Environment for Development

Discussion Paper Series May 2025 ■ EfD DP 25-02

Understanding non-compliance with rights-based fisheries management

in Vietnam

Bui Bich Xuan, Quach Thi Khanh Ngoc, Claire W. Armstrong, Kofi Vondolia, and Pham Khanh Nam

Central America
Research Program in Economics and Environment for Development in Central America Tropical Agricultural Research and Higher Education Center (CATIE)

Chile
Research Nucleus on Environmental and Natural Resource Economics (NENRE)
Universidad de Concepción

China
Environmental Economics Program in China (EEPC)
Peking University

Colombia
The Research Group on Environmental, Natural Resource and Applied Economics Studies (REES-CEDE), Universidad de los Andes, Colombia

Ethiopia
Environment and Climate Research Center (ECRC), Policy Studies Institute, Addis Ababa, Ethiopia

Ghana
The Environment and Natural Resource Research Unit, Institute of Statistical, Social and Economic Research, University of Ghana, Accra

India
Centre for Research on the Economics of Climate, Food, Energy, and Environment, (CECFEE), at Indian Statistical Institute, New Delhi, India

Kenya
School of Economics
University of Nairobi

Nigeria
Resource and Environmental Policy Research Centre, University of Nigeria, Nsukka

South Africa
Environmental Economics Policy Research Unit (EPRU)
University of Cape Town

Sweden
Environmental Economics Unit
University of Gothenburg

Tanzania
Environment for Development Tanzania
University of Dar es Salaam

Uganda
EfD-Mak, School of Economics and Department of Agribusiness and Natural Resource Economics, Makerere University, Kampala

USA (Washington, DC)
Resources for the Future (RFF)

Vietnam
Economy & Environment Partnership for Southeast Asia (EEPSEA), University of Economics Ho Chi Minh City

Understanding non-compliance with rights-based fisheries management in Vietnam

Bui Bich Xuan[1,*] Quach Thi Khanh Ngoc[1], Claire W. Armstrong[2], Kofi Vondolia[3,4], Pham Khanh Nam[5]

Abstract

Understanding fishers' non-compliance behavior is essential for effective management and conservation of small-scale fisheries. Our study took place in Tam Giang Lagoon, central Vietnam, where Territorial Use Rights for Fisheries (TURFs) have been established since 2009. To estimate the proportion of artisanal fishers engaging in illegal fishing, we used a randomized response technique alongside direct questioning to investigate this type of sensitive behavior. We also employed a binary logistic regression model to analyze the factors influencing non-compliance. A combination of RRT and other methods such as direct questioning and regression model gives a more comprehensive understanding of the drivers behind illegal fishing behavior, allowing for tailored interventions that address specific issues within fisheries. Our findings show that awareness of the negative impacts of illegal fishing and the perceived legitimacy of regulations significantly affect compliance, while instrumental incentives and norms do not have statistically significant impacts. Additionally, certain fishers' characteristics are determinants of non-compliance, such as younger fishers and more experienced fishers are more likely to violate regulations, while those with higher education show better compliance. We also discuss policies to enhance compliance within TURFs. This study enriches the literature on fishing regulation compliance and provides valuable insights for policy design and implementation aimed at improving adherence to regulations.

Keywords: Non-compliance, fishing regulations, randomized response technique, TURF, Vietnam.

JEL Codes: Q22, Q28, D63

* *Corresponding Author: xuanbb@ntu.edu.vn*

[1] *Nha Trang University, 02 Nguyen Dinh Chieu, Nha Trang, Vietnam*
[2] *UiT The Arctic University of Norway, 9037 Tromsø, Norway.*
[3] *Department of Applied Economics, School of Economics, University of Cape Coast, Cape Coast, Ghana*
[4] *Centre for Coastal Management - Africa Centre of Excellence in Coastal Resilience, University of Cape Coast, Cape Coast, Ghana*
[5] *University of Economics Ho Chi Minh City, Vietnam*

Understanding non-compliance with rights-based fisheries management in Vietnam

Bui Bich Xuan[1,*], Quach Thi Khanh Ngoc[1], Claire W. Armstrong[2], Kofi Vondolia[3,4], Pham Khanh Nam[5]

[1]*Nha Trang University, 02 Nguyen Dinh Chieu, Nha Trang, Vietnam*

[2]*UiT The Arctic University of Norway, 9037 Tromsø, Norway.*

[3]*Department of Applied Economics, School of Economics, University of Cape Coast, Cape Coast, Ghana*

[4] *Centre for Coastal Management - Africa Centre of Excellence in Coastal Resilience, University of Cape Coast, Cape Coast, Ghana*

[5]*University of Economics Ho Chi Minh City, Vietnam*

** Corresponding Author: xuanbb@ntu.edu.vn*

Abstract

Understanding fishers' non-compliance behavior is essential for effective management and conservation of small-scale fisheries. Our study took place in Tam Giang Lagoon, central Vietnam, where Territorial Use Rights for Fisheries (TURFs) have been established since 2009. To estimate the proportion of artisanal fishers engaging in illegal fishing, we used a randomized response technique alongside direct questioning to investigate this type of sensitive behavior. We also employed a binary logistic regression model to analyze the factors influencing non-compliance. A combination of RRT and other methods such as direct questioning and regression model gives a more comprehensive understanding of the drivers behind illegal fishing behavior, allowing for

tailored interventions that address specific issues within fisheries. Our findings show that awareness of the negative impacts of illegal fishing and the perceived legitimacy of regulations significantly affect compliance, while instrumental incentives and norms do not have statistically significant impacts. Additionally, certain fishers' characteristics are determinants of non-compliance, such as younger fishers and more experienced fishers are more likely to violate regulations, while those with higher education show better compliance. We also discuss policies to enhance compliance within TURFs. This study enriches the literature on fishing regulation compliance and provides valuable insights for policy design and implementation aimed at improving adherence to regulations.

Keywords: Non-compliance, fishing regulations, randomized response technique, TURF, Vietnam.

JEL Codes: Q22, Q28, D63

1. Introduction

Small-scale fisheries (SSFs) support the livelihoods of many coastal communities worldwide, especially in low-income and food-deficit countries. However, SSF often face overexploitation, which is further increased by the prevalence of illegal fishing, which is defined as the intentional disregard of fishery regulations (Battista et al., 2018). Illegal fishing threatens the effective conservation of marine resources, and is linked to depletion of stocks, habitat destruction, and failure of fisheries management policies (Mackay et al., 2020; Song et al., 2020), as well as detrimental social-ecological impacts, causing mistrust and tension among resource users, regulators, policymakers, and the public, further undermining fishery conservation efforts (Lewis, 2015).

To address the problems related to overexploitation of the SSFs, rights-based fisheries co-management tools such as the Territorial Use Rights for Fisheries (TURFs) have been applied and have experienced worldwide proliferation over the last decade (D'Armengol et al., 2018). TURFs provide individuals or groups of fishers with clearly defined property rights, such as access privileges and fishing rights to exploit resources within a designated area that secure fisher's long-term stake in the fisheries, encouraging stewardship incentives and sustainability of the resources (D'Armengol et al., 2018). Unfortunately, illegal fishing is still a central challenge facing the TURF system (Andrachuk et al., 2019; Oyanedel et al., 2018; Thanh et al., 2021a, 2021b), and can undermine the potential of user-right programs. This has led to an increased research focus on knowledge and understanding of fishers' non-compliant behavior with TURF regulations, with the underlying premise that a reduction in non-compliance can be achieved by manipulating factors that favor compliant behavior (Oyanedel et al., 2020a, 2020b). However, poaching is a many-sided phenomenon that cannot be solved using standardized measures; each case should be studied individually, and adaptive actions should be drawn up and implemented accordingly (Ballesteros et al., 2021; Desdner et al., 2015). Based on this premise, we carried out a study focusing on the determinants of non-compliance among the artisanal fishers in Tam Giang Lagoon, Vietnam, where illegal fishing has persisted despite a TURF system established in 2009 (Andrachuk et al., 2019; Thanh et al., 2021a, 2021b).

Co-managed TURF systems offer promise for sustainable small-scale fisheries management; however, the efficacy of this management system is influenced by its overall institutional design and implementation, or in other words, the robustness of institutions (Andrachuk et al., 2019). To evaluate the robustness of the institutions introduced by co-management systems, the conditions identified in Elinor Ostrom's (1990) seminal work, such as the eight principles for the design of

robust institutions, are ideal (Quynh et al., 2020). The degree of institutional robustness corresponds to the degree of adherence to these design principles. Although adherence to the design principles is not necessary to create successful co-management systems, conformity to these principles enhances the likelihood of success (Becker & Ostrom, 1995). Quynh et al. (2020), therefore, employed Ostrom's design principles to examine the robustness of the institutions introduced by TURF systems in artisanal fishing communities in the Tam Giang lagoon, Vietnam. Their findings show that TURF institutions do not fully satisfy Ostrom's institutional design principles, thereby weakening the institutions provided by TURFs and reducing fisheries sustainability. While fishers have noted improvements in fish stocks, the recovery process remains slow (Ho et al., 2016; Quynh et al., 2020; Thanh et al., 2021a). This substandard institutional framework provided by TURFs is considered one of the main reasons for the prevalent illegal fishing activity in the community (Andrachuk et al., 2019; Ho et al., 2016; Quynh et al., 2018; Quynh et al., 2020; Thanh et al., 2021a).

There are many studies regarding the consequence of non-compliance with fishing regulations on fishery livelihoods, as well as effective monitoring and institution related to illegal fishing in Vietnam (Dang et al., 2017; Ha & van Dijk, 2013; Ho & Ngo, 2023; Quynh et al., 2018a; 2018b), yet we have not succeeded in identifying any research focusing on the determinants of fisher's non-compliance with fishing regulations there. A better understanding of what drives fishers' non-compliant behaviors in Tam Giang Lagoon, Vietnam can be used to inform and guide targeted interventions to combat illegal fishing in this area, and potentially also elsewhere. The Tam Giang Lagoon has a long history of human utilization and is a vital source of food security and livelihoods for local communities. However, it has experienced significant resource degradation due to overfishing that is further impacted by the prevalence of illegal fishing, negatively affecting the

livelihoods of local villagers (Andrachuk et al., 2019; Andrachuk & Armitage, 2015; Thanh et al., 2021a, 2021b). A reduction in illegal fishing, and increased fisher's compliance with regulations, can help to enhance livelihoods in the sector, thus contribute to food security (Mackay et al., 2020). When studying illegal fishing, research has often suffered from biased results generated from social desirability bias, e.g., respondents may provide socially acceptable answers rather than their true responses (Boruch, 1971; Hox & Lensvelt-Mulders, 2004; Nuno & St. John, 2014; Warner, 1965). One method that is suggested as a viable option to overcome this bias and produce robust estimates of illegal activities in natural resource utilizatiom is the randomized response technique (RRT) and its variations (Ibbett et al., 2022). Even though the RRT has been widely used to analyze illegal behaviors related to natural resource use across various contexts (such as illegal hunting of wildlife, breaches of fishing regulations, consumption of wildlife, and illegal extraction of natural resources from protected areas), in fisheries its application is rather modest. Particularly, the majority of these studies are related to illegal recreational fisheries (Arias & Sutton, 2013; Blank & Gavin, 2009; Bova et al., 2018; Lewis, 2015; Thomas et al., 2014), commercial fisheries application with exceptions of Oyanedel et al. (2018; 2020b). The RRT involves a questioning technique where the respondent, using dice, is told to answer yes, no, or truthfully (yes or no) for set numbers appearing on the dice. This technique allows a posterior analysis of probable truthful answers while helping to protect the secrecy of individual responses. We therefore used both approaches, the RRT and direct questions to investigate illegal fishing behavior and estimate the proportion of fishers involved in illegal activities within the TURF system in central Vietnam – the Tam Giang Lagoon. In this study, we use the RRT to check how truthful the answers to the direct questions are, e.g., comparing the proportion of fishers involved in illegal activities derived from the RRT with that estimate from the direct questioning data, which was then used as the

response variable for our compliance regression models, to determine the drivers of fishers' compliant behavior.

This study contributes to the current knowledge on (non)compliance with fisheries regulations worldwide, focusing on TURF regulations, a compliance application that is scarce in the literature (see Oyanedel et al., 2018). As showed in Ibbett et al. (2022) when responses to sensitive questions are required, RRT outperforms direct questions in terms of reducing sensitivity bias, though questions asked using RRT are often refused to answer by respondents compared with direct questions, as RRT is harder to understand. Because of the complexities of measuring illegal fishing behaviors (Bova et al., 2024), a combination of the two methods, the RRT and direct questioning, as used in this paper, is considered the most effective way to study this complex issue. Also, the application of the RRT to examine illegal fishing behavior is much less studied in developing country contexts, and commercial fisheries are hardly studied at all (Arias & Sutton, 2013; Blank & Gavin, 2009; Bova et al., 2018; Lewis, 2015; Oyanedel et al., 2018; 2020b; Thomas et al., 2014). This is the first attempt to investigate the level of fishers' stated non-compliance with fishing regulations in Asia as well as factors affecting fishers' non-compliance. The results of our study have the potential to enhance understanding of the relationship between compliance and its drivers, which in turn may provide policymakers with insights into improving management policies regarding compliance with TURF regulations in Vietnam and otherwise where there are similar fisheries.

The remaining content of the paper is structured as follows. Section 2 presents materials (background information on the study and survey design) and methods used in the analysis. Section 3 presents and discusses the main findings. Section 4 concludes the paper by providing some implications for managing compliance with TURF regulations.

2. Materials and methods

2.1. Study area

Tam Giang Lagoon is located in Thua Thien Hue province in central Vietnam. It is the largest lagoon in Southeast Asia with 22,000 ha of water along 70 km of coastline and comprises a series of four lagoons including the Tam Giang, Sam Chuon, Ha Trung-Thuy Tu, and the Cau Hai areas (see Figure 1). The lagoon system has a unique brackish water ecosystem with a diversity of aquatic species including both freshwater and saline water species (Marschke et al., 2012; Thung, 2007). About 300,000 people are living in this area, of which approximately one-third depend directly on the lagoon resources, e.g., aquaculture and capture fisheries (Quynh et al., 2018b; Van Tuyen et al., 2010).

Despite the normal understanding that "farmland is private and water area is open", the Tam Giang Lagoon is not totally open access, but rather includes types of both common and private property (e.g., mobile fishing gear groups vs. fixed fishing gear groups). While fixed gear (fish corrals) fishers acquire long-term fishing ground rights of use (e.g., though fish corrals can be transferred intergenerationally, the rights to them are not alienable), mobile gear fishers are not allowed to fish at the mouth of fish corrals and can only access open areas of the lagoon, which can be seen as a form of common property (Huong & Berkes, 2011).[1] Due to the management of the lagoon as an open access area with poorly defined property rights, the levels of exploitation have been difficult to control, leading to significantly diminished fish stocks and catch yield in the last four decades, threatening fishers' livelihoods (Andrachuk et al., 2019; Huong & Berkes, 2011), e.g.,

annual catch was 4,500 tons per year in the 1970s, but has roughly been halved since the 1980s; and annual fish catch per household reduced from 2,700 kilograms in 1999 to 700 kilogram in 2008 (Thanh et al., 2020, 2021b). In response, local authorities established Fisheries Associations (FAs) in 2005, recognized local community-based organizations designed for building co-management mechanisms at the commune levels. FAs have played an important role in the lagoon's resource management activities as well as a reduction in the illegal fishing activities within the areas, i.e., via patrolling. A further step aiming to ensure that property rights are well-defined was the introduction of Territorial Use Rights for Fisheries (TURFs) to the lagoon in 2009 (Ho et al., 2015). Today, two-thirds of the lagoon area has been allocated to FAs for co-management, with more than half of the FAs (49 out of 83) granted TURF rights (Quynh et al., 2018b).

Membership in the FAs is not restricted to village/commune residents, as others can join the FA as long as they comply with the regulations and pay a registration fee, though access rights are limited to FA members, which vary from 50 to 220 fishers in each (Quynh et al., 2018b). Each FA now has its own regulations, based on provincial fishery regulations, to manage the use of gears, monitoring activities, and social disputes associated with fishing activities within its designed area (Thanh et al., 2021a). TURF regulations are related to entry limitations, fishing gear restrictions such as size and number of bottom traps and fish corrals and mesh net size requirements (not smaller than 18 mm), forbidden destructive fishing gears such as electric fishing, combined electric-seine fishing, motorized push-net, and mollusk/ eel rake, as well as prohibition of fishing in the protected areas (Huong & Berkes, 2011; Quynh et al., 2020).[2] Fishers, including FA members and non-FA members, that fail to comply with TURF regulations are considered to be poachers. The most common illegal activities involve using destructive fishing gear, fishing in the

protected area, using nets with smaller mesh sizes than the requirement, or a greater number of bottom traps than stipulated in TURF regulations (Quynh et al., 2018b).

Although positive social and ecological outcomes have been recorded in some parts of the lagoon since the adoption of the TURF (Ho et al., 2016; Pomeroy, 2013), the problem of illegal fishing is a big concern for maintaining such outcomes in the long-term, hence achieving fisher compliance with the TURF regulations is of critical importance to the sustainability of the lagoon fisheries.

Figure 1 here

2.2. Methods

2.2.1. Sampling

The questionnaire consisted of four parts. Assessment of engagement in illegal fishing using RRT and direct questions was addressed in the first part. The second part focused on fishers' perceptions related to the motivation of compliance, and the interventions to achieve compliance with regulations, while fisher's pro-environmental attitude was investigated in the third part. The survey ended with some questions about fishers' socio-demographic characteristics. Before starting the survey, we informed respondents that the survey was voluntary and that they could refuse to participate or answer any question.

The study was conducted in three fishing villages represented by three FAs (i.e., Cu Lac, Ha Cong, and Ngu My Thanh) in Quang Loi commune, Quang Dien District, Thua Thien Hue province, Vietnam (see Figure 1). An informal group discussion was organized with four people including representatives of local authorities and the FA's leader. A formal focus group was then organized with the participation of ten household representatives, invited by the FA's leader, in Ngu My

Thanh village. A pilot test was conducted with 50 volunteer fishers from Ngu My Thanh village. Face-to-face interviews were conducted in January 2024 with 292 fishers from three fishing villages in Quang Loi commune, Quang Dien District, Thua Thien Hue province, Vietnam (see Figure 1). These villages (Cu Lac, Ha Cong, and Ngu My Thanh) are represented by three Fishery Associations (FAs) that exercise Territorial Use Rights in Fisheries (TURFs). FA leaders supported the survey administration by informing villagers about its purpose, content, and volunteer participation opportunities. Descriptive statistics of the sample are provided in Table 1. A slight majority of respondents were female (56%), on average 50 years old, and with low education (4 years of school on average). It is relevant to note that women play a crucial role in fisheries in the Tam Giang lagoon, given the traditional fishing practices in this area. For instance, in terms of fishing with mobile gear fishing, women actively work with their husbands on the lagoon. For other types of fishing such as push-net and clam collection, women work alone. Though women participate to a lesser degree than men in fixed gear fishing such as fish corrals, e.g., they do assist their husbands in harvesting fish and driving the boat (Lan et al., 2002). Many of the fishers surveyed owned more than one type of fishing gear. The most popular fishing gear were Chinese fish traps (86%) and gillnet (53%) – types of mobile gear, and fish corrals – a type of fixed gear (27%). Photos of fish corrals and Chinese fish traps are provided in Figures 2 and 3, respectively. The Chinese fish trap originated in China with a popular mesh size in the range of 4-6 mm, which can be used to catch very small species, and is considered a significant cause of resource depletion in the lagoon (Nhung, 2015), although exceptions of modified Chinese fish traps with bigger mesh sizes do exist. Fishers in the three surveyed villages do not express the use of destructive methods such as electro-fishing, combined-electric seine fishing, and mollusk/eel rake, though the use of nets with a mesh size smaller than 18mm is quite popular there despite it

being a violation of the fishing regulations. The discrepancy between the adherence to destructive fishing rules and the non-compliance with the net mesh size regulations in the Tam Giang lagoon can be attributed to several key factors: 1) perceived impact: fishers have a clear understanding of the immediate and severe consequences of destructive fishing methods on the ecosystem and fish stocks, whereas the impacts of using small mesh size nets are less obvious (Thanh et al., 2021a); 2) economic incentives: using small mesh size nets help fishers increase their catches to secure their livelihoods (Ho et al., 2016; Quynh et al., 2018); 3) lack of consensus and legitimacy: fishers might feel that the mesh size regulations are unsuitable for local conditions, as they do not reflect reality or consider the diversity of fish species (Ho et al., 2015; Quynh et al., 2018); and 4) inadequate enforcement mechanisms: while the violations of destructive fishing rules are strictly enforced through fines, equipment confiscation, and possible criminal charges, violations of mesh size regulations face no punishment (current local government efforts to restrict the use of illegal mesh sizes are purely informative, without any sanctions/punishments for violations.

Table 1 here

Figure 2 here

Figure 3 here

2.2.2. Models

Because non-compliance with fishing regulations is a sensitive topic, we used the RRT technique as well as direct questions to estimate the proportion of respondents engaged in illegal fishing in the lagoon. The RRT is suggested as the most statistically efficient design (Hox & Lensvelt-Mulders, 2004; Nuno & St. John, 2014) and has been applied widely to rule-breaking related to conservation (Oyanedel et al., 2018; Thomas et al., 2014). In our survey, the questions related to

illegal fishing behavior were asked using both the RRT and direct method. For the RRT, respondents were asked to answer three questions: (1) In the past year, have you ever fished illegally, using destructive fishing gears such as electric fishing gear, electric lagoon seine, motorized push-net, and/or mollusk/eel rake?; (2) In the past year, have you ever fished in areas where you are not allowed to fish (e.g., protected areas)?; and (3) In the past year, have you ever fished illegally, used nets with mesh size smaller than the requirement (<18mm in diameter)?. This was a type of yes/no question. In the forced-response design, respondents are instructed to either: respond to a sensitive question truthfully (answering yes or no) or to give a prescribed yes or no answer via the use of a randomizing device (i.e., dice). For instance, respondents were provided with a dice and a questionnaire consisting of the sensitive questions each displaying the instructions (see Figure S1 in the Appendix for an instruction example of the RRT question used in the survey). They were asked to roll a die before answering each question, facing away from the enumerator, and privately observe the outcome. In this way, it was not possible to know their real answers, so their privacy was fully protected. The die has 6 sides, one side has the word "Yes", one side has word "No", and the four other sides are blank. According to the side that appears when respondents rolled the die, they were asked to provide the following answers. If the die lands on "Yes" (probability = 0.167) respondent's answer was "Yes", on "No" (probability = 0.167) respondent's answer was "No", and on "blank" (probability = 0.667) respondent was asked to answer the question truthfully. The proportion of each sensitive behavior is calculated as follows (Hox & Lensvelt-Mulders, 2004; Nuno & St. John, 2014):

$$\pi = \frac{\lambda - \theta}{s} \qquad (1)$$

where π is the estimated proportion of the sample who have undertaken the illegal behavior, λ is the proportion of all responses in the sample that are "Yes", θ is the probability of the answer being a 'forced yes', s is the probability of having to answer the sensitive question truthfully.

Following the sensitive question using the RRT design, respondents were asked two non-sensitive questions to expose their level of comfort when answering the sensitive questions[3]: (1) Did you feel comfortable in answering truthfully to this mode of questioning? and (2) How comfortable do you believe your colleagues would be in answering truthfully to this mode of questioning?. The levels of comfort ranged from 1 (very uncomfortable) to 4 (very comfortable). Subsequently, the direct question regarding illegal fishing was asked to identify what illegal fishing activity was taken by fishers: In the past year, what type of illegal fishing activities, shown below, have you carried out? (several activities could be chosen). The categories of the answer included: (1) used destructive fishing gears (e.g., electric fishing gear, electric lagoon seine, motorized push-net, and mollusk/eel rake), (2) fished in areas where you are not allowed to fish (e.g., protected areas), (3) used illegal mesh size nets (<18mm in diameter), and (4) none of these.

To understand factors influencing fisher's compliance with the TURF regulations, we ran a binary logistic regression model of non-compliance responses as a function of the individual motivations for compliance in addition to fisher characteristics. The binary logistic regression model is specified as follows:

$$Y_i = \alpha + \beta X_i + \varepsilon_i \qquad (2)$$

where, Y_i is the dependent variable identified via a direct question of illegal behavior, equaling to one if the fisher violates the regulations; otherwise, the variable has a value of zero. α is the intercept term and ε is the error term. β is a vector of parameters corresponding to the independent variables, X_i.

Individual motivations for compliance used in our study were adapted from (Oyanedel et al., 2020b) with adjustments, consisting of three components: instrumental incentives, norms and legitimacy. These components were assessed using a Likert scale to measure agreement/disagreement with two to five statements per component for each type of TURF regulation. We framed statements so that agreement meant fishers perceived the statement as a motivation for compliance with regulations (see Table S1 in Appendix). Principal component analysis (PCA) was used to check the latent structure in the data and estimate a composite index representing complex multidimensional variables with fewer principal components (PCs) (Hotelling, 1933; Jackson, 2005). In this study, we used a weighted average of the PCs with eigenvalues greater than 1 where the share of the total variance is used as weights in the aggregation of the PCs (Heshmati & Rashidghalam, 2020).[4] Although the first PC in the legitimacy variable has a variance of 2.03, explaining 41% of the total variance, all five indicators contributed in constructing the composite index with an eigenvector greater than the threshold of 0.37, thus the relevance of 5 indicators is confirmed (Heshmati & Rashidghalam, 2020), see Table 2S and Table 3S (in the Appendix) for details of the results from the PCA.

3. Results and discussion

To estimate the proportion of respondents engaged in illegal fishing, we used both techniques: RRT and direct questions. Figure 4 shows the estimated proportion of each illegal activity taken by respondents. The two illegal activities, fishing using destructive gears and fishing in the protected areas, had very low shares of non-compliance in both RRT and direct questions, while the estimate of non-compliance for the use of nets with mesh size smaller than the requirement

were high (e.g., 54.5% for the RRT and 56.8% for the direct).[5] Additionally, estimates of the proportion of noncompliant fishers from direct question falls within the 95% confidence interval using the RRT technique (e.g., for fishing with illegal mesh size net: RRT = 54.5% [95%CI = [48.7; 60.2]], direct = 56.8%), suggesting fishers answered the question honestly. In addition, when respondents were asked whether they felt comfortable answering truthfully using the RRT, 84% of respondents indicated they were very comfortable and also believed their colleagues had the same feelings answering the questions using the RRT (see Figure 5). Therefore, we used direct question data regarding the use of nets with mesh size smaller than the requirement as the response variable for our compliance regression model.

Figure 4 here

Figure 5 here

The descriptions of dependent and latent independent variables used in the regression of the binary logistic model are provided in Table 2, and model estimation are presented in Table 3 showing the key determinants of fisher non-compliant behavior regarding mesh-size regulation. Our results underline that fisher awareness of the consequences of illegal fishing (e.g., overfishing in the lagoon such as stock degradation, increased competition among resource users, and reduced fish catch) has positive effects on the likelihood of compliance. A similar result was also indicated in Quynh et al. (2018a) where fishers who rely on fishing for a livelihood were most likely to be aware of consequences of illegal fishing which had a positive impact on the likelihood of their participation in monitoring for more sustainable fishing in the lagoon. The perceived legitimacy of regulations is another important determinant significantly influencing the likelihood of compliance, e.g., fishers with higher perception of management legitimacy are less likely to violate

the mesh-size regulations. This indicates that through participation in decision-making processes (e.g., in the design of management plans) fishers learn about the aims of the TURF system and the consequences of illegal activities, and this in turn creates institutional acceptance motivating fishers to comply with input restrictions and tends to adjust their fishing behavior to reduce pressure on fish stocks (Andrachuk et al., 2019; Quynh et al., 2018b). When fishers consider that the institutional framework is legitimate, they will more likely comply with the regulations (Dresdner et al., 2015; Viteri & Chávez, 2007).

Unexpectedly, we found that neither social norms nor instrumental incentives had a statistically significant effect on fishers' compliance with mesh-size regulations. This finding contradicts much of the existing literature on illegal fishing, which typically finds that fishers facing a lower risk of detection are more likely to violate regulations, while social norms promote compliance (Bisack & Das, 2015; Bova et al., 2017; Dresdner et al., 2015). However, our results warrant careful interpretation. First, norms are defined as collective awareness of preferred, appropriate behavior within a group (Chung & Rimal, 2016). In our case study, the widespread use of illegal mesh-size nets within the community may normalize this activity, making it appear to be only rational behavior, as individual fishers expect others to do the same. As Hatcher et al. (2000) and Bova et al. (2017) suggest, fishers who perceive widespread non-compliance among their peers are more likely to be non-compliant themselves, even when aware of the negative consequences. This conformity incentive can be particularly strong in contexts of resource scarcity and precarious livelihoods. Consequently, despite recognizing the negative stock externality and the mesh-size limitations imposed by the provincial government, fishers may persist in using illegal nets to catch more fish and secure their livelihoods (Andrachuk et al., 2019; Quynh et al., 2018b; Thanh et al., 2021a). Second, the lack of effective enforcement mechanisms (e.g., legal penalties and strict

regulations) not only hinders the implementation of fishing regulations but also signals that using illegal mesh-size nets is acceptable. This can create a situation where non-compliance becomes the norm, and those who follow the rules are penalized, at least through missed opportunities compared to "positive deviants" As Quynh et al. (2018a) indicate, the perception that rule violators profit unfairly (while compliant fishers lose out) can discourage compliance. Currently, enforcement in Tam Giang lagoon focuses on destructive gears (e.g., electro-fishing, combined electric-seine, motorized push-net, and mollusk/ eel rake) and fishing in the protected areas, while neglecting the control of illegal mesh-size nets. Local government efforts regarding illegal mesh sizes are limited to information campaigns without sanctions or punishments, effectively removing any deterrent. Our data set and other studies on fishery management in Tam Giang lagoon confirm the widespread use of illegal mesh-size nets among fishers in the three surveyed villages and other areas of the lagoon (Andrachuk et al., 2019; Quynh et al., 2018b; Thanh et al., 2021a).

The results for individual fisher characteristics showed that age was a determinant of non-compliance with mesh size regulations. While this aligns with other studies, the literature shows mixed effects of age on non-compliance. Some studies suggest that older fishers are more likely to break the rules (Dimech et al., 2009; Silva et al., 2021), while others, including our study and Akpalu & Normanyo (2014), found younger fishers to be potentially less compliant. Fishers with higher education were less likely to violate regulations, while fishing experience positively influenced non-compliance, for instance, the more fishing experience the higher the potential for regulation violations. Regarding gender differences, while some studies indicate greater compliance among female fishers (Brick et al., 2012; Revollo-Fernández et al., 2016) and others note stronger support for conservasion regulations among male fishers (Schroeder et al., 2006), our study found no statistically significant gender differences in non-compliant behavior. Also,

neither the number of household members nor additional non-fishing income sources showed a statistically significant influence on fishers' non-compliance.

Table 2 here

Table 3 here

4. Conclusion and Policy implications

Overfishing and destructive fishing practices can severely deplete fish stocks, threatening the long-term health of aquatic ecosystems and the livelihoods of those who depend on them (Battista et al., 2018; Mackay et al., 2020; Song et al., 2020). Effective fisheries management relies on regulations (Andrachuk et al., 2019; D'Armengol et al., 2018). Hence, understanding why fishers comply or don't comply with regulations is crucial for two reasons: (1) it informs the development of effective strategies to promote adherence to the regulations, ensuring sustainable fishing practices and conserving fish populations, and (2) it identifies the weaknesses in existing regulations and enforcement, enabling improvements for better management outcomes. This study empirically investigates the proportion of fishers engaged in illegal fishing activities using both the RRT and direct questioning methods, as well as determining the drivers of non-compliance using binary logistic models, applied to the artisanal fishery of Vietnam's Tam Giang lagoon. In this lagoon, where TURFs have been established since 2009, illegal fishing poses a significant threat to the TURF program (Andrachuk et al., 2019; Thanh et al., 2021a, 2021b). Our findings offer evidence-based insights applicable not only to the co-managed fisheries of the Tam Giang lagoon but potentially to other regions with similar regulatory frameworks, thus contributing to broader fishery management and policy-making.

In the literature on compliance with conservation rules, most studies using RRT have revealed higher rates of non-compliance compared to direct questioning methods (Blank & Gavin, 2009; Ibbett et al., 2022), while our results align with Oyanedel et al. (2020b) showing no statistically significant differences between the proportions of fishers involved in illegal fishing activities calculated using either the RRT or direct questioning methods. Particularly, the use of destructive gears (e.g., electric fishing, combined electric-seine fishing, and mollusk/ eel rake) seems to have largely disappeared in the three surveyed fishing villages. However, the proportion of fishers using illegal mesh-size gear remains high (i.e., 56.8% according to direct questioning). The 43.2% who comply with mesh size regulations are primarily motivated by their perception of the regulation's legitimacy and their awareness of illegal fishing's negative impacts on the environment, natural resources, and consequently, their livelihoods. The similarity between the results using the two approaches may be due to limitations with the method, as discussed by Ibbett et al. (2022). However, the similarity may also be a function of community acceptance for the specific kind of illegal behavior. This latter reason may clearly impact on the potential success of management measures aimed at reducing the use of illegal mesh size. Here there may be lessons learned from how reduction in use of destructive fishing gear was achieved, largely involving the implementation of strict punishments (REF).

While our study considers fishers' awareness of illegal fishing impacts primarily in terms of environmental and natural resource consequences, future research could benefit from a broader understanding encompassing multiple perspectives to strengthen awareness programs and enforcement strategies. These perspectives can be categorized into three dimensions: 1) individual short-term benefits, such as immediate increases in catch volume and higher profits; 2) collective long-term impacts, including fish stock depletion, ecosystem disruption, biodiversity loss,

community-wide economic losses, and reduced fishing opportunities for future generations; and 3) personal consequences of being caught, comprising both formal punishments (financial penalties, gear confiscation, license revocation, and legal prosecution) and loss of reputation within fishing communities.

The persistence of using illegal mesh-size nets has increased the fish stock degradation in the lagoon (e.g., the reduction in fish size and fish catch is observed in the common areas), while the improvement in size and catch of fish is observed in some areas protected from fishing and in the privatized areas where many fish corrals (50% approximately) were removed under the regulations of the number of gear households can use (Ho et al., 2016; Thanh et al., 2021a). Our observed data show that fishers know of the decline in fish stock and fish catch (e.g., 77% of respondents agreed with the statement showing that Illegal fishing has exacerbated the problem of overfishing in the lagoon such as stock degradation, increased competition among resource users, and reduced fish catch), although many of them insisted they would continue fishing with illegal nets due to the limited livelihood alternatives and the needs of daily life.[6] The continuing use of illegal mesh size nets in the lagoon can be attributed to inadequate mechanisms for punishing the violators. However, controlling the use of this type of net is a complex issue due to potential negative impact on a large proportion of fishers' livelihoods, e.g., most of fishers in the lagoon (more than two-thirds of fishers) are using this type of fishing gear, and many of them have poor living conditions (Ho et al., 2016). Rates of poverty in communities around the lagoon are high, especially among fishing households. Additionally, fishing communities in the lagoon have a higher poverty rate (10.3%) compared to the provincial (7.2%) and national (9.1%) averages (Thanh et al., 2021a). Nevertheless, it is time to halt the use of nets with illegal mesh size in the lagoon as they catch

even the smallest fish, leading to degradation in the lagoon and potentially the depletion of some species shortly.

In the case of our study, instrumental incentives and norms seem to have little effect the compliance with mesh size regulation.[7] However, economic models of fishing regulatory compliance in the literature usually assume an instrumental determination of fisher behavior in which the decision to comply or to violate depends primarily on the expected monetary costs and benefits (Becker, 1968; Oyanedel et al., 2020b; Thomas et al., 2016). Therefore, compliance with mesh size regulation in the lagoon can be improved through the effective implementation of measures regarding instrumental incentives. For instance, management strategies should be focused on deterrence by increasing the expected monetary costs of violation, thus incentivizing compliance through increasing fines as well as the probability of being caught and sanctioned. Moreover, given that this type of illegal fishing has appeared due to socio-economic challenges, economic policies aimed at reducing poverty and unemployment in fishing communities in the lagoon, could be expected to have a positive impact on reducing this type of poaching. It was indicated that place-based resource users tend to pursue more sustainable practices, however place-based attachments may become barriers preventing transitions to sustainable pathways when opportunities for income diversification are scarce (Thanh et al., 2021a). Eco-tourism and community-based tourism are suggested to be promising livelihood alternatives in the Tam Giang lagoon. Uy et al. (2021) showed that ecotourism in Tam Giang lagoon improves household incomes and increases community participation in lagoon environmental protection. However, engaging in alternative livelihoods, such as ecotourism, can be challenging for small-scale fishing due to various socioeconomic factors, including the lack of skills and alternative income opportunities (Hanh & Boonstra, 2019). Currently, tourism business in the lagoon is rather ad hoc,

operated by villagers who have inadequate capacities (e.g., knowledge and skills in the tourism sector, and capital to invest in accommodation facilities) to enable sustainable tourism development (Thanh et al., 2021a). Therefore, improvements in education and labor skills, as well as the creation of alternative jobs, are necessary for encouraging villagers to engage in alternative livelihoods (Hanh & Boonstra, 2019). This highlights the important role of the provincial government in supporting and guiding fishers to participate in emerging industries such as ecotourism and community-based tourism. For instance, the plan of tourism destinations to minimize undesirable side effects and increase the variety of offerings to attract visitors could be designed and provided to the villagers as a guidance for the destinations. Some training courses related to management and operation of tourism activities could be provided for the villagers. The provincial government could also support villagers to develop strategies regarding advertisement and promotion of tourism destinations to domestic and international tourists. Additionally, strategies to attract investments in developing ecotourism infrastructure and facilities, as well as the legal corridor for these investments, could help the sustainable village development.

It is also necessary to promote awareness campaigns among fishers about the dangers to future fish stocks of harvesting large quantities of small fish through the use of illegal nets. Given the positive impact of education on compliance, but the low education level of fishers in the lagoon (e.g., on average 4 years in school in the sample vs. 9.1 and 8.4 years in national and provincial statistics, respectively (GSO, 2022))[8], it is essential to offer programs providing information and education towards sustainable fisheries management. Efforts should also be directed towards enhancing fishers' perception of the legitimacy of the rules to promote fisher compliance with the mesh size regulations. For instance, fisher part-taking in decision-making processes where they not only participate by listening but also are allowed more say in the way in which management is

designed and implemented, will improve levels of compliance with regulations (Quynh et al., 2020).

Despite the absence of the use of destructive fishing gears in the three surveyed villages the persistence of this type of gear has been recorded anecdotally in which the offenders come from outside of the lagoon communities, but it has been very difficult to enforce fishing rights due to several reasons. Firstly, violators often have faster boats while FAs largely use fisher's boats that have low speed to chase the violators, thus, in most cases, they could not catch the violators (Ho et al., 2016). Once the violators leave an FA's zone, a local patrol team does not have authority for enforcement in other zones. Secondly, in principle, FAs conduct monitoring while communal governments, such as the Commune People's Committee (CPC), handle the apprehension and punishment of poachers. However, lax enforcement (e.g., inadequate sanctions and taking bribes from the violators) has limited its effectiveness in deterring illegal fishing activities (Ho et al.,2016; Quynh et al., 2020). Thirdly, fishers in the FAs face the risk of reprisal from violators who can physically attack them, destroy their property (e.g., vessels and fish corrals), threaten their families, while there are no official policies and measures to protect fishers in these situations (Ho et al.,2016; Thanh et al., 2021a). Fourthly, while fisher participation in monitoring plays a crucial role in improving regulation enforcement, low levels of fisher engagement have been recorded in monitoring due to the lack of financial incentive. E.g., currently fisher participation in monitoring is voluntary and there is no financial remuneration for their work, and no official protection from violator reprisals (Quynh et al., 2018b). Therefore, to reduce poaching from outsiders, policymakers should pay attention to strategies with better FA-FA coordination and communication, as well as to encourage fishers willing to be involved in lagoon management (e.g., mutual monitoring and patrolling), safely and effectively (Andrachuk et al., 2019; Ho et al., 2016).

The collaboration between FAs and government entities needs to improve to enhance the effectiveness of sanctioning and stopping violators from outside the lagoon communities (Ho et al., 2016; Quynh et al., 2020).

In conclusion, our research provides valuable insights into the determinants of non-compliance with fishing regulations, although we acknowledge certain limitations in our methodology. While we employed quantitative methods in our analysis, the voluntary nature of our survey participation suggests that additional research would be beneficial to verify whether these findings are representative of the broader fishing community.

Acknowledgments: This work has received funding from the Swedish International Development Cooperation Agency (Sida) through the Environment for Development Initiative (EfD) at the University of Gothenburg under grant agreement No MS-1259. Claire W. Armstrong and Quach Thi Khanh Ngoc acknowledge funding from The Norwegian Agency for Development Cooperation (NORAD, Norway) through NORHED project "Ecosystem-based management of coastal marine resources in Ghana, Indonesia and Vietnam" (ECOGIV).

Footnotes:

1. Fish corrals are the most common and most important fixed fishing gear in Tam Giang Lagoon. These have a V-shape, made from bamboo and fishing nets. There could be several traps within a fish corral (Huong & Berkes, 2011).
2. Destructive fishing activities often lead to overexploitation and habitat degradation. For example, electric fishing and combined electric-seine fishing can stun fish over a wide area, leading to indiscriminate capture and depletion of fish stocks. Additionally, motorized push-nets and mollusk/eel rakes can damage and destroy the lagoon bed habitat. These concerns have prompted local authorities to prohibit the use of these fishing methods to

protect the lagoon's ecosystem, maintain fish stock, and preserve the long-term viability of fishing communities' livelihoods.

3. A survey in which fishers feel comfortable answering questions related to their compliance/non-compliance with regulations would reduce bias thus providing valuable data for estimating the proportion of compliant activity and for designing strategies to achieve compliance.
4. Though the number of indicators regarding the three latent variables are different, there is only one of the eigenvalues in each core PCA that is greater than 1, leading to one PC being considered.
5. The estimated proportion of each illegal activity based on both the Randomized Response Technique (RRT) and direct questioning (e.g., very low shares of non-compliance with the destructive gear use versus a high proportion of illegal mesh size net use) is similar to the descriptive statistics presented in Table 1.
6. Reduced fish catch was also confirmed by Ho et al. (2016) and Thanh et al. (2021a).
7. Instrumental incentives and norms might play an important role in fishers' compliance if they were related to other illegal activities such as electro-fishing and fishing in the protected areas. However, these effects could not be examined in our study due to the low proportions of fishers involved in these two illegal activities.
8. GSO: General Statistics Office of Vietnam. https://www.gso.gov.vn/wp-content/uploads/2022/03/HDI_report_V15-official-version.pdf

Appendix:

In the following, a figure showing an instruction example for the RRT question is presented.

Figure S1 here

Table S1 here

Table S2 here

Table S3 here

References:

Akpalu, W., & Normanyo, A. K. (2014). Illegal fishing and catch potentials among small-scale fishers: Application of an endogenous Switching regression model. *Environment and Development Economics*, *19*(2), 156–172. https://doi.org/10.1017/S1355770X13000478

Andrachuk, M., & Armitage, D. (2015). Understanding social-ecological change and transformation through community perceptions of system identity. *Ecology and Society*, *20*(4). https://doi.org/10.5751/ES-07759-200426

Andrachuk, M., Armitage, D., Hoang, H. D., & Le, N. Van. (2019). A Network Perspective on Spatially Clustered Territorial Use Rights for Fishers (TURFs) in Vietnam. *Coastal Management*, *47*(3), 292–311. https://doi.org/10.1080/08920753.2019.1596677

Arias, A., & Sutton, S. G. (2013). Understanding recreational fishers' compliance with no-take zones in the Great Barrier Reef Marine Park. *Ecology and Society*, *18*(4).

Ballesteros, H. M., Rodríguez-Rodríguez, G., Ferreiro-Seoane, F. J., & Martínez-Cabrera, H. (2021). The Fewer Insider Poachers, the More Normative Compliance: Clues for Managing Poaching in the Shellfish Sector. *Deviant Behavior*, *42*(6), 747–761. https://doi.org/10.1080/01639625.2020.1854635

Battista, W., Romero-Canyas, R., Smith, S. L., Fraire, J., Effron, M., Larson-Konar, D., & Fujita, R. (2018). Behavior change interventions to reduce illegal fishing. *Frontiers in Marine*

Science, *5*(OCT), 1–15. https://doi.org/10.3389/fmars.2018.00403

Becker, G. S. (1968). Crime and Punishment: An Economic Approach. *Journal of Political Econom*, *76*, 169–217.

Becker, C. D., & Ostrom, E. (1995). Human ecology and resource sustainability: the importance of institutional diversity. *Annual review of ecology and systematics*, *26*(1), 113-133.

Bisack, K. D., & Das, C. (2015). Understanding non-compliance with protected species regulations in the northeast USA gillnet fishery. *Frontiers in Marine Science*, *2*(NOV), 1–11. https://doi.org/10.3389/fmars.2015.00091

Blank, S. G., & Gavin, M. C. (2009). The randomized response technique as a tool for estimating non-compliance rates in fisheries: A case study of illegal red abalone (Haliotis rufescens) fishing in Northern California. *Environmental Conservation*, *36*(2), 112–119. https://doi.org/10.1017/S037689290999004X

Boruch, R. F. (1971). Assuring Confidentiality of Responses in Social Research: A Note on Strategies. *The American Sociologist*, *6*(4), 308–311.

Bova, C. S., Halse, S. J., Aswani, S., & Potts, W. M. (2017). Assessing a social norms approach for improving recreational fisheries compliance. *Fisheries Management and Ecology*, *24*(2), 117–125. https://doi.org/10.1111/fme.12218.

Bova, C. S., Aswani, S., Farthing, M. W., & Potts, W. M. (2018). Limitations of the random response technique and a call to implement the ballot box method for estimating recreational angler compliance using surveys. *Fisheries Research*, *208*, 34-41.

Bova, C. S., Potts, W. M., Radford, Z., Schiefer, P., & Hyder, K. (2024). Tools for assessing recreational fisheries compliance—an underappreciated yet essential component of management. *Reviews in Fish Biology and Fisheries*, 1-22.

Brick, K., Visser, M., & Burns, J. (2012). Risk aversion: Experimental evidence from South African fishing communities. *American Journal of Agricultural Economics*, *94*(1), 133-152.

Cepić, D., & Nunan, F. (2017). Justifying non-compliance: The morality of illegalities in small scale fisheries of Lake Victoria, East Africa. *Marine Policy*, *86*(September), 104–110. https://doi.org/10.1016/j.marpol.2017.09.018

Chung, A., & Rimal, R. N. (2016). Social norms: A review. *Review of Communication Research*, *4*, 01-28.

D'Armengol, L., Prieto Castillo, M., Ruiz-Mallén, I., & Corbera, E. (2018). A systematic review of co-managed small-scale fisheries: Social diversity and adaptive management improve outcomes. *Global Environmental Change*, *52*(July), 212–225. https://doi.org/10.1016/j.gloenvcha.2018.07.009

Dang, N. B., Momtaz, S., Zimmerman, K., & Hong Nhung, P. T. (2017). Effectiveness of formal institutions in managing marine fisheries for sustainable fisheries development: A case study of a coastal commune in Vietnam. *Ocean and Coastal Management*, *137*, 175–184. https://doi.org/10.1016/j.ocecoaman.2016.12.021

Dimech, M., Darmanin, M., Philip Smith, I., Kaiser, M. J., & Schembri, P. J. (2009). Fishers' perception of a 35-year old exclusive Fisheries Management Zone. *Biological Conservation*, *142*(11), 2691–2702. https://doi.org/10.1016/j.biocon.2009.06.019

Dresdner, J., Chávez, C., & Barriga, O. (2015). Compliance in Artisanal Fisheries: Do Morality, Legitimacy, and Peer Effects Matter? *Marine Resource Economics*, *30*(4), 349–370. https://doi.org/10.1086/682215

Guirkinger, L., Rojas-Perea, S., Ender, I., Ramsden, M., Lenton-Lyons, C., & Geldmann, J. (2021). Motivations for compliance in Peruvian manta ray fisheries. *Marine Policy*,

124(December 2020), 104315. https://doi.org/10.1016/j.marpol.2020.104315

Ha, T. T. P., & van Dijk, H. (2013). Fishery livelihoods and (non-)compliance with fishery regulations-A case study in Ca Mau Province, Mekong Delta, Viet Nam. *Marine Policy*, *38*, 417–427. https://doi.org/10.1016/j.marpol.2012.06.021

Hanh, T. T. H., & Boonstra, W. J. (2019). What prevents small-scale fishing and aquaculture households from engaging in alternative livelihoods? A case study in the Tam Giang lagoon, Viet Nam. *Ocean & Coastal Management*, *182*, 104943.

Hatcher, A., Jaffry, S., Thebaud, O., & Bennett, E. (2000). Normative and social influences affecting compliance with fishery regulations. *Land Economics*, *76*(3), 448–461. https://doi.org/10.2307/3147040

Heshmati, A., & Rashidghalam, M. (2020). Measurement and Analysis of Urban Infrastructure and Its Effects on Urbanization in China. *Journal of Infrastructure Systems*, *26*(1). https://doi.org/10.1061/(asce)is.1943-555x.0000513

Ho, A. N., & Ngo, P. H. (2023). Combating Illegal, Unreported, and Unregulated Fishing: A Vietnamese Perspective. *International Journal of Marine and Coastal Law*, *38*, 1–35. https://doi.org/10.1163/15718085-bja10117

Ho, N. T. T., Ross, H., & Coutts, J. (2015). Power sharing in fisheries co-management in Tam Giang Lagoon, Vietnam. *Marine Policy*, *53*, 171–179. https://doi.org/10.1016/j.marpol.2014.12.006

Ho, N. T. T., Ross, H., & Coutts, J. (2016). Evaluation of social and ecological outcomes of fisheries co-management in Tam Giang Lagoon, Vietnam. *Fisheries Research*, *174*, 151–159. https://doi.org/10.1016/j.fishres.2015.09.013

Hotelling, H. (1933). Analysis of a complex of statistical variables into principal components.

Journal of Educational Psychology, *24*(6), 417.

Hox, J., & Lensvelt-Mulders, G. (2004). Randomized response analysis in Mplus. *Structural Equation Modeling*, *11*(4), 615–620. https://doi.org/10.1207/s15328007sem1104_6

Huong, T. T. T., & Berkes, F. (2011). Diversity of resource use and property rights in Tam Giang Lagoon, Vietnam. *International Journal of the Commons*, *5*(1), 130–149. https://doi.org/10.18352/ijc.236

Ibbett, H., Dorward, L., Dwiyahreni, A. A., Jones, J. P., Kaduma, J., Kohi, E. M., ... & St John, F. A. (2022). Experimental validation of specialized questioning techniques in conservation. *Conservation Biology*, *36*(5), e13908.

Jackson, J. E. (2005). *A user's guide to principal components*. John Wiley & Sons, Ltd.

Jentoft, S. (1989). Fisheries co-management: delegating government responsibility to fishermen's organizations. *Marine Policy*, *13*(2), 137–154.

Lan, N.T.K., Suong, N.T.T., & Thanh, N.T. (2002). Some Gender Aspects of Communities in Tam Giang Lagoon. In *Lessons in resource management from the Tam Giang Lagoon*, ed. Brzeski, V. J., & Newkirk, G. F. CoRR, Dalhousie University, Halifax, NS, CA.

Lewis, S. G. (2015). Bags and tags: Randomized response technique indicates reductions in illegal recreational fishing of red abalone (Haliotis rufescens) in Northern California. *Biological Conservation*, *189*, 72–77. https://doi.org/10.1016/j.biocon.2014.09.024

Mackay, M., Hardesty, B. D., & Wilcox, C. (2020). The Intersection Between Illegal Fishing, Crimes at Sea, and Social Well-Being. *Frontiers in Marine Science*, *7*(October), 1–9. https://doi.org/10.3389/fmars.2020.589000

Marschke, M., Armitage, D., Van An, L., Van Tuyen, T., & Mallee, H. (2012). Do collective property rights make sense? Insights from central Vietnam. *International Journal of the*

Commons, *6*(1), 1. https://doi.org/10.18352/bmgn-lchr.334

Nhung, P. T. H. (2015). *Nhung, P. T. H. (2016). Conflicts over natural resources and environment: a case of Tam Giang lagoon in the Thua Thien Hue province, central coast of Vietnam. A thesis submitted in University of Newcastle* (Issue November).

Nielsen, J. R. (2003). An analytical framework for studying: Compliance and legitimacy in fisheries management. *Marine Policy*, *27*(5), 425–432. https://doi.org/10.1016/S0308-597X(03)00022-8

Nuno, A., & St. John, F. A. V. (2014). How to ask sensitive questions in conservation: A review of specialized questioning techniques. *Biological Conservation*, *189*, 5–15. https://doi.org/10.1016/j.biocon.2014.09.047

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge university press.

Oyanedel, R., Gelcich, S., & Milner-Gulland, E. J. (2020a). A synthesis of (non-)compliance theories with applications to small-scale fisheries research and practice. *Fish and Fisheries*, *21*(6), 1120–1134. https://doi.org/10.1111/faf.12490

Oyanedel, R., Gelcich, S., & Milner-Gulland, E. J. (2020b). Motivations for (non-)compliance with conservation rules by small-scale resource users. *Conservation Letters*, *13*(5), 1–9. https://doi.org/10.1111/conl.12725

Oyanedel, R., Keim, A., Castilla, J. C., & Gelcich, S. (2018). Illegal fishing and territorial user rights in Chile. *Conservation Biology*, *32*(3), 619–627. https://doi.org/10.1111/cobi.13048

Pomeroy, R. S. (2013). Governance of tenure in capture fisheries in Southeast Asia. *Land Tenure Journal*, *1*, 39–65.

Quynh, C. N. T., Hailu, A., Schilizzi, S., & Iftekhar, S. (2018a). Fisher participation in

monitoring: Does it help reduce excessive investment in fishing capacity? *Fisheries Research*, *206*(April), 138–149. https://doi.org/10.1016/j.fishres.2018.04.024

Quynh, C. N. T., Schilizzi, S., Hailu, A., & Iftekhar, S. (2018b). Fishers' Preference Heterogeneity and Trade-offs Between Design Options for More Effective Monitoring of Fisheries. *Ecological Economics*, *151*(May 2017), 22–33. https://doi.org/10.1016/j.ecolecon.2018.04.032

Quynh, C. N. T., Schilizzi, S., Hailu, A., & Iftekhar, S. (2020). Vietnam's Territorial Use Rights for Fisheries: How do they perform against Ostrom's institutional design principles? *World Development Perspectives*, *17*(February 2019), 100171. https://doi.org/10.1016/j.wdp.2020.100171

Revollo-Fernández, D., Aguilar-Ibarra, A., Micheli, F., & Sáenz-Arroyo, A. (2016). Exploring the role of gender in common-pool resource extraction: evidence from laboratory and field experiments in fisheries. *Applied Economics Letters*, *23*(13), 912-920.

Schroeder, S. A., Fulton, D. C., Currie, L., & Goeman, T. (2006). He said, she said: Gender and angling specialization, motivations, ethics, and behaviors. *Human Dimensions of Wildlife*, *11*(5), 301-315.

Silva, M. R. O., Pennino, M. G., & Lopes, P. F. M. (2021). Predicting potential compliance of small-scale fishers in Brazil: The need to increase trust to achieve fisheries management goals. *Journal of Environmental Management*, *288*(May 2020), 112372. https://doi.org/10.1016/j.jenvman.2021.112372

Song, A. M., Scholtens, J., Barclay, K., Bush, S. R., Fabinyi, M., Adhuri, D. S., & Haughton, M. (2020). Collateral damage? Small-scale fisheries in the global fight against IUU fishing. *Fish and Fisheries*, *21*(4), 831–843. https://doi.org/10.1111/faf.12462

Uy, T. C., Phuoc, D. N., Ha, H. D., & Tien, T. N. L. T. (2021). Roles of ecotourism in household income improvement and natural resources protection in tam giang Lagoon of Quang Loi Commune, quang dien district, thua thien Hue province. *Hue University Journal of Science: Agriculture and Rural Development*, *130*(3C), 21-33.

Thanh, H. T., Tschakert, P., & Hipsey, M. R. (2020). Tracing environmental and livelihood dynamics in a tropical coastal lagoon through the lens of multiple adaptive cycles. *Ecology and Society*, *25*(1). https://doi.org/10.5751/ES-11489-250131

Thanh, H. T., Tschakert, P., & Hipsey, M. R. (2021a). Examining fishery common-pool resource problems in the largest lagoon of Southeast Asia through a participatory systems approach. *Socio-Ecological Practice Research*, *3*(2), 131–152. https://doi.org/10.1007/s42532-021-00085-4

Thanh, H. T., Tschakert, P., & Hipsey, M. R. (2021b). Moving up or going under? Differential livelihood trajectories in coastal communities in Vietnam. *World Development*, *138*, 105219. https://doi.org/10.1016/j.worlddev.2020.105219

Thomas, A. S., Gavin, M. C., & Milfont, T. L. (2014). Estimating non-compliance among recreational fishers: Insights into factors affecting the usefulness of the randomized response and item count techniques. *Biological Conservation*, *189*, 24–32. https://doi.org/10.1016/j.biocon.2014.09.048

Thomas, A. S., Milfont, T. L., & Gavin, M. C. (2016). A new approach to identifying the drivers of regulation compliance using multivariate behavioural models. *PLoS ONE*, *11*(10), 1–12. https://doi.org/10.1371/journal.pone.0163868

Thung, D. (2007). *Environment and resources in the Tam Giang–Cau Hai lagoon. Integrated Management of Lagoon Activities–IMOLA project report. People's Committee of Thua*

Thien Hue Province, FAO and Cooperazione Italian. Hue, Vietnam.

Van Tuyen, T., Armitage, D., & Marschke, M. (2010). Livelihoods and co-management in the Tam Giang lagoon, Vietnam. *Ocean and Coastal Management*, *53*(7), 327–335. https://doi.org/10.1016/j.ocecoaman.2010.04.001

Viteri, C., & Chávez, C. (2007). Legitimacy, local participation, and compliance in the Galápagos Marine Reserve. *Ocean and Coastal Management*, *50*(3–4), 253–274. https://doi.org/10.1016/j.ocecoaman.2006.05.002

Warner, S. L. (1965). Randomized response: a survey technique. *Journal of the American Statistical Association*, *60*(309), 63–69.

Figures:

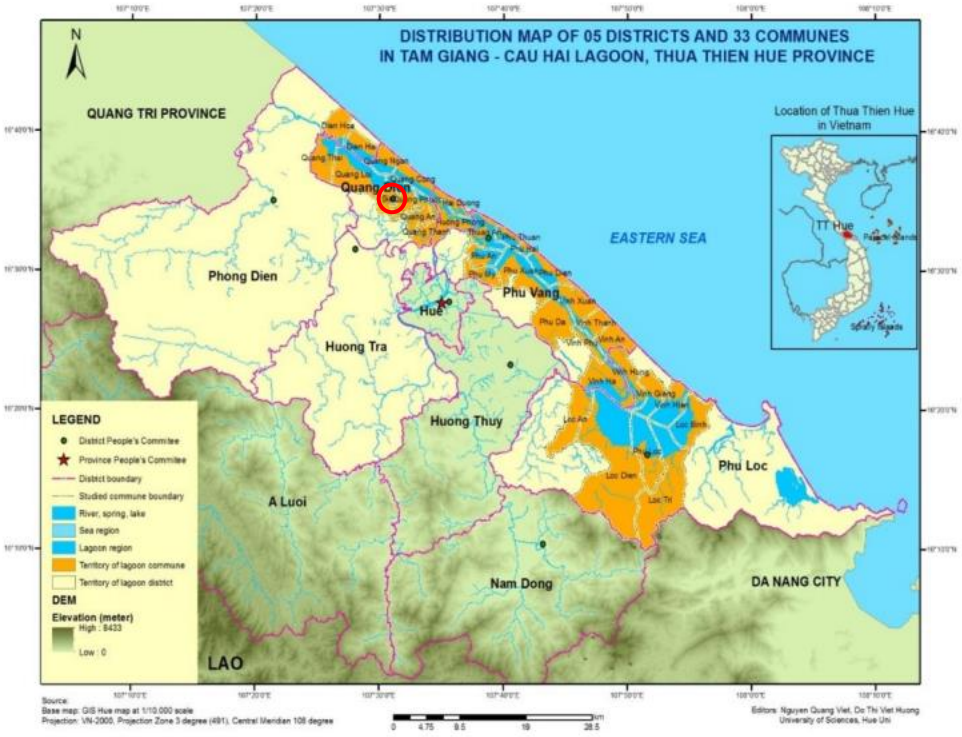

Figure 1. Map of the Tam Giang Lagoon. Source: USAID (2018). Note: The red circle indicates the community selected for the survey.

Figure 2. Chinese fish trap in Tam Giang Lagoon. Source: Nhung (2015)

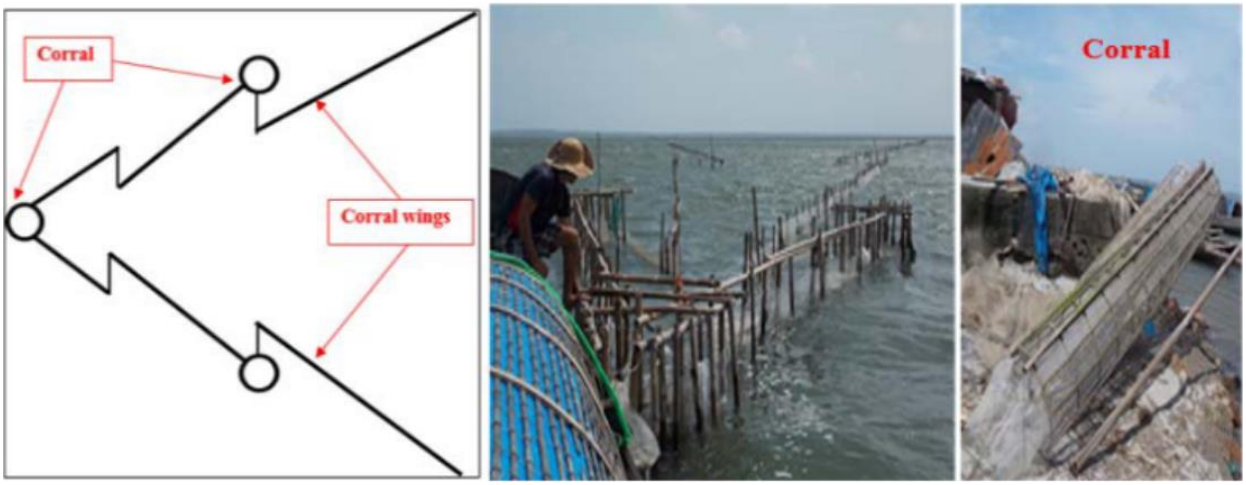

Figure 3. Fish corral in Tam Giang Lagoon. Source: Nhung (2015)

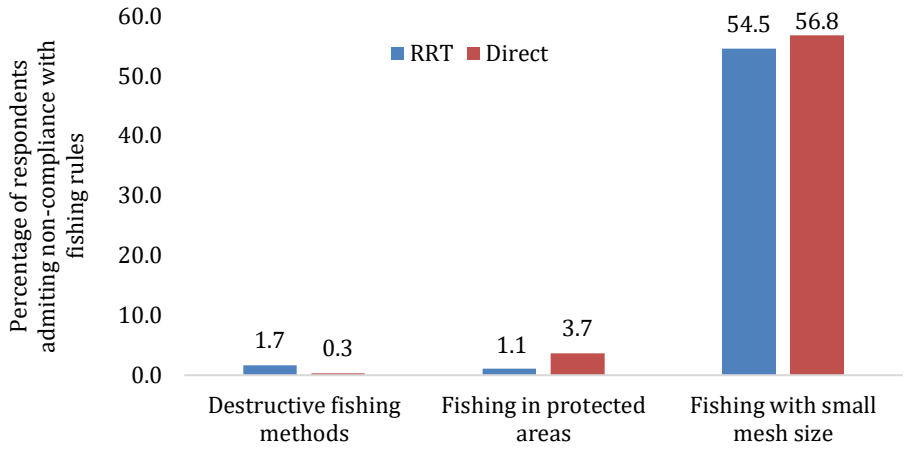

Figure 4. Proportion of non-compliance with 3 fishing rules using the RRT and direct questions.

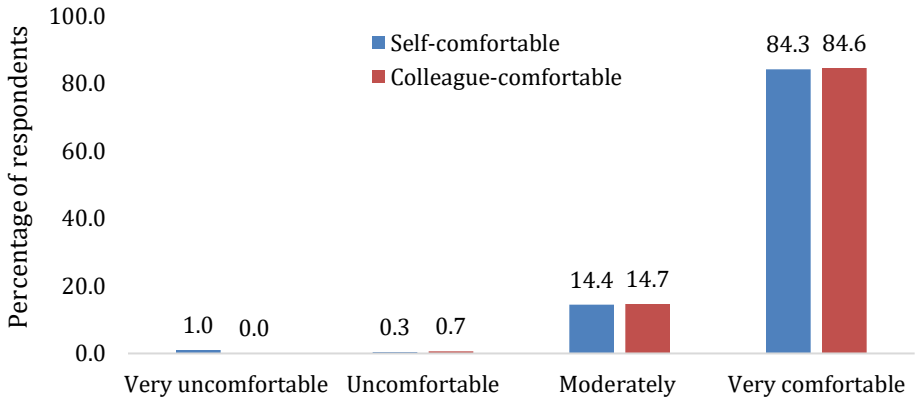

Figure 5. Estimates of self-reported level of comfort and perception of colleagues' comfort when answering the sensitive questions using RRT.

Roll the die. Look at the side and answer the question below accordingly	**Remember the rules:** "Yes" = answer "Yes" "No" = answer "No" "Blank" = answer the question truthfully
QUESTION: In the past year, have you ever fished illegally, using destructive fishing gears such as electric fishing gear, combined electric-seine, motorized push-net, and/or mollusk/eel rake? ☐ Yes ☐ No	

Figure S1. An example instruction for the forced-response randomized response technique.

Tables:

Table 1. Characteristics of respondents (N=292)

Variable	Description	Mean	Std. Dev.	Min	Max
Male	Gender	0.435	0.496	0	1
Age	Age	50.613	12.497	26	80
Education	Number of school years	4.023	3.484	0	16
Fishing gears	Types of fishing activities fishers involved in				
Fish corrals	*In Vietnamese: Nò sáo*	*0.270*	*0.446*	*0*	*1*
Fish aggregating device	*In Vietnamese: Chuôm*	*0.106*	*0.308*	*0*	*1*
Lift nets	*In Vietnamese: Rớ*	*0.003*	*0.058*		
Hammock stake trap	*In Vietnamese: Lưới dạy*	*0.116*	*0.321*	*0*	*1*
Electric fishing	*In Vietnamese: Rà điện*	*0.000*	*0.000*	*0*	*0*
Mollusk/ Eel rake	*In Vietnamese: Cào lươn/ hến*	*0.000*	*0.000*	*0*	*0*
Combined electric-seine fishing	*In Vietnamese: Xiếc điện*	*0.003*	*0.058*	*0*	*1*
Chinese fish trap	*In Vietnamese: Lừ*	*0.856*	*0.351*	*0*	*1*
Light fishing	*In Vietnamese: Soi*	*0.010*	*0.101*	*0*	*1*
Gillnets	*In Vietnamese: Lưới*	*0.531*	*0.500*	*0*	*1*
Aquatic grass collection	*In Vietnamese: Vớt rong*	*0.027*	*0.163*	*0*	*1*
Other occupation	Fishers have other livelihood activities apart from fishing	0.277	0.448	0	1
People	Number of people in the household	4.109	1.488	1	9
Income	Monthly household income from fishing activities	5.092	2.180	1	15
Experience	Number of years being a fisher	26.625	14.025	1	60
N	Number observations	292			

Table 2. Descriptions of dependent variable and latent independent variables used in the regression model estimation.

Variable	Description	Data type
Illegal fishing	Fishers had fished illegally during the last year, e.g., used nets with mesh size smaller than requirement (<18mm in diameter)	Dichotomous (Yes=1, No=0)
Awareness of the consequences of illegal fishing	Fisher awareness of the consequences of illegal fishing such as overfishing, stock degradation, increased competition among resource users, and reduced fish catch	Dichotomous (Yes=1, No=0)
Norms	Principal component score capturing social injunctive and personal norms regarding artisanal fishing (Table 2S, 3S)	Continuous
Legitimacy	Principal component score based on 5 indicators of legitimacy (Table 2S, 3S)	Continuous
Instrumental incentives	Principal component score capturing the probability of enforcement and sanction (Table 2S, 3S)	Continuous

Table 3. Binary Logistic estimates of the mesh size regulation compliance model

Variable	Violation				
	Odds ratio	Standard error	p-value	95% Confidence Interval	
Male	1.527	0.418	0.122	0.892	2.613
Age	0.952***	0.016	0.004	0.921	0.984
Other occupation	1.216	0.349	0.495	0.692	2.136
Education	0.925*	0.041	0.077	0.848	1.001
People	0.898	0.081	0.234	0.753	1.071
Experience	1.026*	0.015	0.075	0.997	1.056
Awareness of consequences of illegal fishing	0.434***	0.139	0.009	0.232	0.815
Instrument	1.007	0.006	0.251	0.994	1.020
Norms	1.007	0.007	0.251	0.994	1.029
Legitimacy	0.988**	0.006	0.048	0.976	1.000
Constant	17.124***	17.537	0.006	2.301	127.445

Model statistics	
N	292
Log-likelihood	-187.034
LR chi2(10)	25.230***
Pseudo R-square	0.063

Note: The dependent variable, the compliance, is binary, adopting the unity value if the fisher did comply with fishing regulation (i.e., regulated mesh size) and zero otherwise. Tests of significance of the odds-ratio is against unity. ***, **, and * indicate 1%, 5%, and 10% significance level, respectively.

Table S1. Summary statistics of the data regarding the indicators used in the principal component analysis (n=292). Responses were assessed using a 5-point Likert scale that ranged from strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5)

Variable	Label	Indicator	Sources	Mean	Std. Dev.
Instrument	INS1	The authorities will likely catch me if I violate the rules	Guirkinger et al., 2021; Oyanedel et al., 2020b	4.53	1.06
	INS2	The authorities will likely sanction me if I violate the rules	Guirkinger et al., 2021; Oyanedel et al., 2020b	4.59	1.01
Norms	NOR1	My friends/ family/ colleagues would disapprove of me if I violated the rules	Guirkinger et al., 2021; Oyanedel et al., 2020b; Thomas et al., 2016	4.48	1.14
	NOR2	I would feel guilty if I violated the rules	Guirkinger et al., 2021; Oyanedel et al.,	4.45	1.08

			2020b; Thomas et al., 2016		
	NOR3	I believe that my colleagues are highly compliance with fishing regulations	Guirkinger et al., 2021; Oyanedel et al., 2020b; Thomas et al., 2016	3.65	1.52
Legitimacy	LEG1	I have complete confidence in the management competence of the local authorities	Cepić & Nunan, 2017; Guirkinger et al., 2021	4.40	1.03
	LEG2	Access and ownership rights have been allocated equitably among FA members	Thomas et al., 2016	4.24	1.16
	LEG3	The penalty system has been enforced stringently and transparently	Guirkinger et al., 2021; Nielsen, 2003	4.08	1.34
	LEG4	The regulations are appropriate for managing the fishery sustainability	Guirkinger et al., 2021; Nielsen, 2003; Oyanedel et al., 2020b	3.92	1.33
	LEG5	I am always included in the decision-making process in my FA	Jentoft, 1989; Nielsen, 2003; Thomas et al., 2016	3.89	1.50

Note: statements regarding compliance motivations were derived from studies on compliance/non-compliance mechanisms, with revisions from experts on the topic and by Vietnamese scientists to fit the local context.

Table S2. Principal component analysis

Variable	Eigenvalue	Proportion	Cumulative
Instrument			
PC1	1.77	0.89	0.89
Norms			
PC1	1.83	0.61	0.61
Legitimacy			
PC1	2.03	0.41	0.41

Table S3. Loading factors (eigenvectors) of the indices

Variable	Indicator	Comp1
Instrument	INT1	0.71

	INT2	0.71
Norms	NOR1	0.65
	NOR2	0.67
	NOR3	0.37
Legitimacy	LEG1	0.52
	LEG2	0.47
	LEG3	0.46
	LEG4	0.41
	LEG5	0.37