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Assessment of the water insecurity of rice and fish farmers in the coastal areas of Myanmar and Vietnam

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Abstract. *Oo AT, Minh DD. 2025. Assessment of the water insecurity of rice and fish farmers in the coastal areas of Myanmar and Vietnam. Asian J Agric 9: 191-200.* Farm households along the coastlines of Myanmar and Vietnam are susceptible to climate-related hazards and the adverse effects of water insecurity. To understand the level of water insecurity of rice and fish farming households, this study examines water insecurity of households by using Guttman's Water Insecurity Indexing (WII) analysis. This study was conducted with 899 farm households from Myanmar and Vietnam. A total of 29 indicators were selected and constituted into four major components. According to a total aggregate score, rice-farming households are more susceptible to accessing water sources and services than fish-farming households in both countries. Compared to farm households in Myanmar, farm households in Vietnam are particularly vulnerable to access to water sources, with scores of 0.414 and 0.334. There is little variation in the water resource management score. However, Myanmar's farm households indicated more inadequate adaptation capacity (0.487) than Vietnam's (0.462). Moreover, an idealized Guttman's scale indicated that farm households in Myanmar had a lower level of intervention capability and adaptive capacity than farm households in Vietnam. The findings highlight the necessity of improving intervention capability and capacity and accessibility measures to improve the water security of farm households in both Myanmar and Vietnam.

Keywords: Adaptive capacity, climate-related hazards, farm households, Guttmann's analysis, water insecurity

INTRODUCTION

Water is essential for human life, socioeconomic development, poverty reduction, and other basic development objectives (MacAlister et al. 2023). However, multiple compounding effects of climate change have jeopardized the security of our water resources. Climate change has exacerbated the rise of sea levels, which impacts livelihoods in low-lying coastline areas. In coastal metropolitan regions in developing Asian countries, water security is under threat due to rapid urbanization, population growth, declining water quality, climate change, and ecological-hydrological changes (Krittasudthacheewa et al. 2019; Aboelnga et al. 2020; IPCC 2022). Farm households in the coastal areas of the Mekong Region are facing urgent water security crises, leading to significant water availability and quality disruptions for agriculture and domestic use (Krittasudthacheewa et al. 2019; MacAlister et al. 2023). One key factor contributing to water insecurity is the increased frequency and intensity of extreme weather events, and it has direct implications for farmers who rely on consistent access to water for irrigation, crop and fish production, and household needs (Krittasudthacheewa et al. 2019; IPCC 2022). Access to safe and secure water sources becomes a crucial concern during and after disasters, affecting not only agricultural production but also the overall health and livelihoods of the communities (Krittasudthacheewa et al. 2019; Lebel et al. 2023).

According to MacAlister et al. (2023), Vietnam and Myanmar fall into the category of water-insecure countries according to the national water security scores ranked for the Asia-Pacific. Myanmar has rich water resources but is plagued by poor infrastructure and increasing impacts of climate-related hazards (Oo et al. 2017; Oo 2018; MONREC 2019; Oo et al. 2023). On the other hand, in Vietnam, the Mekong Delta is heavily impacted by flood and climate change extremes. Even though Vietnam has made substantial progress in water resource management in recent years, it continues to face challenges in ensuring equitable access to safe water and safeguarding water quality (MONRE 2016; Tran et al. 2022; Lebel et al. 2023). By understanding the specific challenges these farming communities face, it is possible to enhance water security, build resilience, and implement targeted measures to meet the needs of each farming community in the face of increasing risks of water security.

There is an increasing number of studies on water insecurity assessment in different contexts and climate change's impact on water systems, management, and security (Jaramillo and Nazemi 2017; Danielaini et al. 2019; Kalogiannidis et al. 2023; Liu et al. 2024). As water security is a multi-dimensional construct in nature, several studies applied 'composite indices to their treatment in order to compare (normalization) and aggregate (weighting and aggregation)' for multiscale comparisons of complex concepts (Huynh and Stringer 2018; Vanham et al. 2018; Doeffinger and Hall 2021). Anthropologists have utilized

Guttman's method to create ethnographically grounded scales that capture variation in a progressive, unidimensional concept across a set of indicators (Jepson and Vandewalle 2016; Danielaini et al. 2019; Aboelnga et al. 2020; Ding et al. 2024). In this study, we employ water insecurity indicators reported across various studies and local-specific dimensions of water insecurity. Similar to Danielaini et al. (2019), the indicators were selected and grouped into four dimensions of water insecurity, namely, insufficient accessibility, acceptability, capability, and adaptive capacity, and the grouping of dimensions was carried out given the definition of the indicators and related metrics of the indicators under broader dimension. Therefore, this study aims (i) to identify the key components of water insecurity in agriculture (rice) and aquaculture (fish) farming households; (ii) to evaluate the prevalent issues that shape the farm household's water insecurity; and (iii) to compare the difference in the water insecurity and vulnerability of both rice and fish farming households in Myanmar and Vietnam.

MATERIALS AND METHODS

Study area

In Myanmar, flooding and saltwater intrusion to farmlands were frequently recorded in Kyaiklat and Dedaye Townships. Kyaiklat Township includes 87 village tracts, while Dedaye Township includes 40 village tracts. Kyauktan Township is located in the SouthEast area of the Yangon Region and consists of 32 village tracts (MIP 2017; Oo 2018). This study covers the two coastal areas most afflicted by saltwater overflow and floods in Myanmar, where the Dedaye, Kyaiklat and Kyauktan Township were reported as the areas most affected by the climate-related extremes. The three townships that were chosen are all low-lying areas with elevations under 5 m (Oo et al. 2018). This empirical research study was carried out in 12 communities: of which 6 in Dedaye and Kyaiklatt Township and 6 in Kyauktan Township (Figure 1.A). By selecting 12 communities in these 3 townships, the impacts of saltwater intrusion and flooding at the individual farm level could be better understood. Six communities in Dedaye and Kyaiklatt Township in the Ayeyarwaddy Region: namely Ka Lar Su, Kyon Thin, Hmyaw Sin, Kunpa Laing, Kyee Chaung and Hpoe Shan Gyi villages, and 6 communities in Kyauktan Township in the Yangon Region: namely Kamarmat, Oke Pho, Thet Kel Kone, Yae Kyaw, Shwe Pyi Thit and Zwe Bar villages were selected.

In Vietnam, six communities spread across three Tam Giang – Cau Hai lagoon districts were chosen for this study. After consultations with commune-level officials, these villages were selected to ensure they met certain criteria, such as being part of the lagoon system and having both agriculture and aquaculture farming communities. There are 11 communes in the Quang Dien district, of which Quang Loi and Quang Thai were chosen. Of the 21 communes in the Phu Vang District, Vinh Xuan and Vinh Phu communes were selected. Additionally, Vinh Hung and Vinh Giang communes were chosen from among the 15 communes in the Phu Loc District (Figure 1.B). For the village profiles in the sampling areas, we developed gender and ethnicity related questions and sought to ensure that women and minority groups participated in the study.

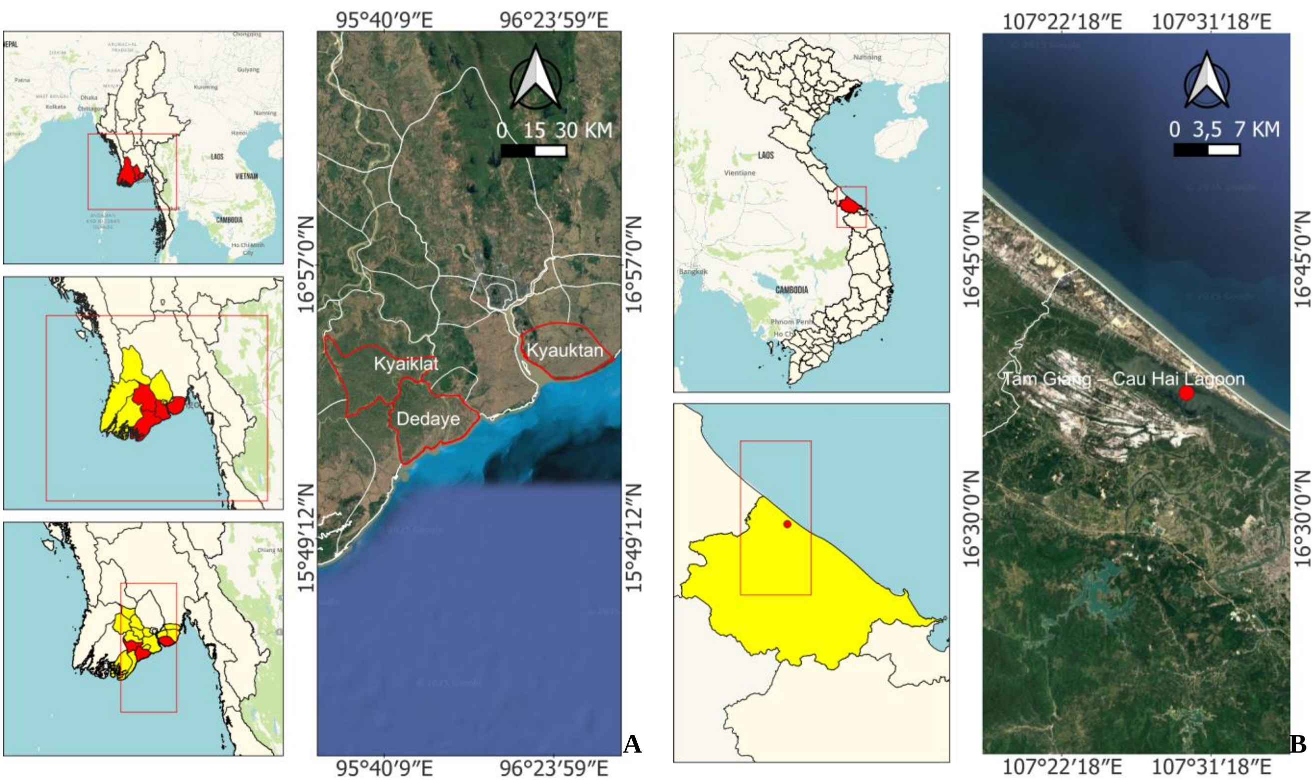

Figure 1. Map showing the study areas: A. Kyaiklat, Maubin City and Dedaye Township, Pharpon District in Ayeyarwaddy Region and Kyauktan Township, Yangon-S City in Yangon Region of Myanmar; B. Tam Giang – Cau Hai Lagoon, Thừa Thiên Huế, Vietnam

Considering the vast geographies and limited knowledge of the risks of water insecurity and climate change impacts, this study was conducted in two regions in Myanmar and one in Vietnam. The survey was carried out between September to October 2021 in Myanmar and from February to March 2022 in Vietnam. Given the complications and impacts of the COVID-19 pandemic during the surveys, a randomized sampling method was considered, where more samples were taken in low-travel restriction areas. For instance, Myanmar had fewer travel restrictions within communities at the time of the survey, while Vietnam had strict travel restrictions inside rural communities during the survey. Initially, villages were selected based on characteristics such as villages located near coastline areas and in which rice-farming and fish-farming farmers are presented. Data are collected in four steps: (i) field observation; (ii) selection of indicators with key stakeholders; (iii) final questionnaire preparation; and (iv) farm household surveys or interviews. A sample of 300 was considered from each sampling region. Regarding geographic disparities, this survey included 599 sample farmers in Myanmar and 300 respondents in Vietnam. A total of 899 samples were acquired for this research.

A total of 29 indicators were selected for this study and the selected indicators were grounded by an extensive literature review. During the survey, responses were assessed in dichotomous scale, one for positive responses and zero for negative responses. Farm households responses were then re-arranged in the data matrix and the experience-based indicators used in the scale development across dimensions. Guttman's scalograms, for example, assess individuals according to their frequency of responses, from highest to lowest. It also includes four dimensions: insufficient accessibility to water sources and related services, inadequate acceptable level of water risks, insufficient capability and adaptive capacity of water resource management (Marzi et al. 2018; Doeffinger and Hall 2021) (see detail in Table 1). Furthermore, indicators related to flooding and flood protection measures, as well as the impacts of climate and hydrological changes on farm households were considered and thus this study offers concrete findings of farm households and local communities and has direct implications for policymakers and development planners in Myanmar and Vietnam. A balanced indexing method was chosen to examine the difference in water insecurity level of farm households in two countries. The applicability, relevance, and uniqueness of the selected indicators were validated at the focus group discussions with key stakeholders, so that the selected indicators were able to capture the status of water insecurity in the specific regions and farming communities in Myanmar and Vietnam. Therefore, this study advances previous work on Marzi et al. (2018) and Doeffinger and Hall (2021) on experience-based scaling of water insecurity and uses an analytical framework including four dimensions or scales of household water insecurity at rice-farming and fish-farming in a coastal region of Myanmar and Vietnam.

During the assessment, all potential participants were requested to sign an ethical consent form; only those who agreed to participate were interviewed. Despite the COVID-19 pandemic in the region, the research team considered community participants norms, values, and ethics, such as following COVID-19 coping measures, keeping participant data anonymous, and practicing secure data management during the research assessment. Despite adhering to the suggested research aims, our study has certain limitations. Before the survey, the enumerators undertook testing and training utilizing several questionnaires. They might not have a solid grasp of the concepts around climate change and the different kinds of questionnaires. One questionnaire may also be used in this study to examine the unique characteristics of the two distinct contexts or nations. However, we conduct a daily data quality check to ensure our data are of the highest quality. Furthermore, this study only considers how climate change affects farm households; it ignores how it affects biodiversity, the ecosystem, cattle, and other animals.

Data analysis

According to MacAlister et al. (2023), global research approach to water security assessment highlights the inconsistency of data availability and the need for additional research to address disparities and knowledge gaps adequately. Therefore, countries should expand their data collection systems to fill the numerous gaps (Larsen et al. 2019; MacAlister et al. 2023; Anghileri et al. 2024). Guttmann's indexing and scaling analysis provides a structured methodology for capturing these complexities by incorporating indicators related to water availability, quality, accessibility, reliability, and governance (Marzi et al. 2018; Doeffinger and Hall 2021; Stoler et al. 2023). Guttmann's indexing and scaling approach also emphasizes the importance of considering not just the physical aspects of water availability but also the social, economic, and institutional dimensions that shape water security. Moreover, Guttmann's analysis goes beyond simple indicators by examining indicators such as water governance structures, community engagement, financial access to water services, and environmental sustainability (Doeffinger and Hall 2021; Veettil et al. 2022; Zhou et al. 2023). Therefore, applying Guttmann's water insecurity indexing analysis in the context of Myanmar and Vietnam offers a valuable framework for understanding the multifaceted nature of water security in these countries. This study considered indicators related to flooding and flood protection measures, as well as the impacts of climate and hydrological changes on farm households. Therefore, this study considers a comprehensive view and knowledge of the factors influencing water insecurity in Myanmar and Vietnam.

The open-ended questions gathered in the survey were carefully coded and categorized for analysis. The responses from the survey were evaluated using a dichotomous scale for each indicator, where a value of zero represented a negative response, and a value of one indicated a positive response. This method allowed for a clear and straightforward assessment of the participants perspectives. The survey comprised questions that addressed 29 indicators organized into four components. A composite indexing analysis using a balanced aggregate method was applied to convey the water insecurity level of rice and fish-farming households to flooding and saltwater intrusion in Myanmar and Vietnam. Each component comprises indicators standardized using a balanced average approach (Oo et al. 2018; Minh et al. 2019). The major component index of the rice and fish-farming households in both countries can be calculated after each index has been standardized following by equation (1):

$$M_h = \frac{\sum_{i=1}^{n} index\, S_h i}{n} \quad \ldots\ldots(1)$$

Where, M_h denotes one of the four main components of agriculture or aquaculture farm households 'h', '$index\ S_h$' represents the subcomponent index or indicator denoted by 'i' of households 'h' and 'n'the number of indicators applied in each major component. This structured approach to data analysis not only facilitated a thorough understanding of the respondents views but also allowed for comparative insights between the two nations involved in the study. By using the Guttman scale, we were able to determine the levels of agreement or disagreement regarding each indicator, contributing to a more nuanced understanding of the issues. Overall, the methodology ensured systematic processing of qualitative data, providing valuable insights while maintaining a high level of reliability in the results obtained from both Myanmar and Vietnam.

RESULTS AND DISCUSSIONS

Accessibility to water sources and related services

Figure 2 displays climate-change extreme events in Vietnam and Myanmar between 1980 and 2020. Storms (49%) and floods (38%) were the most observed natural hazards in Vietnam, whilst floods (36%) and miscellaneous accidents (26%) were the most occurring natural disasters in Myanmar. Twenty-nine indicators were selected, validated, and evaluated to determine the differences in water insecurity levels of rice farming and fish farming households in Myanmar and Vietnam (Table 1). Of the 29 indicators chosen, 13 were included in the water accessibility component, 4 in the water acceptability component, 5 in the capability component, and 7 in the adaptive capacity component. The adaptive capacity component was considered to reflect the ability of both farming systems to the adverse effects of water-related problems and ecological-hydrological changes to mitigate or adverse the potential damages with these consequences. In the component of insufficient accessibility to water sources and related services, the mean index is 0.414, with rice-farming households experiencing a higher degree of insufficient access to water sources and water-related services at 0.412 and fish-farming households at 0.404. This study indicated that farm households in both countries have challenges with accessibility to water sources and related services. Although disputes with neighbors over water management occur, such instances constitute only slightly more than 20% of cases, with most families adopting their water treatment practices.

Nevertheless, households confront certain barriers in accessing public water sources and wastewater treatment, which is unsurprising, given the limited water-related services in most rural areas of the study. For instance, it is noted that Myanmar was among 26 countries with an estimated zero level of wastewater treatment (MacAlister et al. 2023). Furthermore, the drainage system is restricted, affecting not just farm households water use but also water utilization in production, particularly in water quality-sensitive sectors like fish farming. It is also noted that Myanmar and Vietnam were among the 20 lowest-scoring countries for water use efficiency in 2019 (MacAlister et al. 2023). The Vietnamese government has put considerable effort into implementing water supply and sanitation reforms and programs, but there is still a large rural and urban divide. Access to safe water and sanitation in Vietnam's rural areas was only around 45-51%, while it was about 82% in urban areas (Pham et al. 2023). In Myanmar, however, access to "improved water" is indicated as 83% (urban 93%, rural 78%) and to sanitation as 76% (urban 83%, rural 73%) (Global Water Partnership 2016). The findings also show that farm households generally experience issues with water resource management and accessibility, with the majority using their own water treatment practices.

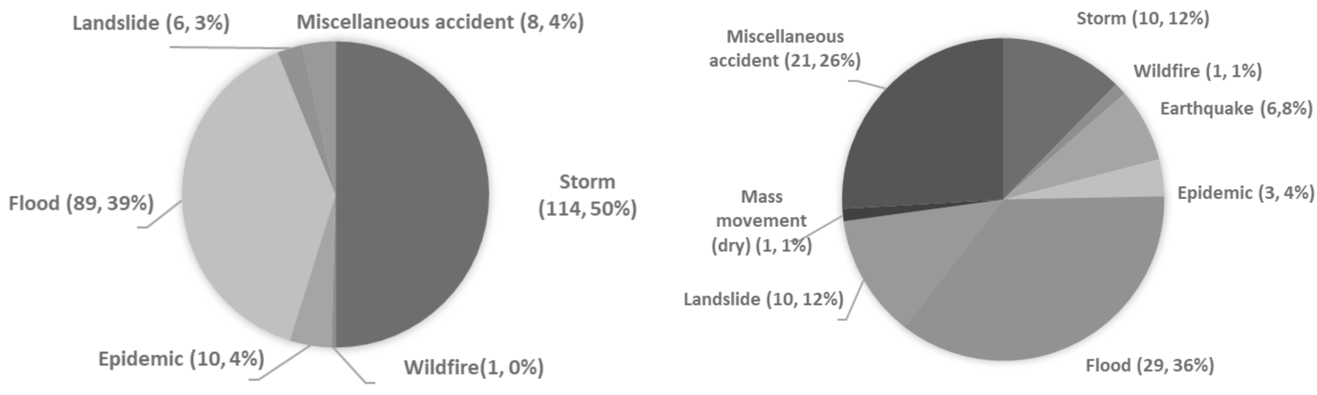

Figure 2. Occurrence of climate-change extreme events in Vietnam and Myanmar from 1980-2020 (Source: World bank climate change knowledge portal)

Table 1. Comparison of water insecurity indexing scores for two farming systems in Myanmar and Vietnam by weighting indicators

Indicators	Rice-farming households		Fish-farming households		Total cumulative scores	
	Vietnam Freq. (%)	Myanmar Freq. (%)	Vietnam Freq. (%)	Myanmar Freq. (%)	Vietnam Freq. (%)	Myanmar Freq. (%)
Idealised Guttman Scale for insufficient accessibility to water sources and related services						
Households report water conflict problems	88 (0.53)	51 (0.106)	58 (0.433)	6 (0.052)	146 (0.487)	57 (0.095)
Slept very few hours due to water collection duty	51 (0.31)	79 (0.164)	40 (0.298)	7 (0.061)	91 (0.303)	86 (0.144)
Dispute with neighbors/ tenants/ owner due to water	47 (0.28)	58 (0.12)	35 (0.261)	6 (0.052)	82 (0.273)	64 (0.107)
Reduced time for daily work/income-generative activities due to water collection	59 (0.355)	100 (0.208)	45 (0. 336)	12 (0.104)	104 (0.347)	112 (0.188)
Reduced time for studies or missed school due to water collection	47 (0.283)	48 (0.099)	38 (0. 294)	2 (0.017)	85 (0.283)	50 (0.084)
Collected water from an undesirable/ dirty source	39 (0.235)	89 (0.184)	35 (0.261)	12 (0.104)	74 (0.247)	101 (0.169)
The household does not have private sanitation facilities	46 (0.277)	368 (0.762)	32 (0.239)	99 (0.861)	78 (0.26)	467 (0.781)
Households do not have private water facilities	60 (0. 361)	311 (0.643)	48 (0.358)	39 (0.339)	108 (0.36)	350 (0.584)
Household members do not have access to improved non-drinking water source	65 (0.392)	105 (0.217)	54 (0.403)	14 (0.122)	119 (0.397)	119 (0.199)
The drainage system does not surround the household	121 (0.729)	70 (0.145)	97 (0.724)	22 (0.191)	218 (0.727)	92 (0.154)
Household members do not have access to improved drinking water sources	126 (0. 759)	98 (0.202)	98 (0.731)	15 (0.13)	224 (0.747)	113 (0.189)
Household members do not have access to improved sanitation facilities	37 (0.223)	431 (0.892)	27 (0.201)	108 (0.939)	64 (0.213)	539 (0.902)
Households do not have access to public drinking water system	123 (0.741)	392 (0.81)	97 (0.724)	51 (0.443)	220 (0.733)	443 (0.74)
Overall score	0.421	0.35	0.404	0.263	0.414	0.334
Idealised Guttman Scale for the inadequate acceptable level of water risks						
Households do not have access to public wastewater treatment	124 (0.747)	464 (0.961)	97 (0.724)	110 (0.957)	221 (0.737)	574 (0.96)
Having experienced an increase in flood event	32 (0.193)	153 (0.316)	34 (0.253)	17 (0.148)	66 (0.22)	170 (0.284)
Currently having difficulty/problem with flood/ flooding	96 (0.578)	117 (0.242)	77 (0.575)	9 (0.078)	173 (0.577)	126 (0.21)
Currently having difficulty/problem with water scarcity	71 (0.428)	267 (0.552)	63 (0.470)	32 (0.278)	134 (0.447)	299 (0.499)
Overall score	0.486	0.518	0.506	0.365	0.495	0.488
Idealised Guttman Scale for the insufficient capability of water resource management						
Having experienced a decrease in river water quality	47 (0.283)	262 (0.541)	44 (0.328	58 (0.504)	91 (0.303)	320 (0.534)
Currently not satisfied with flood protection	73 (0.439)	96 (0.198)	67 (0.5)	43 (0.035)	140 (0.467)	139 (0.232)
Currently not satisfied with healthy human settlement	53 (0.319)	7 (0.012)	41 (0.306)	1 (0.043)	94 (0.313)	8 (0.014)
Currently not satisfied with sufficient water availability	63 (0.379)	31 (0.064)	45 (0.336)	14 (0.122)	108 (0.36)	45 (0.075)
Currently not satisfied with water and sanitation infrastructures	77 (0.464)	60 (0.124)	55 (0.411)	7 (0.061)	132 (0.44)	67 (0.112)
Overall score	0.377	0.188	0.376	0.214	0.377	0.193
Idealised Guttman Scale for insufficient adaptive capacity in water resource management						
Currently not satisfied with healthy waterways	79 (0.476)	166 (0.344)	52 (0.388)	15 (0.13)	131 (0.437)	181 (0.303)
Disagree that it is important to use water much more efficient	71 (0.427)	44 (0.091)	53 (0.395)	4 (0.035)	124 (0.413)	48 (0.08)
Disagree that it is important to minimize water use consumption	67 (0.404)	52 (0.107)	55 (0.410)	5 (0.043)	122 (0.407)	57 (0.095)
Having the opinion that only the government is responsible for improving the eco-hydrological status	35 (0.211)	236 (0.488)	44 (0.328)	56 (0.487)	79 (0.263)	292 (0.487)
Having no solution to minimize the impacts of flooding events and salter instructions	33 (0.199)	268 (0.555)	40 (0. 298)	58 (0.509)	73 (0.243)	326 (0.546)
Climate and hydrological changes adversely affect household social and economy	127 (0.765)	472 (0.975)	100 (0.746)	113 (0.983)	227 (0.757)	585 (0.977)
Having concerns regarding the change in flooding events and saltwater intrusion into farms	119 (0.717)	439 (0.907)	95 (0.709)	114 (0.991)	214 (0.713)	553 (0.923)
Overall score	0.457	0.495	0.468	0.454	0.462	0.487

Acceptable level to water-related risks

Regarding the acceptability of risk associated with water resource management, farm households experience a relatively high risk level, as shown by index values of 0.495 in Vietnam and 0.48 in Myanmar. The fish-farming households exhibit a higher risk level, with an index value of 0.506, while the rice-farming households belong to a lower risk level, with an index value of 0.486 in Vietnam. The most challenging issue for farm households is not having access to the basic wastewater treatment system, with an index score of 0.737 in Vietnam and 0.96 in Myanmar. Notably, approximately fifty percent of farm households in this study area indicated a challenge and difficulty due to increased water shortages and freshwater supply. Thus, more concerted efforts are required to reduce those risks by improving the effectiveness and efficiency of water resource management policies and strategies in the study areas. Actions and measures that improve the accessibility and quality of water treatment systems may be beneficial in addressing this issue. Given that most farm households indicated a substantial challenge related to flood and saltwater intrusion, it is critical to have a comprehensive and integrated strategy for water resource management that addresses these issues in a coordinated and effective manner. This might involve establishing appropriate infrastructure such as dikes or embarkments, policies, and actions to improve water accessibility and quality and strengthen community resilience to flood and saltwater intrusion.

Incapability to manage water resources

Regarding the insufficient capability of farm households regarding water resource management, the indexing scores exhibit a relatively low level of capability, with an average score of 0.377 in Vietnam and 0.193 in Myanmar. This component has no statistical difference between the fish-farming and rice-farming households. About one-third of farm households in Vietnam reported they are not satisfied with flood protection, human settlement, water availability, and sanitation infrastructures. In contrast, a very small percentage of farm households reported this incapability with water resource management in Myanmar. Thus, this study highlights the need to prioritize measures that address the incapability of farm households related to flood protection, human settlement planning, water availability, and sanitation infrastructures in the study areas. Moreover, the study highlights the need for a comprehensive and integrated approach that considers human settlement, water supply, sanitary infrastructures, and resilience measures to reduce incapability and flood impacts on farming in the coastal areas of Myanmar and Vietnam.

Adaptation capacity in water resource management

The adaptive capacity component comprising seven criteria pointed out that the majority of farm households are still having insufficient capacities to cope with adverse changes and water insecurity in the region, with an average score of 0.462 in Vietnam and 0.487 in Myanmar. About 98% of farm households in Myanmar and 75% of farm households in Vietnam agreed that the worsening climate and hydrological changes are adversely affecting to social and economic conditions of their farm households. And, about 92 and 72% of farm households in Myanmar and Vietnam also agreed that they are experiencing the adverse effects of flood events and saltwater intrusion to farms. The findings suggest that farm households in both countries are extremely vulnerable to the adverse effects of climate and hydrologic changes, saltwater intrusion, and flooding. The results also indicate that the fish-farming households are slightly more vulnerable to climate and hydrological changes than the rice-farming households. In this study, about half of farm households in Myanmar and one-third of farm households in Vietnam are concerned over government responsibility for improving the current ecological-hydrological status in the study areas. Perhaps, the rest of the farm households perceived that it should be bilateral approaches while both communities and private and public organizations should conduct measures to improve the ecological-hydrological conditions in the region. Although the Vietnamese government has put considerable effort to meet most of the sustainable development goal-6 (water for all) by implementing mostly on water supply and sanitation over the past two decades, there is still need for increased capital, technology and expertise to upgrade infrastructure and water supply networks, mostly in the rural areas (World Bank Group 2023). In the case of Myanmar, the government spending on service was still low and amid the pollical crises, there are no or little concerns over to invest in national water sector by the government. Although the overall availability of water is abundant, there are distinct regional differences, such as lack of water or difficulty to access the water resources in dry zone, flooding in the delta, flash floods in the mountains and dry zone, salinization in the delta areas (Global Water Partnership 2016; World Bank Group 2023). Therefore, more investment to fulfill the needs for adequate availability of clean and sufficient water as well as empower the adaptive capacity of rural households in Myanmar is still largely needed. Therefore, both private and public organizations should make efforts to minimize the impacts of flooding, saltwater intrusion, and climate change impacts on water resources as well as less impacts on the social and economic conditions of farm households. Moreover, awareness campaigns should be organized to educate farm households about their role in improving water use efficiency and efficacy. These efforts will be crucial in minimizing the adverse effects of climate and hydrological changes on farm households livelihood activities and well-beings.

Idealized assessment of water insecurity by Guttman's dimensional scores

Following Guttman's scaling assessment, this study categorizes four dimensions of water insecurity, where we synthesized 13 criteria in the first dimension, four in the second dimension, 5 in the third dimension, and 7 in the fourth dimension (Table 2). The number of criteria in each dimension differs based on the compilation of previous research reference materials and information availability for each criterion. Sufficient and adequate data about rice- and fish-farming households can verify the different dimensions of water insecurity in the coastline areas of Myanmar and Vietnam. Figure 3 illustrates the significance of four dimensions among rice and fish-farming households in each country and a cumulative average percentage of farm households in each country. The results indicated that in terms of accessibility to water sources and services, most households belong to group A2-marginal water accessibility, accounting for over 65.7% in Vietnam and 85% in Myanmar. A relatively large proportion of households belong to group A3-low water accessibility, with an average of 28 and 11.7% for farm households in Vietnam and Myanmar, respectively. Despite the development of irrigation and machinery systems, fish-farming households usually encounter more difficulties in water accessibility than agricultural households in both countries.

Moreover, the results also indicate that the levels of acceptability to water-related risks are distributed across three main indices in Vietnam. But in Myanmar, the level of acceptability to water risks is mainly concentrated in category B1- high acceptability. The households that perceived the highest level of this dimension belong to group B1, with an average of 39.7% in Vietnam and 73.3% in Myanmar. It is interesting to note that both fish-farming and rice-farming households have similar levels of perceived acceptability. The second indicator (B2) consists of approximately 32.3% of households, where the rice-farming households have a higher percentage of perceived acceptability at 36.1%, while fish-farming households account for 27.6% of it.

Finally, a relatively low proportion of households (B3) agree that they have a high level of water risk acceptability at 22%. Only a very small percentage of households perceived a low level of damage in the criterion (B4) in Vietnam. In Myanmar, however, the rice-farming households perceived high acceptability to water risks at 69.6%, followed by a similar level of marginal (15.1%) and low acceptability (14.5%). However, the highest acceptability to water risks was observed by 88.7% of fish-farming households. In contrast, those farm households in Myanmar reported a small and equal contribution of marginal and low water acceptability. These findings suggest significant challenges posed by water-related risks such as saltwater intrusion and flooding in the study areas. Most farm households reported difficulties in accessing and utilizing water resources, and their livelihood and production processes are impacted by these water-related risks. The differences in levels of perceived damage between fish-farming and rice-farming households may reflect differences in the specific challenges posed by water-related risks. Thus, this finding highlights the need for targeted interventions to address the unique needs of different farming systems.

Regarding the insufficient capability of water sources, which is measured by five criteria, it is observed that farm households in both groups are quite satisfied with intervention capability dealing with issues related to water resource management in Vietnam. Most farming households belong to group C1, with an indexing score of 51.7%. However, there is not much difference between rice farming and fish farming households. The remaining levels are relatively evenly distributed for the indicator (C2) and (C3) - about 13% of households. Surprisingly, the proportion of households in the indicator C4 is quite high at 22.1%, and this ratio is not much different in both farm households. Compared to Vietnam, Myanmar is left behind in terms of insufficient capability of water resource management, with low incapability accounting for 45.7% and marginal incapability at 37.7%. Most rice-farming households account for C3-low capabilities (47.5%), while the fish-farming households belong to category C2 (marginal incapability with 40%). This could be due to Myanmar's limited infrastructure availability and water resource management capability compared to Vietnam. However, rice-farming and fish-farming households reported low and medium capabilities in Myanmar. Therefore, in terms of insufficient capability of water resource management, farm households in Vietnam are evaluated at high intervention capabilities, especially in fish-farming households. At the same time, this was accounted for in low and medium capabilities with farm households in Myanmar.

Moreover, this study employed seven indicators to assess the adaptive capacity of the farm households, such as satisfaction with healthy waterways, water utilization, and water consumption; only the government has responsibility for improving eco-hydrological status, and no solution to minimize the impacts of flooding events and salter instructions, climate and hydrological changes adversely affect household social and economy and concerns regarding the change in flooding events and saltwater instructions. We categorized farm households adaptive capacity level into four levels to measure farm households adaptive capacity level. The results show that households are evaluated at a high adaptive capacity of D1, 47%, whereas fish-farming households were reported at 48.5%, and rice-farming households were 45.8% in Vietnam. In Myanmar, however, the low adaptive capacity with ecological-hydrological changes was evaluated at D3, with the highest scores being 67.6%, where 65.2% of fish-farming households and 68.2% of rice-farming households were reported. This could be due to the lower literacy rate of Myanmar compared to Vietnam, as the education status of the farmers is directly related to the adaptive capacity of farmers in response to the impacts of extreme climate events and natural disasters (Oo et al. 2018; Oo 2018).

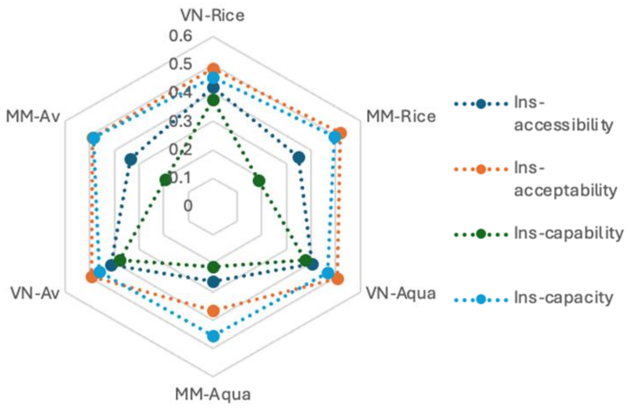

Figure 3. Dimensions of water-insecurity status for rice- and fish-farming households in Myanmar and Vietnam

Table 2. Comparison of water insecurity indexing scores for two farming systems in Myanmar and Vietnam

Indicators	Rice-farming households		Fish-farming households		Total cumulative scores	
	Vietnam Freq. (%)	Myanmar Freq. (%)	Vietnam Freq. (%)	Myanmar Freq. (%)	Vietnam Freq. (%)	Myanmar Freq. (%)
Idealised Guttman Scale for accessibility to water sources and related services (13 indicators)						
Adequate water-sanitation access – A1	3 (1.8)	4 (0.8)	3 (2.2)	1 (0.8)	6 (2)	5 (1.6)
Marginal water-sanitation access – A2	109 (65.7)	406 (83.9)	88 (65.7)	108 (94)	197 (65.7)	514 (85)
Low water-sanitation access – A3	45 (27.1)	65 (13.4)	39 (29.1)	5 (4.4)	84 (28)	70 (11.7)
Very low water-sanitation access – A4	9 (5.4)	9 (1.9)	4 (3)	1 (0.8)	13 (4.3)	10 (1.7)
Total	166	484	134	115	300	599
Idealised Guttman Scale for acceptability level to water risks (4 indicators)						
Highly likely water risks acceptability – B1	64 (38.6)	337 (69.6)	55 (41.1)	102 (88.7)	119 (39.7)	439 (73.3)
Marginal water risks acceptability – B2	60 (36.1)	73 (15.1)	37 (27.6)	6 (5.2)	97 (32.3)	79 (13.2)
Low water risks acceptability – B3	29 (17.5)	70 (14.5)	37 (27.6)	6 (5.2)	66 (22)	76 (11.8)
Very low water risks acceptability – B4	13 (7.8)	4 (0.8)	5 (3.7)	1 (0.9)	18 (6)	5 (1.7)
Total	166	484	134	115	300	599
Idealised Guttman Scale for insufficient capability for water resource management (5 indicators)						
High intervention capability for satisfying socioeconomic activities – C1	85 (51.2)	41 (8.5)	70 (52.2)	20 (17.4)	155 (51.7)	61 (10.2)
Marginal intervention capability for satisfying socio-eco activities – C2	19 (11.4)	180 (37.2)	20 (14.9)	46 (40)	39 (13)	226 (37.7)
Low intervention capability for satisfying socioeconomic activities – C3	26 (15.7)	230 (47.5)	13 (9.7)	44 (38.3)	39 (13)	274 (45.7)
Very low intervention capability for satisfying socio-eco activities – C4	36 (21.7)	33 (6.8)	31 (23.1)	5 (4.3)	67 (22.3)	38 (6.3)
Total	166	484	134	115	300	599
Idealised Guttman Scale for adaptive capacity for water resource management (7 indicators)						
High adaptive capacity to deal with eco-hydro changes – D1	76 (45.8)	1 (0.2)	65 (48.5)	1 (0.8)	141 (47)	2 (0.6)
Marginal adaptive capacity to deal with eco-hydro changes – D2	44 (26.5)	122 (25.2)	29 (21.6)	35 (30.5)	73 (24.3)	157 (26)
Low adaptive capacity to deal with eco-hydro changes – D3	31 (18.7)	330 (68.2)	24 (17.9)	75 (65.2)	55 (18.3)	405 (67.6)
Very low water risks acceptability – D4	15 (9)	31 (6.4)	16 (11.9)	4 (3.5)	31 (10.3)	35 (5.8)
Total	166	484	134	115	300	599

Note: Source = Household's survey in 2021-2022

The second highest adaptive capacity group was evaluated at the medium adaptive capacity (D2), with scores of 26% in Myanmar and 24.3% in Vietnam. Only a small proportion of households reported high adaptive capacity scores (D1) being total scores of 0.6%, very low adaptive capacity scores (D4) being 5.6% in Myanmar, and low adaptive scores (D3) being total scores of 18.3% and very low adaptive capacity (D4) being total scores of 10.3% in the case of Vietnam. There are no significant differences between the two farm farming systems in Myanmar and Vietnam in these low and very low adaptive capacity categories. In this study, farm households in Myanmar are evaluated at low adaptive capacity, while the farm households in Vietnam belong to high adaptive capacity to deal with water resource management. Oo et al. (2018) observed that many social and economic conditions of the farm households influence the adaptive capacity. Thus, further studies are necessary to understand better the reasons or factors that influence the low and high adaptive capacity of farm households in Myanmar and Vietnam.

Regardless of the farming systems, rice-farming and fish-farming households in Myanmar and Vietnam are increasingly vulnerable to water security issues and susceptible to eco-hydrological changes and extreme climate events such as floods, water pollution, and saltwater intrusion. In terms of idealized Guttman's scaling analysis, the acceptability of water risks was evaluated as high scores, and the accessibility to water sources and related services in the region was recorded as medium in both Myanmar and Vietnam. In Myanmar, however, low intervention capability for satisfying socioeconomic activities and lower adaptive capacity to deal with ecological-hydrological changes were evaluated as the highest scores. In Vietnam, however, high adaptive capacity and high intervention capability were recorded. This study has highlighted the need to improve the intervention capability and adaptation capacity of farm households in the coastal areas of Myanmar. This study has pointed out the need for increased accessibility of farm households to water sources and water-related services in both countries. Therefore, policy interventions and community-based initiatives considering the different farming systems should play a vital role in developing adaptive strategies to mitigate water insecurity in the coastal areas. Strengthening flood protection measures, promoting awareness for improving water use efficiency, and supporting farming system resilience-building efforts are integral to addressing the long-term challenges posed by water insecurity in the rural areas of Myanmar and Vietnam.

Overall, the study highlights the importance of adopting a comprehensive approach that addresses the various dimensions of the water insecurity indices and considers the specific needs and challenges of farm households in ensuring the sustainable management and utilization of water resources in the coastal areas of Myanmar and Vietnam. By utilizing the localized indices and considering the various water user's groups in water insecurity evaluation, stakeholders can gain valuable insights into the complex ways that the water insecurity affects a diverse community. These insights can then used to inform targeted interventions, policy development, and resource allocation to improve water access, equity, and sustainability. Finally, we note that ongoing monitoring and evaluation are essential to track changes in water insecurity over time and assess the effectiveness of interventions aimed at addressing these challenges in both Myanmar and Vietnam. Further research is needed to better understand the reasons that influence the adaptive capacity and capability of farm households. Additional measurement considering the political, institutional, and environmental factors within the same income groups or farming systems can be conducted and compared within and between countries for mitigating adverse effects of natural disasters, and ecological-hydrological changes in the coastal areas of Myanmar and Vietnam.

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