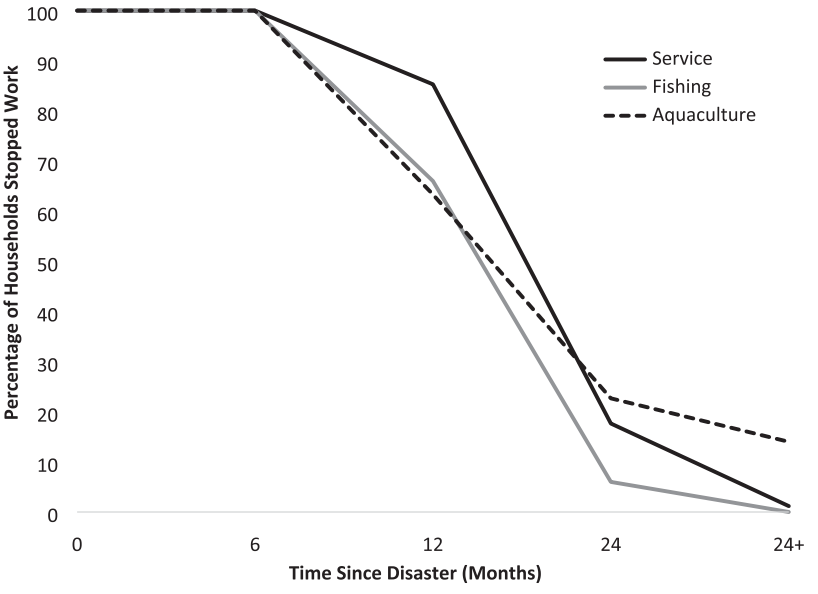

Figure 3. Percentage of households who stopped main livelihood activities following the Formosa incident. Source: Household survey, 2018.

cities people were turning to frozen fish in the supermarket. This combination meant that it took a long time for the majority of coastal households to even partially recover from the disaster.

Our household perceptions survey found that at minimum of one livelihood activity was impacted by the toxic spill in each household, affecting nearly two-thirds of workers in all households. We further examined household livelihoods retroactively just prior to the Formosa incident and again 30 months later. Losses on investments made prior to the incident included business expenditures spent before the toxic spill (including pre-paid rental space in markets stalls) and fisheries products caught or harvested prior to the toxic spill but were seen as contaminated once the toxic spill occurred. Fish farmers experienced the highest losses on investments (339 million VND or 14,600 USD) due to accumulated fish or shrimp that were being raised (but had not yet been harvested). Coastal service households faced lower losses on investments since they had less stored or contaminated seafood. For losses due to the fisheries shutdown, fish farmers were most impacted (164 million VND or 7065 USD). However, fishers also experienced such losses (130 million VND or 5,601 USD) in part linked to a long period of reduced fishing intensity, even as fishers were able to return to fishing more quickly than fish farmers.

Table 1 further highlights total losses, with aquaculture households having lost 503.2 million VND (21,665 USD) per household, then fishing households 231.3 million VND (9958 USD) per household, and coastal service households 102.0 million VND (4392 USD) per household. Note that both fishing and fish farming households lost similar portions of their total income, around 98 percent, even as fish farmers earn twice that of fishers on average. In a country where the average yearly income of rural households is 130 million VND or 5600 USD (MARD, 2018), losing an average of 11,000 USD per

Table 1. Household (hh) economic losses due to the Formosa incident.[a,b,c]

Indicator	Service	Fishing	Fish farming	Average
Losses on investments made prior to incident (USD/hh)	$1877	$4353	$14,600	$6501
Losses due to fisheries shutdown (USD/hh)	$2514	$5601	$7065	$5016
Total losses (USD/hh)	$4391	$9954	$21,665	$11,517
Total loss valuations vs yearly hh income (%)	37.8	97.8	98.7	78.4
Total loss valuations vs total asset value (%)	21.6	36.6	44.1	33.9

[a]While households were categorised into three main categories – fish, fish farming, service-related – many households engaged in multiple livelihood activities including wage labour. For example, the total number of day labourers from study households (hh) was 948 (336 from service hh, 352 from fishing hh, 260 from aquaculture hh).
[b]Yearly income and total asset value just prior to the Formosa incident were used as controlling variables to determine impact levels (depth or percent of loss) and to facilitate comparison between household groups, examining livelihoods 30 months post-Formosa incident.
[c]Monetary figures were originally in Vietnamese Dong (VND) and were converted into United States Dollars (USD) using the online XE Currency Convertor at the market rate on 1 January 2019. This rate is 0.0000430542 USD to 1 VND or 23226.5358022545 VND to 1 USD.
Source: Household survey, 2018.

household is significant. Comparison of the lost value with the total asset value of households also indicates a significant impact. Across all households the lost value is equivalent to 34 percent of asset value, with fishers and fish farmers experiencing an even higher rate (37 and 44 percent respectively).

4.2. How households managed and assessed the support they received

Drawing on the work of Folke et al. (2010), we focus on three types of strategies households engaged in following the Formosa incident, namely coping responses where livelihood activities were maintained, adaptive responses where livelihood activities were modified, and transformative responses where livelihood activities changed. Note that this is a broad characterisation, as it is not easy to categorise such strategies. For example, one house might view an activity as a coping response and another as an adaptive strategy, depending on the socio-economic situation of a household and the opportunities they have in a particular situation (Somers, 2009).

Households were asked how they were able to handle income loss after the Formosa incident. Three main strategies across fishing, fish farming and coastal service households emerged, namely reducing expenditures, accessing loans and adopting a new component or activity within existing livelihood activities (Table 2). Fishing households in particular – over sixty percent – were forced to reduce their expenditures, whereas at least a quarter of all households had to access loans. For households adopting a new component within an existing livelihood activity (56 percent of all households), fishing households who had practiced river fishing added in pelagic fishing (in the ocean) and fish farming households added in new fish ponds.

In terms of coping responses, to maintain existing livelihood activities, households accessed loans through banks, money lenders, and relatives. They also connected with other people and organisations to diversify their income generation activities. Adaptive or modified responses were also used, meaning that people made changes to their livelihood activities. In many cases, this involved adopting a new component within existing activities including moving from near-shore to off-shore fishing or switching from brackish water fish farming to fresh water fish farming. We also observed a few transformative responses, in the sense of changing livelihood activities, although this was less common.

Table 2. Household responses[a].

	Service ($n = 170$)	Fishing ($n = 200$)	Fish Farming ($n = 150$)	Average
Maintained existing livelihood activities				
Reduce expenditures	25.9	62.0	25.3	39.6
Access loans	24.1	29.0	25.3	26.3
Sell assets	1.8	12.0	6.0	6.9
Receive assistance from relatives	5.3	2.0	5.3	4.0
Establish new business linkages	2.9	4.0	2.0	3.1
Modified main livelihood activities				
Adopt new component or activity	24.7	92.0	42.6	55.8
Expand existing activities	31.2	18.5	42.0	29.4
Changed livelihood activities				
Adopt new, non-impacted activity	17.6	10.0	7.3	11.7
Quit impacted activity	2.4	2.0	2.0	2.1

[a]Household responses as percentage of households per main livelihood activity. Within households' main livelihood activity, households could list multiple responses, and so these responses do not add up to 100%.
Source: Household survey, 2018.

Only a few households were able to adopt new livelihood activities, namely those in the coastal service sector. Agriculture, fresh water fish raising, and sending a household member abroad to work are three such examples. Around two percent of households quit their impacted activity, moving into other work.

Households did eventually receive financial compensation for the Formosa incident. As Table 3 shows, households received an average of 82.9 million VND (3596 USD), with fish farming households receiving over 100 million VND (4305 USD) and fishing households receiving nearly 90 million VND (3875 USD) per household. Interestingly, coastal service households were the most compensated in terms of total compensation versus total loss, with fish farming households receiving the least amount of compensation versus total loss (in spite of having the most financial compensation among the households in absolute terms).

Households who received financial compensation felt that this was an important aspect of their recovery, particularly from a financial perspective. Nearly all households felt compensation was either helpful or very helpful. A combination of safe water quality, increased consumer confidence, and financial compensation enabled households to reinvest in their main livelihood activities. Another fisher reflected:

> When the Formosa incident occurred in April 2016, I had to stop fishing. I struggled to find any other paid work. At that time, I had received rice, seeds, and technical aid for farming

Table 3. Compensation from government, with household reflections[a].

	Service ($n = 170$)	Fishing ($n = 200$)	Fish Farming ($n = 150$)	Average
Cash as compensation (USD / hh)	$2094	$3875	$4305	$3596
Compensation versus total lost value[b] (%)	71.4	65.3	38.4	59.6
Views on compensation (% hh)				
Compensation is not significant	2.4	3.5	12.0	5.6
Compensation is helpful	38.2	49.0	44.0	44.0
Compensation is very helpful	59.4	47.5	44.0	50.4

[a]Across our sample, 100% of hh received urgent support e.g.15 kg polished rice per person per month for a duration of 6 months or cash for resolution of contaminated fishery products; 100% of hh also received cash as part of compensation for lost products and income.
[b]This was calculated for each household (compensation received versus total lost value, which is the sum of the ex-ante and ex-post loss), and then an average was applied for the three household groups.
Source: Household survey, 2018.

> from the government. Recently, I received cash as part of the compensation package to households impacted by the spill. Although this came a little late, the cash compensation helped a lot and enabled me to resume my livelihood activity.

According to a report by the Ministry of Finance in 2018, the government was able to provide direct cash compensation to those identified as being impacted across the four provinces. This is because of the settlement with Taiwan Formosa Plastics for 500 million USD. In addition to cash, the Vietnamese government gave over 19,000 tonnes of rice to impacted households in the months following the fish kill. The government also monitored the safety of the ocean environment. As the government switched from emergency relief to recovery support, more programmes were introduced including loan access, scholarships for students, health insurance, and livelihood training programmes. The government also worked with the Fisheries Department and other relevant agencies to build environmental monitoring systems, provide consistent water testing, engage in food safety monitoring, and work towards ecological rehabilitation of aquatic stocks.

That said, compensation was not without challenges. It took time for funds to be released, between one to two years following the Formosa incident. A female household head in Quang Binh explained:

> My family relies on my son who works as a hired laborer on a fishing boat. After the incident occurred, we had no income for over 6 months. Life became very hard. Getting a new job was not easy for my son as many other people were also looking for a new job. The cash compensation provided was helpful, but it came very late after 1.5 years.

A few protests also took place over compensation packages. People were angry that their neighbours received more than they had, and blamed the government for this. One key informant (a civil servant) noted that it was a 'nightmare to give out the compensation', and because the compensation criteria were quickly set by higher levels of government to begin delivery, certain aspects were not considered. The Formosa incident also illustrates the tensions that can emerge in deciding who to compensate: protests erupted in Nghe An province which did not qualify for compensation measures (Martinez Cantera, 2017). It is likely that ocean currents – which shift with the seasons – moved the chemical effluent northwards at a later point in time. By that point, however, decisions were already in place in terms of which provinces would receive compensation.

4.3. Household economic recovery, 30 months following the Formosa incident

While we learned that most people were able to return to their livelihood activities with time, we were also interested in household-level incomes 30 months after the Formosa incident. Table 4 shows how households have recovered economically from this environmental disaster. In late 2018, fish farming households were not yet operating at pre-Formosa incident income levels (79 percent), nor were fishing households (86 percent), but recovery in terms of income levels was nonetheless high. In contrast, coastal service households were now earning slightly more than before. What is unclear is how households used compensation packages and in which ways financial compensation influenced the generally high levels of economic recovery.

Table 4. Economic recovery of household income and individual worker income 30 months post-incident.

Indicator	Service	Fishing	Fish farming	Average
Average HH income 30 months post-incident (USD/hh/year)	$13,060	$13,325	$25,578	$16,774
HH income (30 m) compared with just prior[a] (%)	103.9	85.8	79.3	89.8

[a]Note that income was not adjusted for inflation, rather respondents were asked about their current household income level, and then asked to compare their current income with their income just prior to the incident.
Source: Household survey, 2018.

How do households perceive their recovery to the Formosa incident? We find that the economic data are closely linked to the household subjective data. Households sustain an overall belief in their economic recovery. Most households indicated that their livelihoods were now fully or nearly recovered (59 and 40 percent respectively), with only a slight variation between coastal service households, fishing households and fish farming households. It is the one percent of households who were not able to recover that remains concerning. Interviews with key informants suggest that such households faced a range of challenges, from household shocks (illness, disability), to having only a few household members that can earn an income, to systemic precarity. Note that while we have data on economic recovery from a livelihood perspective, we recognise that there are a series of socio-economic aspects to recovery that this paper has not unpacked.

5. Discussion and conclusion

Although fish work can be precarious, linked to the unpredictable nature of fishing livelihoods and fisheries decline (Betcherman et al., 2019; Marschke et al., 2020), coastal households in central Vietnam have been managing such precarity for decades (Armitage & Marschke, 2013; DaCosta & Turner, 2007; Tuyen et al., 2010). Coastal households move between fishing, fish farming and other livelihood activities, depending on the livelihood opportunities that arise (Marschke & Betcherman, 2016), and as a way of managing risk (Betcherman & Marschke, 2016). Climate variation in the form of intensified typhoons, floods and flash floods have also been impacting coastal households (Razafindrabe et al., 2014; Shaw, 2006). Rydstrom (2019) argues that repetitive crises in coastal communities may be the 'new normal'. Although Rydstrom (2019) is referring to the intensity and frequency of floods and storms that have persistently been hitting central Vietnam, this thinking is apt for all types of environmental crises. The toxic leak represents yet another type of environmental crisis facing this population, however, the immediate loss of all fishing-related livelihoods was unprecedented.

After the toxic effluent, coastal households in our data set stopped all fisheries-related livelihood activities (fishing, fish farming, fish venting, etc.) for months on end, and in some households for over a year. This time-span reminds us of how significant the Formosa incident was. This was also different from past environmental crises (mostly typhoons or floods) in that housing and infrastructure was not ruined. Rather, people suffered sustained job loss(es). Our household perceptions survey suggests that: (a) fish farmers lost the most income and had the least flexibility in terms of adapting fish farming practices given how fish farming production cycles work; (b) coastal service households had the quickest financial recovery and lost the least amount of income in both absolute amount and proportion; and (c) fishing households were the most

mobile in the sense that they could change fishing grounds during the unsafe water quality period. That said, fishing and fish farming households faced the same losses in absolute income terms.

Most households were able to deal with the Formosa incident, mainly by coping in the initial months through reducing expenditures and accessing loans, but in some cases by being able to adapt (adding onto or expanding existing activities) or even transform their livelihoods through diversification into non-fishing activities or migration abroad. These livelihood strategies can be read in several ways. For example, change can be viewed as an example of active transformation, where people find something more stable to engage in Folke et al. (2010), including local business ventures and other non-fisheries-related activities. Or, such a response can also be viewed as an example of sustained precarity, in cases where people leave fisheries to migrate elsewhere for low-paid work such as construction or off-shore fish work (Rigg, 2019). Regardless through which lens one views a particular household response, this toxic spill was a major stressor for coastal households in central Vietnam.

Recovery, in terms of household income but also in other ways, was the most difficult for poorer households. Households who did not own a fishing boat or worked as fish labourers struggled to find day jobs. Female-headed households who relied on renting out their fishing gear for others to use, could not do so; and, those that did not own fishing gear could not find wage work after the chemical leak. Women who relied on fish vending owed money for market space rental and were shut down for months. Poorer women in Vietnam tend to be at an even greater disadvantage than poorer men when environmental disasters strike (Rydstrom, 2019). Similar gendered impacts have also been observed in the 2004 Indian Ocean tsunami (Hines, 2007), the Bangkok floods (Yasmeen & Nirathron, 2014) and the Fukushima nuclear meltdowns following the earthquake (Armano et al., 2017). Environmental disasters magnify the precarity facing poorer households and may intensify gender disparities.

The considerable financial compensation package distributed within 18 months of the Formosa incident contributes to the mostly successful recovery narrative within our data set. Interviewees had the benefit of financial compensation when they reflected on the chemical leak, how they responded, and how they were currently managing. There has been limited to no financial compensation for past typhoons, floods, or other industrial disasters in this region. The data indicate that key to recovery was the ability of households to sustain themselves during the fishery shutdown that lasted for over nine months, and in the months when livelihood activities were re-emerging. Financial compensation came when people were fully re-engaging in coastal activities, whereas earlier compensation would have helped households through the most difficult period. Follow-up research is needed to reflect upon the role of compensation in helping households recover from a chemical disaster, with attention to timeliness, compensation criteria, fairness of allocation, and consideration of the experiences of households with and without such compensation. Such insights could help inform compensations policies in the future.

The Formosa incident highlights the tensions between economic development, environmental monitoring and coastal livelihoods (Lee, 2019). This case shows how households can suffer serious economic hardships and sustained precarity, yet can also work towards recovery strategies. Households were working on their recovery –

coping, adapting and in a few cases transforming – long before any compensation was given. Even so, belated compensation further contributed to people's recovery, and may have influenced their reflections of the event. This presents a challenge for policy makers: although many households can innovate and work towards livelihood resiliency, minimal social protection measures are important, particularly important for poorer households. The Formosa incident also serves as a prescient reminder of why manufacturing companies need to be carefully monitored, perhaps even more so in the case of steel plants where cyanide is a known effluent (Dao et al., 2018). Environmental disasters are dynamic and unpredictable (Dalby, 2017), yet it is this very uncertainty that must be taken into account in any coastal governance strategy.

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