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Impact of externalities on fishers' risk-taking decisions: Evidence from an experimental study at Lake Victoria, Uganda

Philipp Daniel Händel [a,*], Dorothy Birungi Namuyiga [b,#]

[a] University of Kassel, Department of Economics, Nora-Platiel-Straße 4, 34109 Kassel, Germany
[b] National Agricultural Research Organisation, P.O. Box 295, Entebbe, Uganda

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ABSTRACT

Risk decisions by fishers are often accompanied by certain or uncertain externalities. However, the consideration of these externalities in their risk decisions has received little attention so far. In this study, we investigate how resource users incorporate certain or uncertain externalities into their risk decisions. We do this by conducting a lab-in-the-field experiment with Ugandan fishers at Lake Victoria. The fishers make a financially relevant risk decision with different levels of certainty about how a risky decision affects the income of a second fisher. In the treatments, a risky decision has either no impact, a possible positive or negative impact, a possible negative or no impact, or a certain negative impact on the other fisher's income. Our results show that fishers take significantly less risk when risky decisions have a certain negative effect on the income of another fisher than when they have no effect and the other fisher receives a fixed income. They also show that risk-taking only increases significantly compared to individual risk decisions when fishers know the other fisher's income but their risk decision has no impact on it.

1. Introduction

Risk-taking behavior of fishers often harms the resource and thus the livelihoods of other users, it, therefore, can lead to a negative externality. These externalities of individual risk decisions may not always be predictable. In this study we look at how fishers take these externalities into account while making risk decisions.

Fishing is a risky endeavor, the size of the catch often depends on unpredictable factors for the fishers and additionally there is a risk of drowning, a risk of piracy and especially with illegal fishing a risk of getting caught by authorities. Some fishing methods, especially illegal methods, can have a negative impact on the resource and thus lead to a reduction in the income of other fishers. Some fishing practices have certain consequences for the resource, such as the destruction of fish habitat by trawling in specific areas. However, as discussed in the context of balanced harvesting in Lake Victoria (Natugonza et al., 2022), other consequences of especially illegal fishing methods on the resource are unclear.[1] The same applies also to other risk-related practices like the investment in new technology, as visible at the example of aquaculture cages. These cages can have an impact through potential over-enrichment of the lake leading to eutrophication or escaping species potentially altering the genes of the fish stock and therefore the income of other fishers

* Corresponding author.
E-mail addresses: philipp.haendel@uni-kassel.de (P.D. Händel), dbirungi8@gmail.com (D.B. Namuyiga).
Present address: Mountains of the Moon University, P.O. Box 837, Fort Portal, Uganda

[1] Fishing of juvenile fish is currently banned in Lake Victoria to protect fish stocks, but advocates of balanced harvesting say that fishing of juvenile fish is not a problem and should not be banned.

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(Krause et al., 2015; Akpalu and Bitew, 2019). Given that the externalities of these risk-related decisions are not always certain, it is of high interest to understand how certainty and uncertainty of the externality affects the risk-taking behavior itself, which is our main research question. In this study we focus on small-scale fisheries, where we see a prominent example of the interaction between risk-taking and potential externalities. However, different levels of certainty about externalities can also be found in risk decisions outside of fishing, such as investments in new industries or technologies, where the environmental impact is unclear.

We know from behavioral research that people take the impact of their behavior on others into account when making decisions (Fehr and Schmidt 1999). Regarding risk behavior, we can, therefore expect that people show less risky behavior if risky behavior harms others. This was found by de Oliveira (2021) in the case of certain harm in a study at an American university. When risk decisions are made, the impact on others are often uncertain. How this uncertain externality affects the risk decision is, however, disputed. We are also not aware of any study that compares risky choices with uncertain impact on another person's payoff with risky choices that have a certain impact on another person's payoff. This is, however, particularly interesting in relation to natural resources, where there are different perceptions about the certainty of the impact of a decision on others. Especially with regard to small-scale fisheries with many users and low finances, it is important to understand the behavioral context to build the best possible programs to manage the resource. However, most studies in this field are conducted with students and not with resource users and previous studies show that student samples are not ideal to understand behavior in the field (Henrich et al. 2010).

Our research is motivated by the particular situation of small-scale fishers at Lake Victoria. The fishery of Lake Victoria is facing challenges with the depletion of fish stocks, partially caused by illegal and unsustainable fishing practices (Njiru et al. 2018). Lake Victoria is the world's second-largest freshwater lake, shared by Tanzania (51 %), Uganda (43 %), and Kenya (6 %) (LVFO 2017). The fishery in Lake Victoria significantly contributes to the economies of all riparian nations and provides direct and indirect employment to over six million people (Fiorella et al. 2021). The lake's fish is not only an export commodity but also a crucial component in the food and nutrition security for the rapidly growing population in the Lake Victoria basin (FAO 2018; Glaser et al. 2019). The surging demand for fish, compounded by environmental circumstances such as flooding and climate change, as well as the impacts of COVID-19, has escalated pressure on the ecosystem and social structure of the lake (Glaser et al. 2019; Bennett et al. 2020; Nyboer et al. 2022). Consequently, fishing activities at Lake Victoria are under stress, and illegal fishing practices could worsen the current situation and affect the incomes and livelihoods of many people. As illegal fishing is a risky activity, it is important to understand the risk-taking behavior of fishers in this environment. While most fishers anticipate negative outcomes for the lake resulting from illegal fishing, their perceptions of how the lake and their peers' livelihoods are affected by illegal fishing vary (Klein et al. 2021). This study aims to enhance our comprehension of how differing perspectives on the impacts of high-risk behavior influence risk-taking behavior and, consequently, illegal fishing. The environment of Lake Victoria, is, therefore, particularly interesting for our study. We conducted the study with Ugandan fishers at Lake Victoria. We think that the insights can help in similar settings of small-scale fisheries and leads to an overall better understanding of uncertain externalities and risk-taking.

In our lab-in-the-field experiment with Ugandan fishers at Lake Victoria, fishers make risk decisions based on the risk elicitation method of Eckel & Grossmann (2008). The first decision is an individual risk choice that all participants have to make. In the second risk decision, half of the fishers make a risk choice that has either no effect, a possible positive or negative effect, a possible negative or no effect, or a certain negative effect on the income of one fisher in the other half. These different consequences for the income of another fisher represent different externalities. Our results show that a certain negative externality leads to significantly lower risk-taking than no externality. Furthermore, our results also show that especially in the absence of externalities (but with the income of the other fishers known), fishers increase their risk-taking compared to an individual risk decision where no income of another fisher is known.

2. Literature

According to Trautmann & Vieider (2012), there are several classes of the social dimension of a risk decision that have been insufficiently investigated experimentally, especially with regard to environmental problems: Risk decisions after observing another agents' behavior, risk decisions that are observed by other agents, risk decisions that affect other agents' outcomes and risk decisions where the outcome depends on another agents' choice. In risk decisions of fishers, all these dimensions are visible. Studies on the different classes of the social dimension on risk-taking with fishers are, however, rare. Most studies on risk behavior of fishers measure risk preferences to understand their relationship to personal characteristics or to understand how they correlate to certain kind of behavior (e.g. Eggert and Lokina 2007, Eggert and Martinsson 2004, Crentsil et al. 2020). Only few studies look at the social dimension of risk behavior of fishers. A notable example is a previous study at Lake Victoria, where Dannenberg et al. (2022) look at risk behavior after a decision maker has observed another person and show a change in risk behavior depending on what behavior has been observed. To our knowledge, however, there is no study with fishers that looks at risk behavior that affects another person.

The social dimension of fishers' decision-making is mostly studied with regard to cooperative behavior and not risk behavior (e.g., Diekert et al. 2022, Rocha et al. 2020, Castillo et al. 2011, Hopfensitz et al. 2019, Schill and Rocha 2023). The closest these studies come to our goal is by measuring how an uncertainty component changes cooperative behavior of fishers. They show that different from students, fishers' willingness to cooperate is not influenced by uncertain events (Hopfensitz et al., 2019, Rocha et al. 2020, Schill and Rocha 2023). The studies, therefore, show that fishers are used to include uncertainty into their cooperative decisions, but not necessarily how fishers incorporate the impact on others into their risk decisions.

Outside the literature on fishers behavior, there are a few studies that look at how risk behavior changes due to the effect it has on others. If decision makers are aware of another person's previous risk decisions, they align their risk decision for this person with that other person's risk preferences (Bolton et al. 2015; Harrison et al. 2013; Jagau and Offermann 2018; Pahlke et al. 2015). An incorporation of the other person's outcome is also visible with individual risk decisions that affect others, when decision makers do not know the other person's preferences. De Oliveira (2021) looks at certain positive or negative externalities of risk decisions. In her paper, the participants play a Gneezy & Potters (1997) risk investment game, and the payoff of another person is either positively or negatively changed, depending on how much risk the decision maker takes. De Oliveira (2021) shows that people take less risk when risk-taking reduces the payoff of another person, but not more risk if risk-taking is beneficial for another person. Bolton et al. (2015) and Gaudeul (2016) extend this perspective by looking at risk decisions that result in the same risky gamble for oneself as for the affected person. In their studies, participants first make a risk decision that affects only themselves and then make a risk decision that affects themselves and another person. Both papers find that participants take more risks when the risk decision is made only for themselves, as if it also affects another person in the same way. From this literature, we can expect less risk-taking, if a risky decision leads to a risky gamble for another person or has a certain negative impact on the earnings of this person. Brennan et al. (2008) and Güth et al. (2008), however, come to a different conclusion. They measured the reservation price of a prospect where the outcome for oneself or another person is either risky or safe. Participants in both studies only show other-regarding concerns when their own payoff is certain, but not when their payoff is uncertain. If their own payoff is uncertain, there is no significant difference in the reservation price between a certain or uncertain payoff of the other person. We, therefore, can expect that people take less risk if risky decisions have certain negative consequences for another person, but we see varying results with uncertain consequences for another person. According to our knowledge, there is no study that systematically compares how behavior changes based on the certainty of the consequences of risk decisions.

Resulting of these studies, we can, therefore, say that to some extent the payoff of the other person is incorporated into the own decision making. This seems to be especially the case, when the own decision leads to certain negative consequences for the other person. The literature on social preferences also shows that people incorporate the outcome for others into their decision-making (Carpenter 2010; Cooper and Kagel 2016; Fehr and Schmidt 1999; Charness and Rabin 2002; Fehr and Charness 2023). In our theory section we will, therefore, look at the incorporation of others outcome into the own expected utility function, similarly to how it is often used in those concepts to understand how externalities potentially affect risk decisions in our setting.

Another important factor to consider regarding risk-taking involving others is social comparison. Various studies examined risk-taking decisions after establishing a social reference point of another person's baseline income. These studies show that risk decisions are influenced by the possibility of either decreasing (social loss) or increasing (social gain) the distance to this social reference point. This can result in more or less risk-taking depending on the individual's risk attitude and the distance to the reference point (Lindskog et al. 2022). The further away the potential incomes are from the reference point, the higher is the willingness to take risk with social loss and with social gain (Gamba et al. 2017). Closer to the reference point, participants are less willing to take risk, if they can earn at most as much as the reference point (social loss), but more risk-seeking if they can earn at least as much as the other person (social gain) (Linde and Sonnemanns 2012). Drawing a conclusion on how social comparison affects risk decision becomes even more challenging when the reference point is subject to constant change or uncertainty, as observed in our experiment.

3. Design of the experiment

Our study design is based on the risk elicitation task of Eckel & Grossmann (2008). This task was chosen as it easily allows the introduction of uncertain externalities by using specific values without the necessity to explain a complex mechanism. Furthermore, this risk elicitation task has only one decision, which makes it less difficult to understand for our target groups compared to other risk-elicitation methods like a multiple price list (Charness and Viceisza 2012; Bruns 2023).

Our study focuses on different risk decisions that participants make. How the risk decisions affect the decision maker is the same for all decisions in all treatments. Participants are given five different risk options and have to choose one of them that determines their payment. Each risk option consists of a high and a low value that has a 50 % probability of being paid out to the decision maker if this option is chosen. The high and low value of each risk option, the expected value, and the implied Constant Relative Risk Aversion (CRRA) range are presented in Table 1. The payout is determined by individually drawing a black or white marble at the end of the experimental session. To ensure the participants of the equal chance of a payment of the high value (white marble) or the low value (black marble), the bag is filled with marbles in front of the participants. The participants make their decisions based on knowledge of the high and the low values alone. They get no information on expected values and CRRA ranges. Given the CRRA ranges, risk-seeking individuals would choose risk option 5, risk-neutral individuals choose risk option 4 or 5 . Risk-averse individuals choose either risk option 1, 2, or 3.

The experiment consists of three parts, which are played in a fixed order. At the end of the experiment one part is randomly chosen for all participant and the decision in this part is paid out. To ensure that the participants comprehend each part properly we increase the complexity of the task with each additional part, similar to Bolton et al. (2015). Participants get the instruction for one part, play it and then get the instruction for the next part. The participants are informed that the experiment consists of three parts and that only one part will be paid out at the beginning of the experiment. In the first part, all participants make the individual risk decision only for themselves, without any possible effects on other participants. In the second part, participants are paired and divided into player A and player B. Participants know whether they are player A or player B, but they don't know who they are paired with. Player A makes an

[2] Exchange rate at the time of the study 1 € ≈ *UGX* 3780, 1 \$ ≈ *UGX* 3810 Constant relative risk aversion (CRRA) is based on the mean of the utility functions of both values c: $u(c) = \frac{c^{1-\rho}-1}{1-\rho}$ with ρ being the CRRA value ($\rho \neq 1$). If $\rho = 0$, a person is risk neutral.

Table 1
Risk options of individual risk decisions, with values in Uganda shillings (UGX).[2]

Risk Option	Low value ($x_{i,low}$)	High value ($x_{i,high}$)	Expected value	CRRA range lower limit	CRRA range upper limit
1	6000	6000	6000	2	
2	5000	7500	6250	0.668	2
3	4000	9000	6500	0.395	0.667
4	3000	10,500	6750	0	0.394
5	2000	11,500	6750		0

Table 2
Overview of how the low and high value of the potential payment of player B is defined in each treatment.[3]

Treatment	Low value player B ($y_{i,\ low}$)	High value player B ($y_{i,high}$)	Value comparison	Externality
OWN	6000 UGX	6000 UGX	Highest low value, middle high value	No externality
SAME	Low value of player A	High value of player A	Lowest low value, highest high value	Negative or positive externality
UNC_NEG	Low value of player A	6000 UGX	Lowest low value, middle high value	Negative or no externality
C_NEG	Low value of player A	Low value of player A	Lowest low value, lowest high value	Certain negative externality

individual risk decision that potentially affects player B's payoff. In the second part, player B makes no decision. We divide the participants into players A and players B before making the decision to reduce the complexity of the game. We also want to ensure that participants understand that in this part of the experiment players B do not have any possibility to reward or punish the decision of players A and, therefore, decisions are solely made based on individual preferences. In part 3, the participants are matched in new pairs. In part 3, player B can choose strategically which of player A's decisions to punish, and afterward player A makes a similar decision as in part 2 without knowing which decision player B punishes. While the players know that the experiment consists of three parts, they don't know the instructions of later parts due to the increasing complexity. This approach enables us to concentrate solely on externalities in part 2, without having to consider part 3.

How player B is affected by player A's decision in part 2 differs between treatments, as presented in Table 2. There are four different treatments, which are randomized at the session level (OWN, SAME, UNC_NEG, C_NEG). In all treatments, the risk option choice of player A defines the payoff of player A in the same way as in part 1 and the treatments only differ in the way the decision affects player B's payoff. In the control treatment (OWN), player B is not affected by the decision of player A and receives the same payoff as in risk option 1 (6000 UGX), despite the decision of player A. There is, therefore, no externality. In the SAME treatment, the risk option, which player A chooses, is implemented in the same way for player B. This means that player B can earn the high and the low value of the chosen option of player A with equal probability. A high-risk decision, therefore, has an uncertain positive and an uncertain negative externality. In the UNC_NEG treatment, the risk decisions only have an uncertain negative externality. Here, player B either earns the low value of the chosen option of player A, or the same value as in risk option 1 (6000 UGX). In the C_NEG treatment, player B always gets the low value of the risk option chosen by player A. High risk-taking of player A is harmful to player B and, therefore, has a certain negative externality.

4. Theory and hypothesis

Based on the expected value the dominant strategy for any risk-neutral player would be to choose risk option 4 or 5, despite the treatment. The social optimum for the UNC_NEG and C_NEG treatment, however, would be to choose risk option 1. For any other risk option in these treatments the increase in the expected value for player A is lower than the decrease in the expected value for player B. Solely based on the expected value our design is, therefore, a simple social dilemma game for the UNC_NEG and the C_NEG treatment. In the OWN treatment and the SAME treatment, we see no decrease in the expected value for player B and the social optimum and the dominant strategy are to choose risk option 4 or 5. Social preferences theory describes that people take the outcome for others into account while making their decision (Carpenter 2010; Cooper and Kagel, 2016). Given the expected value and social preferences, we would, therefore, expect lower risk-taking for the C_NEG and the UNC_NEG treatment and high risk-taking for the SAME and OWN treatment. However, the decision is not only a decision of income distribution but of risky outcomes and people have differing risk preferences.

A simple theoretical model that considers both risk preferences and social preferences is an expected utility theory model that we extend with a social component. The expected utility for each risk option i in part 1 can be calculated by summing up the utility ($U_{A,i}(x_{i,q})$) of both potential values and divide them by two. For part 2, we furthermore add the expected utility a decision maker A gets from the potential earnings of the affected player B. We calculate the expected utility based on player B's earning similar to the utility decision maker A gets from the individual decision, by summing up the utility ($U_{B,i}\left(y_{i,q}\right)$) decision maker A gets from each value of risk option i for player B and dividing it by two. Our basic assumption from social preferences literature is that high earnings for player B

[3] Exchange rate at the time of the study 1 € ≈ UGX 3780, 1 $ ≈ UGX 3810.

lead to a high utility of player A and low earnings for player B lead to a low utility of player A.[4] We furthermore incorporate a weighting factor λ that shows that it differs between decision makers how dependent their overall expected utility is from the utility they get from the earnings of the linked player B. For each decision maker A, we can, therefore, create an expected utility function EU_i of each risk option *i* that depends on the utility the decision maker A gets of the low and high value of risk option *i* for oneself ($x_{i,low}$; $x_{i,high}$) and the linked player B ($y_{i,low}$; $y_{i,high}$).

$$EU_i\left(x_{i,low}, x_{i,high}, y_{i,low}, y_{i,high}\right) = (1-\lambda)\frac{U_A\left(x_{i,low}\right) + U_A\left(x_{i,high}\right)}{2} + \lambda\frac{U_B\left(y_{i,low}\right) + U_B\left(y_{i,high}\right)}{2}$$

Our basic assumption from expected utility theory is that decision maker A will choose the risk option *i* with the highest expected utility for oneself. Player A's potential earnings for each risk option *i* are the same for all treatments, so differences between treatments can solely be explained by the expected utility that decision maker A receives from player B's potential earnings ($\frac{U_B\left(y_{i,low}\right)+U_B\left(y_{i,high}\right)}{2}$), given that some form of social preferences exist and $\lambda > 0$.

For risk option 1, the potential earnings of player B are the same in all treatments, therefore, all considerations are for $i > 1$, as here the values of $y_{i,low}$ and $y_{i,high}$ differ between treatments. We further assume that the utility of a higher value is higher than that of a lower value. In addition, we expect that if the expected utility for high-risk options is higher in one treatment than in the other, participants are more likely to choose higher risk options in that treatment than in the other.

Based on these considerations, we expect that higher risk options are chosen in the OWN treatment than in the UNC_NEG treatment, in which higher risk options are chosen than in the C_NEG treatment. The reason for this is that first, in the UNC_NEG treatment the value of $y_{i,low}$ for $i > 1$ is lower than in the OWN treatment and, second, in the C_NEG treatment the value of $y_{i,high}$ for $i > 1$ is lower than in the UNC_NEG treatment, while $y_{i,low}$ has the same value as in the UNC_NEG treatment. Similarly, we can see the value of $y_{i,high}$ is highest in the SAME treatment, middle in the UNC_NEG treatment, and lowest in the C_NEG treatment, while the value of $y_{i,low}$ is the same in all these three treatments. According to our theoretical model, the expected utility of each risk option $i > 1$ is always the lowest in the C_NEG treatment and second lowest in the UNC_NEG treatment. However, the difference in utility of a risk option $i > 1$ between the OWN treatment and the SAME treatment depends on player A's utility function for player B's income ($U_{B,i}\left(y_{i,q}\right)$). If this utility function has a concave shape (risk-seeking), a risk option $i > 1$ is more attractive in the SAME treatment than in the OWN treatment. However, if the utility function is convex (risk-averse), higher-risk options are less attractive in the SAME treatment than in the OWN treatment. Based on the empirical literature, we assume that the utility function is rather convex than concave, as risk decisions for others are often risk-averse. Therefore, high-risk behavior is considered less attractive in the SAME treatment than in the OWN treatment. Based on these considerations, we can assume that people take the highest risk in the OWN treatment, followed by the SAME treatment, followed by the UNC_NEG treatment, and lastly the C_NEG treatment. In other words, the more harmful a risk decision is, the less risk a decision maker takes. Our theoretical model, therefore, allows us to make some general assumptions about risk decision making with externalities leading to our pre-registered main hypothesis about the relationship between externalities and risk behavior[5]:

> *The more harmful risk-taking is to the other person, the less likely fishers are to take risks. This means that risk-taking decreases from no consequences for another person (OWN) to the same consequences for another person (SAME) to potentially negative consequences for another person (UNC_NEG) to certain negative consequences for another person (C_NEG).*

This main hypothesis assumes that externalities have an impact on risk-taking behavior primarily through incorporating the potential payoffs of the other person into the own decision-making. However, there is a strand of the literature that argues that individual risk-taking outweighs other-regarding preferences (Brennan et al. 2008; Güth et al. 2008). According to this literature, there should be no effect of the treatments and risk-taking behavior should be the same across treatments. In our theoretical model, this means that λ is zero or close to zero. As our study design is closer to studies that see an influence of social preferences on risk-taking behavior with either certain negative externalities or uncertain externalities (e.g., de Oliveira 2021, Bolton et al. 2015), we, however, base our theoretical considerations on the assumption that $\lambda > 0$.

Another strand of literature deals with social comparison. Social comparison means that participants gain or lose utility by differences in earnings. To incorporate this social comparison in our expected utility function, we would need to add an additional component of comparison, making the model much more complex as we are in a risk-related environment. Additionally, research on social comparison in risk-related environments is mainly based on fixed reference points, which are at the edge of the potential payoffs or outside of it (e.g. Linde and Sonnemanns 2012; Gamba et al. 2017; Lindskog et al. 2022). Regarding our research design, it is difficult to build any hypotheses based on this body of literature, because most of our treatments have no fixed reference points. Presumably, the effect of the social reference point would be most pronounced in the treatments with certain reference points, such as the OWN and C_NEG treatments and potentially lead to higher risk-taking due to the higher social gains than losses. However, as our design is not found similarly in the relevant literature on social comparison, it is difficult to build a hypothesis on how the effect of social comparison on risk decision differs between treatments.

[4] This basic assumption can be linked to different mechanism described in the literature ranging from warm glow up to guilt aversion.

[5] In the pre-registration we also registered two further hypotheses for the third part, which is not studied in this paper.

In this study we test these considerations in the very specific setting of Lake Victoria fisheries. This is important as Henrich et al. (2010) showed in their famous paper that standard student samples are often not representative enough when focusing on a target population in Non-Western countries. Cooperation studies with a risky component also show differences between students and small-scale fishers (Hopfensitz et al., 2019, Rocha et al. 2020, Schill and Rocha 2023). In the context of our study, we combine a risk component with a social component and, based on this knowledge, might get misleading results if we don't use our target sample. Lake Victorian fishers are especially interesting as the small-scale fishery is embedded in a fragile ecosystem. Given previous research at Lake Victoria, we can expect that many fishers choose risk neutral or risk-seeking options (Eggert and Lokina 2007). However, due to the novelty of this research, we cannot make any target specific hypotheses on treatment effects beside our main hypothesis.

5. Data collection and sampling

To measure how fishers' risk behavior is affected by potential externalities, we conduct a lab-in-the-field experiment with Ugandan fishers at Lake Victoria. Lab-in-the-field experiments allow us to measure behavioral mechanisms in a controlled environment, while also considering the specific characteristics of the target group (Gneezy and Imas 2017). The study was carried out between August and September 2022 in cooperation with local authorities at 23 different Ugandan landing sites in all regions that border Lake Victoria (see Fig. 1). The organization of the experimental session, including planning and communication with the authorities and participants, was done by local researchers, which also helped in the preparation and translation of the instructions. The experimental sessions were held in the landing sites (or beaches) where the fishers work and live, if possible in roofed facilities. A picture of the setting and an example of the instructions are presented in Appendix D and Appendix E.

We aimed at a sample that represents fishers of different species and fishers with different roles in the fishing process, but also different locations (island or mainland). As common in this setting, the fishers were recruited through landing site chairpersons using community lists (Dasgupta et al. 2024). We then randomly selected participants from the list according to their fishing role (boat owner or crew member), understanding of the local language, ability to use a tablet, and targeted species (Dagaa or Nile tilapia / Nile perch). We conducted 36 sessions in total, and each session consisted of 14 to 18 participants. In total, 644 fishers took part in the experiment.[7] As half of the participants are players A, we have 322 players A taking part in the experiment. For the treatments UNC_NEG and C_NEG, we have 80 observations of players A, and for the treatments SAME and OWN we have 81 observations of players A. The experiment was conducted in a classroom setting, the participants were randomly seated with some distance between them and were given folders to shield their decision. Additionally, they were told to not communicate with each other during the session. Due to the COVID-19 pandemic, we provided the fishers with masks and sanitizer to reduce the risk of infection. After finishing the experiment, the participants answered an intensive questionnaire and played a common pool resource game, which is not part of this paper.[8]

The instructions for the experiment were in *Luganda*, which is the most widespread local language on the Ugandan coast of Lake Victoria. The explanation was provided orally to the participants with the support of posters. In each session, the same extensively trained local research assistant used a treatment-specific script. She explained the random mechanisms for the chosen round and the earning of the low or high value using balls or marbles, which are put in a bag for the random draw in front of the participants. To make the risk decisions vivid, each explanation was accompanied by an interpretation of how the decision reflects the choice between gears, without mentioning illegal gears. Before making their decisions, the fishers had to answer comprehension questions in each part of the experiment. The correct answer was given to them afterward to ensure that everyone understood the experiment. In case of problems with understanding the experiment or the questionnaire, we had two further local research assistants helping the fishers. The experiment was programmed in oTree (Chen et al. 2016). The participants made their decisions on tablets, which were connected via a local network. The local network connection allowed interactions and ensured that all participants waited if necessary. All participants were supposed to be able to read *Luganda* and have some experience with the use of smartphones. The average education of the participants is, therefore, expected to be a little higher than the general average education of fishers at Lake Victoria.

We randomized the treatments on the session level with the restrictions to have the same amount of sessions per treatment and not the same treatment within one landing site. The randomization in the roles of player A and player B was done by the computer and independent of their sitting arrangement or any decisions made in the experiment. The random allocation of roles was explained by the research assistants, and participants were informed on their tablets about their roles right before making the decision in the part 2 of the experiment. The role was displayed on their tablets for the rest of the experiment. Participants earned on average UGX 17,576 for the participation in the whole study, of which an average of UGX 6374 came from this experiment and the rest came of the subsequent experiment and a show up fee.[9] The earnings were within the range of the average daily earnings per crew member. The study was ethically approved and pre-registered.[10]

[6] Same Map is also used in Dannenberg et al. (2024)

[7] Before the 36 sessions we conducted two pilot sessions and one session with the same instructions, but different design of the decision page of the last decision.

[8] The results of the common pool resource game are published in a separate paper (Dannenberg et al. 2024)

[9] The total time that participants needed for the experiment was about 3 hours. Exchange rate at the time of the study 1 € ≈ *UGX* 3780, 1 $ ≈ *UGX* 3810.

[10] Ethical approvals: GfeW No. q6RvhKTZ (https://gfew.de/ethik/q6RvhKTZ) ; MAKSSREC 06.22-573; Pre-registration: As Predicted #105407 (https://aspredicted.org/4MP_56H) - Given the experience with the first pilots, we had to take out the measurement of stated preferences by player B as it was not a necessity and was difficult to understand for the participants. This paper only focusses on the first question and hypothesis.

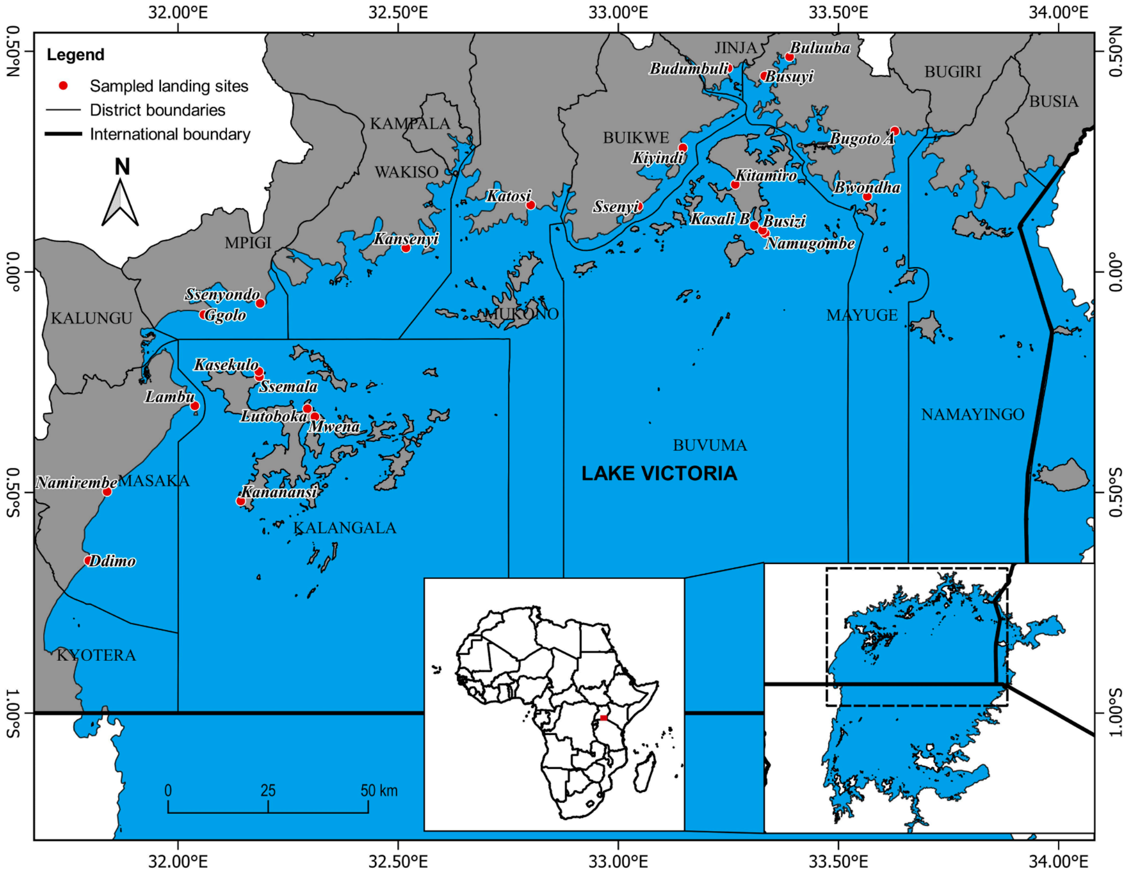

Fig. 1. Map of visited landing sites at the Ugandan part of Lake Victoria.[8]

6. Results

6.1. Respondent characteristics

The mean age of the participants is 35.1 years (standard deviation 10.4) and 14.3 % of the participants are female. Most observed resource users are boat owners (83.7 % of female participants, 52.4 % of male participants, and 56.9 % of all participants). The high share of boat owners in our sample can be explained by them often being better qualified and therefore able to read and use the tablets, which was a prerequisite for participation in the experiment. Boat owners are often responsible for the gear choices and take the highest financial risk. Crew members, however, take more physical risks while fishing. In our sample, 41.6 % of the participants/ respondents are from landing sites, which are located on islands. Regarding gear choice, 26.7 % of the fishers fish Mukene (Dagaa) with small seine nets, 54.2 % of the fishers use gillnets and 17.9 % use hooks. Gillnet and hook fishers mainly fish Nile Perch and/or Tilapia. The rest of the participants (< 1 %) stated to use other gears and fish other species. According to the latest frame survey of Ugandan fisheries in 2020, 39.4 % of the fisher boats are on the two main island districts, 19.3 % of the boats fish Mukene, 59.4 % fish Nile Perch and 20.2 % fish Tilapia (The Republic of Uganda 2021).[11] While we deliberately oversampled boat owners, the frame survey data implies that the distribution of fishers on the island and mainland is still similar to the distribution at the Ugandan coast of the lake, as well as the share of fishers per species.[12]

[11] The Frame Survey only gives an indication of the number of gears and not on the numbers of fishers using them, therefore the comparison to boats per species is more valid for comparison to our data. However, with regard to the risk decision the differentiation on used gear (esp. hook and gillnet) is more interesting than the differentiation regarding target species.

[12] Our sample consists of 26.7% Mukene fishers 59.8% Nile Perch fishers and 12.9% Tilapia fishers. The higher share of Mukene fishers can be explained by more fishers per boat, the lower share of Tilapia fishers might be explained by Nile Perch being the more prominent fish and the fishers / boat owners not being able to state that they fish both.

6.2. Risk decisions

In the first part of the experiment, all participants make the same risk decisions, which we, therefore, can use as a measurement of risk preferences. Overall 21.7 % choose the risk neutral risk option 4 and 27.5 % choose the risk seeking risk option 5. Therefore, nearly half the participants are either risk-neutral or risk-seeking, and the other half is risk-averse (16.0 % chose risk option 1, 15.4 % chose risk option 2, and 19.4 % chose risk option 3) .[13] We, therefore, have a higher share of risk averse fishers than Eggert & Lokina (2007), where only 32.0 % show risk averse behavior. Using Mann-Whitney U tests (MWU), we see no significant differences in the distribution of risk preferences in part 1 between treatments, considering both players A and players B.[14] This is expected as there is no difference in the decision environment in part 1. However, the main decision in part 2 is made only by players A and if we compare only the decisions of players A, we can see differences between treatments in part 1 (see Fig. 2). Players A in the C_NEG treatment choose weakly significantly lower risk options than participants in the SAME treatment (MWU, $p = 0.0668$). We can also see that players A in the UNC_NEG treatment choose significantly lower-risk options than players A in the SAME treatment (MWU, $p = 0.0437$). All other comparisons of risk option choices between the treatments in part 1 show no significant differences. There is no difference in the decision environment between treatments for part 1. That we see no significant differences between treatments for the sample of all fishers shows, that the randomization mechanism of the computer has chosen randomly more risk-averse participants as players A in the treatments C_NEG and UNC_NEG compared to the other treatments. It is, therefore, important to not only rely on the non-parametric tests, but also control for the individual risk decision in the first game.

For part 2, we only look at players A's risk decision, since players B do not make a decision in this part of the experiment. A high share of players A (57.5 %) choose the same risk option in part 1 and part 2. We use a Wilcoxon signed-rank test (WSR) to measure whether, in the different treatments, a significant change in the chosen risk option between part 1 and part 2 is visible (see Table 3). In the C_NEG and the SAME treatment, we cannot see a particular different share of participants that choose a higher risk option or a lower risk option in part 2 compared to part 1. Thus, for these treatments, we cannot detect significant changes in behavior using a WSR test. In the UNC_NEG and the OWN treatments compared to part 1 more participants choose a higher risk option in part 2 than those who choose a lower-risk option. The difference is significant for the OWN treatment (WSR, $p = 0.043$), but not significant for the UNC_NEG treatment (WSR, $p = 0.150$) (see Table 3). Meaning, we can observe a significant increase in overall risk-taking between part 1 and part 2 in the OWN treatment, but not in the other treatments. This is especially interesting, as the OWN treatment is the only treatment, where the individual risk decision has no impact on other participants.

Fig. 3 shows that the resulting risk decisions in part 2 are staggered as expected in our main hypothesis. In part 2, fishers in the C_NEG treatment take on average the least risk, then participants in the UNC_NEG treatment, then participants in the SAME treatment, and participants in the OWN treatment take on average the highest risk. When comparing risk behavior between treatments, there is a significant difference in risk-taking between the C_NEG and the OWN treatments (MWU, $p = 0.022$), but no significant difference between the other treatments. This difference between treatments is not visible in part 1 of the experiment. Thus, we can confirm that participants take significantly more risks when the risk decision has no effect (OWN) compared to a certain negative effect (C_NEG) on another person. However, using the MWU test, we cannot find a significant difference between the other two treatments (SAME, UNC_NEG) and if we compare the decision in the OWN and the C_NEG treatments to them. Given the significant difference in risk decisions between the SAME and UNC_NEG treatment in part 1, it is especially interesting to see that no significant difference is visible in part 2.

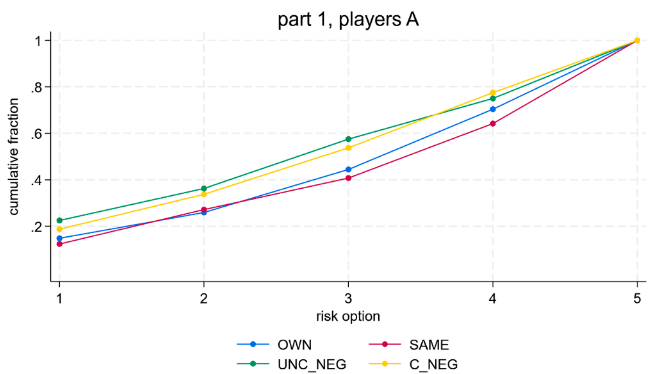

Fig. 2. Cumulative decision of players A for risk options in part 1. The figure shows for each risk option which share of the fishers that are player A in the respective treatment decide for this risk option or a lower on. The higher the line, the less risk-taking are the fishers in this treatment.

[13] A more nuanced differentiation regarding the chosen risk option can be found in Appendix A

[14] A Figure concerning the cumulative decision of all players for risk options in part 1 can be seen in Appendix A.

[15] Abbreviations: WSR - Wilcoxon-signed rank test; SD: standard deviation.

Table 3
Within development of risk decisions between parts.[15]

Treatment	Number of players A	Mean (SD) part 1	WSR |z|-value	WSR p-value	Mean (SD) part 2	Lower in part 2 than part 1	Higher in part 2 than part 1
OWN	81	3.444 (1.405)	2.019	0.043	3.642 (1.408)	12	28
SAME	81	3.556 (1.423)	0.076	0.940	3.420 (1.540)	17	18
UNC_NEG	80	3.088 (1.494)	1.440	0.150	3.213 (1.565)	10	18
C_NEG	80	3.163 (1.427)	0.136	0.891	3.100 (1.489)	16	18

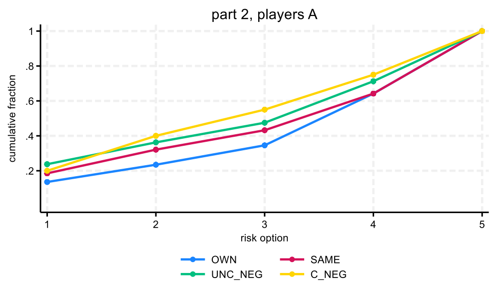

Fig. 3. Cumulative risk decisions of players A for risk options in part 2. The figure shows for each risk option which share of the fishers that are player A in the respective treatment decide for this risk option or a lower on. The higher the line, the less risk-taking are the fishers in this treatment.

6.3. *Results of the regression analysis*

As discussed, it is important to control for the previously made decisions, when looking at treatment differences. In Table 4 we use an ordered probit estimation to get an understanding of the decision-making of players A based on the treatment differences in the different parts of the game. The baseline treatment is the OWN treatment. Besides looking at the treatment effects, we include the decision in part 1 and also add further control variables. In column 1 and column 2, we look at the first risk decision, which is the same in all treatments, and see, similar to the non-parametric tests, no significant higher or lower risk-taking between the OWN treatment and the other treatments.[17] Columns 3 and 4 show that changes in risk option choices between part 1 and part 2 are significantly different in all treatments compared to the OWN treatment. We can also see that high-risk decisions in the first game lead to a significantly higher probability of decreasing the risk decision. As there are fewer options for an increase in risk taking with the choice of higher risk options in part 1, this can be expected. Columns 5 and 6 show that the risk decision in part 2 is highly significantly correlated to the previous risk decision in part 1. Meaning, if a fisher took high risks in part 1, the likelihood of taking high risks in part 2 is high. While controlling for this relationship, we see in column 5 and column 6 that in part 2 being in the treatment C_NEG leads to a significantly higher likelihood of choosing a lower risk option than being in the OWN treatment.

Table 4
Ordered probit estimation of risk decision by player A.[17]

	(1) Choice of risk option part 1	(2)	(3) Difference in chosen risk option of part 2 and part 1	(4)	(5) Choice of risk option part 2	(6)
SAME	0.106	0.179	−0.269**	−0.304**	−0.187	−0.201
	(0.169)	(0.171)	(0.118)	(0.138)	(0.115)	(0.140)
UNC_NEG	−0.250	−0.213	−0.296**	−0.318*	−0.216	−0.217
	(0.181)	(0.181)	(0.147)	(0.165)	(0.154)	(0.172)
C_NEG	−0.206	−0.150	−0.415***	−0.394**	−0.311**	−0.278*
	(0.183)	(0.189)	(0.132)	(0.155)	(0.124)	(0.148)
Risk option part 1			−0.460***	−0.454***	0.344***	0.359***
			(0.045)	(0.045)	(0.058)	(0.058)
Control		X		X		X
N	322	318	322	318	322	318
Pseudo R^2	0.006	0.018	0.102	0.107	0.065	0.072

Coefficients of ordered probit model, robust standard errors, clustered at session level in parentheses. Levels of significance $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. All choices are made by player A, the baseline treatment is OWN. Control variables are age, gender, whether they are boat owners, the gear that they use, whether they are from an island, whether they earn more than other fishers at their landing site and whether they had all control questions of the respective part correctly.

[16] Acronyms: N: number of observations
[17] In Appendix B we look at the same regression models with SAME as the baseline treatments and see significant differences between treatments in part 1 but not in part 2, which is in line with our findings from the non-parametric tests.

As control variables, we include age, gender, the role on the boat (boat owner), the main fishing gear, whether they are from an island, whether they say that they earn on average more than the others at their landing site and whether they answer all control questions of the respective part correctly. Fishers from an island choose weakly significant lower-risk options in part 1. People who earn more than others at their landing site are weakly significantly more likely to reduce their chosen risk option in part 2 compared to part 1. However, we cannot see any other significant effect of the regarded control variables on the decision-making (see Appendix B).

Research on cooperative and prosocial behavior suggests that identification with or social proximity to other participants may lead to higher social preference and thus more other-regarding behavior (Chen and Li 2009; Balliet et al. 2014; Diekert et al. 2022). In our sample, the relationship to the other participants is particularly interesting as the study was conducted within the local communities. To understand the relationship in our sample, we conduct several sub-sample analyses in Appendix C based on indicators of close relationships or the importance of these relationships to the participants. We examine identification with their landing site, concern for others' opinions, social proximity to other participants, and whether they live on an island. Although the resulting smaller sub-sample sizes require cautious interpretation, the results suggest that close relationships lead to significantly lower risk-taking when risk-taking has an impact on others. For all indicators, it can be seen that participants in the C_NEG treatment take particularly lower risks than in the OWN treatment if they fall into this category. For the SAME and UNC_NEG treatment, we see a similarly lower willingness to take risks for most categories, but not for all.

7. Discussion

In our study we investigate how different types of externalities influence the risk-taking behavior of Ugandan fishers on Lake Victoria. The results show that fishers are less risk-taking when their actions have a direct negative impact on another person's income (C_NEG) than when their actions have no impact on another person (OWN). Furthermore, we observe that the introduction of another player in part 2 leads to a significant increase in risk taking behavior in the OWN treatment, but not in the other treatments. This change is significantly different from all other treatments.

The OWN treatment is the only treatment in which risk decisions have no impact on the other person's payout. In the OWN treatment, participants have the chance to perform better than their peers without risking negative effects on their peers' income. They also have a certain social reference point. In terms of social comparison, a focus on potential social gain could explain this increased willingness to take risks. This would mean that the players want to take advantage of the opportunity to do better than their teammate (social gain) but focus less on the risk of doing worse than their teammate (social loss). Another explanation could be a learning experience leading to higher risk-taking through better understanding of the game. However, in both cases a similar increase in risk-taking should be visible in the other treatments as well, which is not the case. Therefore, this cannot be the only explanation.

Our results show that fishers do not show increased risk-taking when risk-taking behavior affects the other person. The difference in behavioral change between parts 1 and 2 is greatest between the treatment with certain negative externalities (C_NEG) and the treatment with no externalities (OWN) and results in significantly lower risk-taking with certain negative externalities than with no externalities. These results are consistent with those of de Oliveira (2021), who shows that participants take significantly less risk with certain negative externalities than with no externalities. We can also conclude that in the presence of uncertain externalities (UNC_NEG and SAME), risk-taking does not increase to the same extent as in the no externalities treatment (OWN), and thus there is a significantly different change in behavior. However, we cannot find a significant difference in the resulting risk-taking behavior. Interestingly, the missing possibility of a positive externality in the UNC_NEG treatment does not lead to significant differences to the SAME treatment.

If the focus on social gains or a learning experience solely explains the change in risk behavior in our experiment, an increase in risk would be expected for all treatments and not only for the OWN treatment. Especially for the C_NEG treatment, the social gains can be much higher. The impact on the others' fishers payoff, therefore, as well needs to be taken in consideration to explain the decision-making of fishers. When participants in these treatments consider the benefits and harms of the other person through behavioral changes, social preferences might be weighed against the potential social gain and loss. This can also explain why we observe a significant difference in risk-taking behavior between certain negative externalities and no externalities. With the clear negative consequences for the other player in the C_NEG treatment, the potential social gain through higher risk taking seems to play a less prominent role. With respect to the differences between treatments, we, therefore, assume that both social comparisons and social preferences influence how the potential payoff of the other participant is considered during the risk decision.

The high proportion of participants who did not change their behavior between games could also indicate that, similar to Güth et al. (2008) and Brennan et al. (2008), many fishers focus more on individual risk than on the potential payoffs of other participants. However, if this were true for all participants, we would not see a significant change in behavior in the OWN treatment, nor would we see any differences between it and the other treatments. The idea that individual risk decisions outweigh other-regarding preferences therefore seems to be unsuitable to explain fishers' behavior in our study.

Our more explorative sub-sample analysis, where we separate the participants according to their closeness to other participants using different indicators, shows how important the relationship to the other fishers is for their behavior. We see that if people are close to the other participants they are more likely to engage in lower risk-taking in the treatments with uncertain and certain externalities. This sub-sample analysis indicates that especially for our groups of fishers the relationship to the other person seems to play an important role in how much they take the effect of their risk decision on the other persons outcome into account. Similar effects of social proximity or identification on the incorporation of outcomes for others into the own decision-making can be found in the literature on social preferences and cooperation (Chen and Li 2009; Balliet et al., 2014; Diekert et al., 2022).

8. Conclusions and implications

Although the observed difference in risk-taking decisions between treatments is similar to our main hypothesis, it cannot be fully confirmed. Nevertheless, our study provides valuable insights into fishers' behavior and the factors that influence their willingness to take risks. We can show that, overall, fishers take less additional risk if they expect it to lead to a reduction in the income of a peer. However, the resulting risk-taking is only significantly different between the no externality and certain negative externality treatments. With uncertain externalities, we have been able to show that participants do not change risk behavior as they do in the absence of externalities and that treatment effects regarding the resulting risk-taking occur for people with close relationships to the other participants. With uncertain externalities, we see no difference in behavior when positive externalities are possible or when they aren't.

Our main simple theoretical model is based on the idea that due to social preferences the outcome for others is incorporated into risk decision-making whenever certain or uncertain externalities are present. The results, however, emphasize that our model can only partly explain risk decisions with externalities. Social comparison could be an important addition to this theoretical framework as without externalities the participants increase risk-taking, which can be explained by the desire to earn more than the other participant. Our study further indicates that if there is a closer relationship to the affected person, also uncertain externalities have an effect on the risk decision. A more comprehensive theory on risk-taking in the presence of externalities can learn from our study by considering social identity, social comparison and social preferences.

Another important approach for future research is to link our results to the literature on cooperation in social dilemmas. We only investigate a one-way relationship between individual risk-taking and externalities because we were interested in this mechanism. However, risk decisions are made in a social environment with a higher complexity of interdependencies. This is only partly regarded by the studies on cooperation in a risky environment (Hopfensitz et al., 2019; Rocha et al., 2020; Schill and Rocha, 2023), as they only looked at cooperation and not on individual risk-taking. Furthermore, research in this realm should look much more on the relationship fishers have with each other and how it affects their decision-making.

Our study is motivated by risk-related decisions of fishers at Lake Victoria, which often have a negative impact on the income of others. We want to understand how awareness of these externalities changes risk decisions. To do this, we confronted fishers with a financially relevant risk decision and differently certain externalities. Based on our results, we anticipate that focusing fishers on the negative impact of their risk-taking behavior on others can lead to a reduction in risk-taking by these fishers. Campaigns on Lake Victoria to sustain the resource, such as the current military operations in Uganda or the recent ban on small seine nets, often focus on regulations and enforcement. In contrast, our study focuses on fishers' understanding that their risk-taking can have negative consequences for other fishers. We suggest to launch information campaigns in addition to the regulatory campaigns, as these can have a risk-reducing effect on risky behavior, such as illegal fishing. An effect can be particularly expected if the campaigns aim to convince fishers of the certainty of a negative impact of their risk behavior on people, they identify with. For example, an information campaign about the negative effects of illegal fishing can emphasize the specific negative consequences for fishers at the same landing site. After all, our results suggest that even when there is uncertainty about the impact on others, raising awareness of potentially harmful impacts on close people can lead to less potentially harmful risk behavior by fishers. The importance of informing fishers about the harmful consequences of their actions to others was also frequently mentioned by local fisheries officials during our field study. In personal conversations, they said that better education about the consequences of fishers' actions for the fish stock and thus also for other fishers would help reduce harmful behavior like illegal fishing. Our findings underline this statement.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT and DeepL in order to improve readability and language. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Philipp Daniel Haendel reports financial support was provided by Federal Ministry of Education and Research Berlin Office. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2024.106757.

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