

## Article

# The Influence of Environmental Transformation on Small-Scale Fishing Communities' Livelihood

Rabiul Islam <sup>1,\*</sup>, Ahmad Bashawir Abdul Ghani <sup>1</sup>, Sabina Sultana <sup>2</sup> and Emil Mahyudin <sup>3</sup>

<sup>1</sup> School of International Studies, University Utara Malaysia, Bukit Kayu Hitam 06010, Malaysia; bashawir@uum.edu.my

<sup>2</sup> School of Languages, Civilisation and Philosophy, University Utara Malaysia, Bukit Kayu Hitam 06010, Malaysia; mst\_saa\_sultana@ahsgs.uum.edu.my

<sup>3</sup> Department of International Relations, Universitas Padjadjaran, Bandung 45363, Indonesia; emil.mahyudin@unpad.ac.id

\* Correspondence: rabiul@uum.edu.my

**Abstract:** In Malaysia's northern area, small-scale fishing (SSF) communities in inland open water are among the most vulnerable people. This study looked at the impact of climate change on small-scale fishing communities in Malaysia's northern region from a vulnerability standpoint, using two vulnerability indexes. One is the Livelihood Vulnerability Index' (LVI) and the other is the Vulnerability Framework Approach of IPCC (LVI-IPCC method). The primary purpose of this study is to assess how climate change affects small-scale fishing communities. Data on SSF households were collected at random from three states to suit the research goal: Kedah, Penang, and Perlis. For an interview, a total of 352 SSF families were contacted. According to the Livelihood Vulnerability Index (LVI) research, SSFs in Perlis are more susceptible than those in Kedah and Penang. Adjustments to food policy, health services, informal credit facilities, training, and the establishment of more effective early warning systems are all necessary initiatives that the government must take to enhance the quality of life for SSF communities.

**Keywords:** climate change; inland open water; livelihood; small-scale fishing; sustainability



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## 1. Introduction

Fisheries and aquaculture contribute significantly to numerous aspects of a community, including livelihoods, food supply, and food security, at both the local and global levels. The fisheries and aquaculture sectors directly or indirectly sustain more than 600 million people, according to [1], and this figure is steadily increasing. The fishing business employs 58.3 million people worldwide. In 2014, Asia had the most fishers and aquaculture employees (84% of the total world fisheries), followed by Africa (10%), Latin American nations (approximately 4%), and the Caribbean (approximately 4%). Fish offer necessary nutrition to approximately 4 billion people, with 400 million individuals in the world's poorest countries receiving at least half of all animal protein and key minerals.

On the other hand, the trading of fish and fisheries products is vital for civilizations and economies. Fish is one of the most-traded food commodities on the planet, accounting for over 37% of worldwide output. In 2012, it accounted for around 10% of the total agricultural exports and 1% of the global commerce trade in value terms [2]. As a result, for many people in developing nations, fish is a vital source of protein as well as a source of income. Nonetheless, climate change is having an immediate and quiet impact on the fishing industry, with global ramifications that are unevenly distributed. Climate change is projected to have a wide range of direct and indirect consequences on both marine and inland fisheries, with implications for fishery-based livelihoods, small-scale fishermen, coastal communities, and individuals with lower incomes.

Fishery operations provide a variety of living options for fishing communities, but these opportunities may be lost due to a decrease in fish availability as a result of climate change. Furthermore, fishing communities do not have enough access to or control over resources such as specialized knowledge, money, or fishing equipment. Reduced fish production, on the other hand, indicates that they are consuming fewer vital vitamins, minerals, and animal protein. Versatile living dimensions are offered by fishery activities to the fishing communities, but as an impact of climate change, these opportunities might disappear due to the decrease in fish production. Moreover, fishing communities have inadequate access to and control over resources such as knowledge, cash availability, and related tools that are needed for fishing [3,4]. On the other hand, a decrease in fish production leads to a decrease in essential vitamins, minerals, and animal protein in their diet. So, the impact of climate change not only adversely affects fisheries but also limits the access of fishing communities to both money and food. This situation is even worse for small-scale fishing communities because no other alternative choices are available. These people have only limited capacity to cope and adopt alternative climate-resilient food- and income-generating activities. As there is a relationship between climate change, fisheries, and the well-being and adaptation of fishing communities, it is necessary to conduct studies on this issue [5].

As the conversation so far has revealed, the negative impact of climate change on fisheries and small-scale fishing communities is a worldwide and local phenomenon. This phenomenon raises challenges such as dwindling fish stocks, physical capital losses, infrastructure damage, illness risk, and food security vulnerability, among others. Small-scale fishermen are particularly vulnerable to the negative effects of climate change since they have no alternative options. These concerns are causing serious challenges, such as worsening living conditions for fishing communities, food security, low levels of adaptation among fishing communities, malnutrition, and poor fisheries management, to name a few. As a result, it is necessary to help small-scale fishing communities escape poverty [6]. These challenges should be effectively handled in Malaysia's northern area.

Climate change affects the fisheries sector severely across the world [7], especially considering inland, open-water, small-scale fisheries (SSFs), which are experiencing other non-climatic threats such as overfishing, loss of habitat, pollution, and disturbance. Moreover, SSF communities in developing countries, where 90% of fishery-dependent people live, are facing complex and localized impacts due to their limited mobility, widespread poverty, remoteness, and high dependence on fishing, as well as on subsistence farming [8].

Climate change's impact on inland fisheries has risen to the top of the priority list in recent years due to its immediate and potential consequences for the environment and human civilization, particularly considering food security [1]. Climate change is expected to have a wide range of effects on inland fisheries and the people who rely on them, from the cellular level to the ecosystem level, as well as social and economic implications. Malaysian fishing communities are disproportionately impacted by climate change's negative effects on fisheries, especially in interior fisheries, which are heavily influenced by temperature, rainfall, floods, soil erosion, and thunderbolts. As a result, climate change puts inland fishermen's livelihoods in jeopardy. This is something that concerns us. Climate change's visible repercussions must, in any case, be addressed. As a result, humanity's long-term survival is threatened [9].

To put it another way, climate change affects a fishery-based community's livelihood systems in many ways, prompting in-depth vulnerability and adaptation research [10]. While several studies have examined the impact of climate change on the vulnerability and adaptive capacity of the fisheries sector at the national level [11,12], there has been little research on the effects of climate change on the livelihoods of small-scale fishing communities and households in developing countries. National-scale studies are unable to yield precise enough results to be used at the household or community level [9], whereas local vulnerability evaluations of agricultural livelihood systems predominate [13–16].

Physical, biological, and chemical processes in aquatic systems are altering the fishing industry due to climate change. As a result of these variables, fish habitats are continually changing. In addition, fish life cycles, species abundance, fish compositions, and distributions are all undergoing significant changes. All these aspects have the potential to affect fisheries' livelihood options, management policies, food supply, and development sustainability. Extreme climatic events such as sea-level rise, cyclones, floods, storms, and heavy rainfall can all have a direct influence on fishing activities. The physical infrastructure of fishing villages, on the other hand, is harmed in the following ways: Capital assets such as fishing gear, boats, fish landing sites, roads, and other post-harvesting facilities are destroyed or seriously damaged. Climate change has also damaged other non-climatic influences in the fishing industry, according to research by [5,17]. The authors claim pollution, overfishing, damage to fish habitats, and other non-climatic pressures, are examples.

Climate change can affect the susceptibility as well as the adaptation of individual families in a community. 'Vulnerability' refers to an individual's exposure to community pressures as a result of numerous changes in social and environmental situations [1,18]. Moreover, the Intergovernmental Panel on Climate Change [15] outlines three important components that are used to evaluate the idea of climate change vulnerability: Exposure to a specific climatic event, the degree of sensitivity of that specific climatic event, and the adaptive ability of the community to which the climatic event happens. The influence of climatic phenomena such as rising sea levels, cyclones, severe rainfall, riverbank erosion, temperature rises, drought, and so on has a significant impact on a community's livelihood [15,19–22].

Due to the fleeting nature of the resources, the harsh climate of the oceans, and the perishability of the product, fishing is acknowledged as one of the living activities with the largest number of hazards [23]. Fish productivity, abundance, and dispersion may all be affected by climate change [5,24]. As a result of these changes, the cost of catching fish will rise. Fish drying has always been a time-consuming process that has been particularly vulnerable to climate change. Temperature fluctuations and heavy rains can stymie the process, increasing the cost of fish processing. Furthermore, considering the climatic impact on fish capturing and processing [4], previous research discovered that populations relying on fisheries experienced a major impact on their employment status, income, and nutrition. Fisheries-dependent communities are the most vulnerable, according to [5,6,25] since they lack the ability to foresee and adapt to changes in climatic occurrences.

Each home in a neighborhood has a different level of vulnerability. Climate change can affect families differently depending on the amount of adaptive ability and sensitivity, according to several research studies [14,26,27]. Furthermore, these two factors are intertwined with a community's livelihood assets and tactics. According to [28], a link was found between household income and adaptability. According to this study, households in a community that is comparatively impoverished have a lower capacity to adjust to such shocks. The reason for this is that lower-income households have less access to different assets such as capital, cash, and physical goods. Furthermore, they have fewer skills and abilities to take advantage of available resources. Small-scale fishing communities are regarded as being more sensitive to climatic shocks and pressures since most studies indicated they are substantially impoverished within the community [5,29].

'Vulnerability' is a hot issue in global change studies and climate change research at present [15]. The concept of vulnerability, which has been employed in a variety of climate change studies, combines ecological and social science viewpoints. It is usually noted in the study of natural sciences, for example, that there is always a trend toward embracing the notion of physical flows. This perspective also emphasizes the movement of material and energy among the many system components. In addition, the actor system perspective is employed in the social sciences, which stresses both the flow of information as well as the linkages between diverse issues that are important in generating social decision outcomes. The IPCC, on the other hand, combines scientific and social sciences views to

define vulnerability as “the degree to which a system is sensitive to, and unable to deal with, detrimental consequences of climate change, including climatic vulnerability” [30,31].

In this inquiry, this criterion was employed to identify vulnerability. According to [15], “Vulnerability is a result of a system’s sensitivity and adaptive capacity, as well as the sort, degree, and tempo of climate change and fluctuation to which it is subjected”. Each of these three components of vulnerability (e.g., exposure to change, sensitivity to change, and adaptability to change) has a specific impact on vulnerability, according to the IPCC definition. Vulnerability and exposure, as well as sensitivity and vulnerability, for example, have a link. Adaptive capacity, on the other hand, reduces vulnerability, implying that adaptive capacity has a negative impact on vulnerability.

The IPCC defines the three components of vulnerability separately. “The nature and extent to which a system is susceptible to substantial climatic variations” is defined as “the nature and extent to which a system is exposed to large climatic shifts” [15,32]. According to another definition, vulnerability is “the degree to which a system is touched, either adversely or favorably, by climatic variation or change” [15]. According to the IPCC, adaptive capacity is described as “a system’s ability to react to climate change, to minimize potential damage, to grab opportunities, or to deal with the consequences” [15]. Though adaptive capacity is generally considered a requirement for a community’s ability to adapt to change in the aftermath of climatic disasters [5,33], it may be improved by employing practical coping strategies [34,35].

The goal of this study is to use the livelihood vulnerability index and Vulnerability Framework Approach of IPCC to examine the impact of climate change on small-scale fishing communities in Malaysia’s northern area from a vulnerability standpoint.

## 2. Methodology

### 2.1. Population

The target population is small-scale fishing-based communities in the inland water area of Malaysia’s northern region. However, due to a lack of finance and a time limitation, small-scale fishing villages in Malaysia’s Northern Region were chosen for this study.

### 2.2. Design of Sampling

This research chose households from the intended sampling frame using a random sampling procedure. This study employed a web-based random number generator application to assure randomization. It continued generating numbers until the sample size was reached. Random numbers were created for this purpose using the website <https://www.random.org/>, accessed on 25 October 2021. Randomness and Integrity Services Limited is an Irish firm that has been providing random numbers since 1998. Accordingly, [36] exploited this relationship in their research.

### 2.3. Number of Samples

It is vital to calculate the appropriate sample size for each primary research project before beginning. In an article titled “Small Sample Techniques” devised a table for estimating sample size [24]. Regardless of population size, the maximum sample size is 384, according to this table. The table’s fundamental flaw is that it was created for a finite population. However, in its survey guide “Designing Home Survey Samples: Practical Guidelines” [22], it suggested a method for calculating the sample size for conducting primary research that is specifically tailored for household surveys. This formula was used to calculate the sample size for this investigation. The following is the specified formula:

$$nh = (z_2) \cdot (\alpha) \cdot (1 - \alpha) \cdot (d) \cdot (h) / (t) \cdot (\beta) \cdot (e_2) \quad (1)$$

For the preceding Equation (1), the parameters are explained in the following Table 1.

**Table 1.** Explanation of the parameters in Equation (1).

Name of the Parameter	Explanation
$n_h$	is denoted as the sample size of those households that are been selected
$z$	is the desired level of confidence level
$\alpha$	is considered as an estimate of a key indicator that would be measured in the survey
$d$	sample design effect
$h$	is a multiplier to account for the anticipated rate of non-response
$t$	is the proportion of the total population accounted for by the target population and upon which the parameter, $\alpha$ , is based
$\beta$	symbolizes as the average household size which is the number of persons per household
$e$	is the error term

#### 2.4. Data Collection Method

Both quantitative and qualitative methodologies were used in this investigation. Most of the time, quantitative approaches are employed to acquire the study's background data. On the other side, qualitative data were used in this study to obtain more thorough and standard information [37,38]. Primary data were collected through questionnaire surveys. In addition, the prepared questions for household surveys were included in the quantitative methodologies for this study. Oral interviews, vulnerability matrices, key information interviews, and focus group discussions were among the qualitative methodologies used in the study [7].

#### 2.5. Mathematical Calculation

In this part, the mathematical computation of LVI is broken down into three steps.

Step 1: This stage determines the values for each of the main components. Because all major components and subcomponents contribute equally to the overall index, the values of the components and their subcomponents were determined using a balanced weighted approach. However, past investigations have shown that the subcomponents are measured on distinct scales. As a result, the subcomponent values must be normalized using the formula below:

$$\text{Index } X_a = \frac{X_v - X_{min}}{X_{max} - X_{min}} \quad (2)$$

The initial sub-component for a specific region is denoted by  $X_a$  in Equation (2). The  $X_{min}$  and  $X_{max}$  symbols represent the minimum and maximum values for each sub-component, respectively.

Step 2: After standardization, the sub-components were averaged to calculate the values of each major component. The sub-components were averaged using the equation below.

$$P_a = \frac{\sum_{i=0}^m \text{Index } X_{ai}}{n} \quad (3)$$

Each  $P_a$  in the following equation represents one of the major components for a given area  $a$ , with  $\text{Index } X_{ai}$  denoting the sub-components, indexed by  $i$  that make up each major component. Finally,  $n$  denotes the number of sub-components that each major component contains.

Step 3: The next step was to compute the value of LVI after receiving the data for each of the seven key components. The averaged value of LVI was calculated using Equations (3) and (4).

$$\text{LVI}_a = \frac{\sum_{z=1}^7 H_{P_z} P_{az}}{H_{P_z}} \quad (4)$$

After calculating the LVI, the next step is to calculate the Climate Vulnerability Index (CVI). To do so, we must calculate the index of the three dimensions of vulnerability,

which comprises step 4 (e.g., exposure, sensitivity, and adaptive capacity). The next three equations (Equations (5)–(7)) show the mathematical calculations.

$$Exp_o = \frac{H_{expo1}ND + H_{expo2}CV}{H_{expo1} + H_{expo2}} \quad (5)$$

The index for exposure ( $Exp_o$ ) includes natural disasters ( $ND$ ) as well as climate variability ( $CV$ ). In the above equation,  $H_{expo1}$  and  $H_{expo2}$  represent the corresponding weights for the components of exposure.

$$Sens = \frac{H_{sens1}H + H_{sens2}F + H_{sens3}W}{H_{sens1} + H_{sens2} + H_{sens3}} \quad (6)$$

In Equation (6), the index for sensitivity ( $Sens$ ) is calculated, where  $H_{sens1}$ ,  $H_{sens2}$ , and  $H_{sens3}$  were the weights of the major components of health, food, and water, respectively.

$$AdCp = \frac{H_{adcp1}SD + H_{adcp2}LS + H_{adcp3}SN}{H_{adcp1} + H_{adcp2} + H_{adcp3}} \quad (7)$$

Finally, in Equation (7), the index for adaptive capacity ( $AdCp$ ) is calculated where  $H_{adcp1}$ ,  $H_{adcp2}$ , and  $H_{adcp3}$  represent the weight of the socio-demographic profile of the selected community, their livelihood strategies, and the community's social networks, respectively.

After calculating the index value of exposure, the index value of sensitivity, and the index value of adaptive capacity, in step 5, they are combined to obtain the  $CVI$ . The following equation is used to calculate the  $CVI$ :

$$CVI = 1 - \left\{ \frac{M_1 Exp_o + M_2 AdCp}{M_1 + M_2} \right\} * \left\{ \frac{1}{Sens} \right\} \quad (8)$$

In Equation (8),  $M_i$  is denoted as the number of major components that are in the  $i$ th dimensions of vulnerability. The value of each dimension is between the maximum value of 1 and the minimum value of 0.

## 2.6. Livelihood Strategy

The Livelihood Vulnerability Index (LVI) is a combination of multiple indicators. The indicators are as follows: To assess exposure, the indicators are natural disasters and climate change. The second indicator is the household's social characteristics and economic characteristics that affect their adaptive capacity. The final indicator is the quality of the household's current health, food, and water resources that limit their sensitivity to the impact of climate change [9]. However, [4] also identifies seven major components of LVI, which are almost identical to those in [9]. These include the sociodemographic profile of a community, a community's livelihood strategies, social networks, people's access to a health facility, access to food, access to water resources, and, finally, the impacts of natural disasters and several climatic variabilities. Each component consists of a number of sub-components or indicators. The LVI method is very flexible in terms of adding or removing indicators. Scholars have applied two approaches to the LVI method. One approach is to calculate the LVI as a composite index of the seven crucial components, whereas the other approach advocates for presenting the seven components in IPCC along with the three prescribed major contributing factors (e.g., exposure to change, sensitivity to change, and adaptive capacity to change) of vulnerability.

However, the LVI method is more useful and preferred over SLA for several reasons. Chief among them is that the LVI is considered to provide different institutions with an applied tool for understanding demographic, social, and health factors contributing to climate change at the community level. For instance, [9] proposed that the LVI method is very useful to quantify the strength of the current livelihood of a community by characterizing the quality of their health and water resources. Additionally, the LVI approach also

emphasizes the alteration capacity of communities' livelihood strategies regarding those exposures that are related to climatic events [6].

Researchers collected data for seven major components from each household. Each of the major components had certain subcomponents (see Table 2). After aggregating the data, a composite index was developed by the authors, and this index was used to compare the vulnerability status between the two districts of Mozambique. The authors suggest that to estimate vulnerability to climate change, LVI is not only a pragmatic approach but can also be set as a baseline for various comparisons.

**Table 2.** Major components and subcomponents that are used by [9].

Major Components	Sub Components
Socio-Demographic Profile	<ol style="list-style-type: none"> <li>1. Dependency Ratio.</li> <li>2. Percent of female-headed households.</li> <li>3. Percent of households where head of the household has not attended school.</li> <li>4. Percent of households with orphans.</li> </ol>
Livelihood	<ol style="list-style-type: none"> <li>1. Percent of households with family member working in a different community.</li> <li>2. Percent of households dependent solely on agriculture as a source of income.</li> <li>3. Average Agricultural Livelihood Diversification index.</li> </ol>
Health	<ol style="list-style-type: none"> <li>1. Average time to health facility (minutes).</li> <li>2. Percent of households with family member with chronic illness.</li> <li>3. Percent of households where a family member had to miss work or school in the last 2 weeks due to illness.</li> <li>4. Average Malaria Exposure Prevention Index.</li> </ol>
Social Network	<ol style="list-style-type: none"> <li>1. Average Receive: Give Ratio.</li> <li>2. Average Borrow: Lend Ratio.</li> <li>3. Percent of Households that have not gone to their local government for assistance in the past 12 months.</li> </ol>
Food	<ol style="list-style-type: none"> <li>1. Percent of households dependent on family farm for food.</li> <li>2. Average number of months households struggle to find food.</li> <li>3. Average Crop Diversity Index.</li> <li>4. Percent of households that do not save crops.</li> <li>5. Percent of households that do not save seeds.</li> </ol>
Water	<ol style="list-style-type: none"> <li>1. Percent of households reporting water conflicts.</li> <li>2. Percent of households that utilize a natural water source.</li> <li>3. Average time to water source (minutes).</li> <li>4. Percent of households that do not have a consistent water supply.</li> <li>5. Inverse of the average number of liters of water stored per household.</li> </ol>
Natural Disasters and Climate Vulnerability	<ol style="list-style-type: none"> <li>1. Average number of flood, drought, and cyclone events in the past 6 years.</li> <li>2. Percent of households that did not receive a warning about pending natural disasters.</li> <li>3. Percent of households with an injury or death as a result of the most severe natural disaster in the past 6 years.</li> <li>4. Mean standard deviation of the daily average maximum temperature by month.</li> <li>5. Mean standard deviation of the daily average minimum temperature by month.</li> <li>6. Mean standard deviation of average precipitation by month.</li> </ol>

Source: [9].

Moreover, Table 3 shows the distribution of household sizes in the three study states. The most frequent household size is 4 and the least frequent is 7. Moreover, the Shapiro–Wilk test value for the household size is 0.24, which means the household size is normally distributed.

**Table 3.** Distribution of household size in the study areas.

Household Size	Kedah	Penang	Perlis	Total
2	10	9	8	27
3	28	29	26	83
4	41	41	46	128
5	20	27	28	75
6	15	10	6	31
7	1	5	2	8
Total	115	121	116	352

Source: Field Survey (2021).

Above the household surveys, 352 samples were taken in this SSF. Thirty oral interviews and 30 key-informant interviews were taken from each community. The key-informant interview is a type of qualitative in-depth interview. Both types, key-informant and in-depth interviews, forego preconceived questions to instead focus on the dynamic flow of conversation between the researcher and participant(s). However, depending on the resources, as well as the type of data needed, companies often choose one method over the other. Key informants are experts. Thus, researchers only use key informant interviews when they can secure a participant with unique knowledge of a topic. In-depth interviews can be conducted with anyone. Key-informant interviews frequently take less time to administer than standard in-depth interviews. This is because there are typically fewer “experts” to interview as compared to the public (from which a sample of participants might be chosen for in-depth interviews). In addition, there were 6 focus groups from each state, and each focus group consisted of 10 people. In total, 500 questionnaires were administered, of which 400 were returned and 352 were accurately completed.

There is a general perception that women are more socially vulnerable than men because of higher poverty rates and fewer job opportunities, and this perception is more widespread for female-headed households due to fears of intergenerational poverty transmission [39]. Female-headed households are forced to play multiple, conflicting roles after losing their spouses, and have to work in marginal, part-time, informal, and low-income jobs due to lack of access to high-paying jobs. These women are unable to maintain their health due to problems such as poverty, poor socioeconomic status, and multiple responsibilities [40]. As a result, they experience more high-risk behaviors and lower quality of life and family satisfaction. They also suffer from stress, mental disorders, depression, drug abuse, and financial and cultural poverty.

Since most women in the study area have low literacy and are unable to pursue a specific occupation, they face many problems after their husband’s death regarding accepting the head of the household role. In some cases, children from these families are forced to work as child workers and stay away from school. Somehow the cycle of poverty within the family is reproduced, and poverty is passed on to the next generation, with an indefinite future awaiting them.

Children in small families, especially first and only children, tend to have higher school and personal achievement levels than children of larger families. The financial costs of maintaining a household are lower. It is easier for both parents to combine careers with family life. Therefore, smaller families are less vulnerable than larger families.

Due to the gender stereotypes and the patriarchal system in the area under study, accepting a woman as the head of a household can be difficult even for male children, and there can be resistance, so women have intra-family pressures in addition to social pressures. In Asian society, women are not provided with proper economic and social

support, and the socio-cultural conditions do not allow them to work outside the home in many cases, so the economic burden of these families is more on the children. Thus, many children are forced to start working at an early age, drop out of school, and no longer have a chance to have a better life in the future, resulting in the reproduction of poverty and disability in female-headed families.

Poverty is expressed as those receiving assistance, families below the poverty line, and individuals older than 65 and younger than 18 in poverty. A high rank indicates a high rate of poverty and a more vulnerable population. Advanced age by itself does not create vulnerability. However, certain problems that are more common in old age can increase vulnerability. They include decreased strength, poor tolerance of physical activity, functional limitations, decreased sensory awareness, a greater prevalence of chronic conditions, multi-morbidity, cognitive impairment, and medication. That is why older families are more vulnerable than younger families.

### 3. Results and Discussion

#### 3.1. Vulnerability Status of SSFs

Social scientists have recently drawn attention to another aspect of SSFs that has a bearing on conservation, namely that many small-scale fishers lead vulnerable lives and are extremely susceptible to misfortune [5]. The origins of these vulnerabilities, however, are often found outside the fisheries themselves, and are related to basic human needs such as access to drinking water, health facilities or schools for their children, or simply the need for political recognition. For these people, poor or degrading environmental conditions are not the primary cause of “poverty”. IPCC defines the three components of vulnerability separately. Exposure is “the nature and degree to which a system is exposed to significant climatic variations”. Sensitivity is defined as the degree to which a system is affected, either adversely or beneficially, by climate variability or change. However, the ideas of adaptation and coping are closely associated with each other, even though the theory on coping comes from the literature related to food security.

The overall age structure of the household heads lies between 18 years to 85 years, though the average age of the household heads for the overall study is 41.4 years. However, female household heads’ age is higher (41.9 years) compared with their male counterparts (41.3 years). Furthermore, the average age of the household heads for Kedah and Penang is more than 41 years (41.9 and 41.4 years, respectively), whereas for Perlis, it is less than 41 years (40.7 years precisely). Moreover, 16.8% of household heads’ (59 household heads) age is below 30 years, whereas 8.3% of household heads (29 household heads) are aged 60 years old and above. Furthermore, 50.3% of household heads’ age (177 household heads) lies between 30 and 45 years, and the remaining 87 household heads’ ages are between 46 and 60 years.

Moreover, 46.59% of household heads (164 household heads) reported that they attended school, of which 153 household heads are male and the remaining 11 are female. Furthermore, 56 household heads (48.70%) attended school in Kedah, 64 household heads (52.89%) attended in Penang, whereas only 44 household heads (37.93%) attended in Perlis. Additionally, the average years of schooling for the household heads are 7.2 years, whereas, specifically, for Kedah, it is 7.5 years, for Penang, it is 6.7 years, and for Perlis, it is 7.7 years. In addition, 50% of the total household heads (82 household heads) have 1 to 6 years of schooling.

In terms of social networking, 36.93% of households (130 households) reported that, in the past month, they have borrowed money either from their relatives or friends. However, in terms of lending money, surprisingly, only 15.06% of households (53 households) reported that they have lent money to relatives and friends in the past month. On the other hand, 22.44% of households (79 households) said they received help from their friends and relatives.

The vulnerability status of SSFs in the Northern Region owing to climate change is explored in this section. Furthermore, the livelihood vulnerability index (LVI) was utilized

to analyze the SSF community's climatic vulnerability, as were the LVI sub-component values for each state and the study regions' lowest and maximum values. Table 4 also includes the primary component values as well as the composite LVI value for each state.

**Table 4.** LVI major component index values and overall LVI value for three states.

	Kedah	Penang	Perlis
Sociodemographic Profile	0.295	0.308	0.322
Livelihood Strategies	0.511	0.501	0.462
Social Networking	0.315	0.322	0.250
Health	0.228	0.278	0.284
Food	0.502	0.354	0.387
Water	0.107	0.111	0.182
Natural Disaster and Climate Vulnerability	0.556	0.464	0.612
LVI	0.354	0.326	0.359

The LVI method's first key component is the sociodemographic profile (SDP). The dependency ratio, percentage of female-headed households, percentage of households where the household head did not attend school, average number of family members in the household, percentage of households where women family members are not allowed to work outside the house, and the average age of the household head are all subcomponents of SDP in this study. Moreover, in Table 4, the index values for SDP and its subcomponents are presented. The SDP index values for Perlis (0.322) are higher than Penang (0.308) and Kedah (0.295).

In terms of livelihood strategies components, Kedah showed greater vulnerability (0.510) than Penang (0.502) and Perlis (0.462). Additionally, the social networking indicators were dissimilar for the three states. Overall, the households of Penang were more vulnerable than those of Kedah and Perlis in the social networking component (0.322 versus 0.315 and 0.250, respectively). The households of Perlis reported traveling an average of 16.21 min to a health facility while Kedah and Penang households reported an average of less than 15 min. After combining the sub-components, the overall health vulnerability score was higher for Perlis (0.284) than that for Penang (0.278) and Kedah (0.228). In addition, households of Kedah reported that they struggle to find adequate food for their families an average of 2.76 months per year compared to 2.75 months in Perlis and 2.39 months in Penang. The average food vulnerability score for Kedah was lower (0.502) than that for Perlis (0.387) and Penang (0.354). However, in the case of the water component, Kedah has a lower vulnerability score (0.107) than Penang (0.111) and Perlis (0.182).

All three states are quite similar in terms of natural disasters and the climatic vulnerability index, based on the reported number of floods, storm, rock rain, and cyclone events in the past 5 years, the percent of households who said they received no warning, the percent of households reporting a disaster-related injury or death, and the percentage of households who lost their physical assets due to extreme climatic events. Perlis households were more vulnerable (0.612) than Kedah (0.556) and Penang (0.464) households in terms of natural disaster and climatic vulnerability index.

Perlis has a higher LVI score (0.359 versus 0.354 and 0.326, respectively) than Kedah and Penang, indicating a greater sensitivity to climate change impacts. Table 4 shows the index values for each of the LVI's seven primary components, as well as the overall LVI value for the three states. Furthermore, when it comes to food, Kedah is more vulnerable than the other two states (0.502 versus 0.354 and 0.387). Perlis is also more vulnerable than the other two states in terms of water (0.182 versus 0.107 and 0.111). Perlis is, likewise, more vulnerable than the other two states in terms of sociodemographic status and health (0.322 versus 0.295 and 0.308, and 0.284 versus 0.228 and 0.278, respectively). Kedah is more vulnerable (0.511 compared to 0.501 and 0.462) in terms of livelihood strategy, and Penang is more vulnerable (0.322 versus 0.315 and 0.250) in terms of social networking

than the other two states. Finally, Perlis is more vulnerable to natural disasters and climate vulnerability than the other two states (0.612 versus 0.556 and 0.464).

However, the degree of vulnerability among the households within a community is not alike. Moreover, these two aspects are significantly related to a community's livelihood assets and strategies. According to this study, households that are relatively poorer within a community have less ability to adapt in terms of such shocks. The reason behind this is that relatively poorer households have less access to various assets such as capital assets, cash assets, physical assets, etc. Moreover, they also have fewer skills and less ability to take advantage of the existing resources. Since most of the studies found that small-scale fishing communities are relatively poor within their community, they are, thus, considered to be more vulnerable in terms of climatic shocks and stresses.

### 3.2. The Degree of Different SSF Communities of the Study Areas

The degree of climatic exposure, climatic sensitivity, and adaptive capacity of distinct SSF communities of the research regions are explored in this part using the LVI-IPCC framework, which is also the study's end purpose. Table 5 shows the values of the LVI-IPCC contributing elements for three states (Kedah, Penang, and Perlis).

**Table 5.** LVI-IPCC contributing factors calculation for Kedah, Penang, and Perlis, Malaysia (IPCC, 2001).

Contributing Factors to Vulnerability	Kedah	Penang	Perlis
Adaptive capacity (Socio-demographic profile, livelihood strategies and social network)	0.731	0.681	0.751
Sensitivity (Health, food and water)	0.261	0.229	0.272
Exposure (Natural disaster and climate vulnerability)	0.556	0.464	0.612
LVI-IPCC	−0.046	−0.050	−0.038

The sociodemographic profile, livelihood methods, and social networking are all aspects that contribute to adaptable capacity. In comparison to the other two states, Perlis has the highest adaptive capacity score (0.751) based on the LVI-IPCC contributing variables. On the other hand, the three key components of LVI, health, water, and food, are regarded as contributory factors for climatic sensitivity. Perlis has the highest adaptive capacity score, but it also has the highest sensitivity index of 0.272. Finally, natural disasters and climate vulnerability are factors that contribute to climatic exposure. Perlis, on the other hand, is regarded as the most vulnerable state in terms of climate change. It received a score of 0.612, which is significantly higher than the values of 0.556 and 0.464 for Kedah and Penang, respectively. Perlis households are more vulnerable to climate change than those in Kedah and Penang, according to climatic vulnerability studies. In contrast to households in Kedah and Penang, households in Perlis are shown to be the most vulnerable (−0.038 versus −0.046 and −0.050) according to the LVI-IPCC data.

IPCC defines the three components of vulnerability separately. Exposure is “the nature and degree to which a system is exposed to significant climatic variations”. Although it is expected that exposure to diverse climatic shocks and climatic stresses (e.g., a rise in the temperature, rise in the level of sea, cyclones, droughts, floods, and land erosion) are exaggerated because of these climatic alterations, frequent repetition of these sorts of exposure can cause massive loss and destruction of people's resources. As a result of this, it would negatively hamper their adaptive capacity and climatic resilience.

Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate vulnerability or change. On the other hand, according to IPCC, adaptive capacity is the ability of a system to adjust to climate change, moderate potential damage, take advantage of opportunities, or cope with the consequences. Though adaptive capacity is often considered as a prerequisite for the respective communities' adaptation ability to change after the occurrence of climatic events, it can be increased by enacting certain practical coping strategies.

Adaptive capacity is the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Climate adaptation is widely defined as the “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects”, which includes actions to moderate, avoid harm, or exploit beneficial opportunities. In this sense, adaptation is widely recognized as a promising way to enhance the adaptive capacity of a system in alleviating or minimizing the vulnerability to climate change impacts. It was further argued that adaptation takes many shapes and forms depending on the context of a community, region, or country [41]. It is not a homogeneous process and is affected by various factors and is often undertaken at the local level [42]. Considering its importance, IPCC placed local knowledge of adaptation at the center of discussion for formulating adaptation strategies to protect people and communities.

This study supports previous studies that have found that high index values for food, water, and health components act as primary drivers for vulnerability [43]. Moreover, working outside the community for part-time IGAs and high dependency ratios are very common among poor communities. The households have lived in their houses, on average, for the last 40 years, which indicates that they have very limited opportunities to shift to another location. Furthermore, they have less access to financial capital assets, which they believe is the most important asset within the capital asset pentagons. Additionally, from the oral interview, it was found that most SSF households do not have their own physical assets, such as land, fishing gears, boats, fishing nets, and others [44].

#### 4. Conclusions

The purpose of this research was to explore how climate change affects SSF communities in Malaysia’s northern region. The study’s particular goals were to (i) examine the vulnerability status of SSF communities in Malaysia’s northern area owing to climate change, and (ii) assess the degree of climate change exposure, sensitivity, and adaptation capability of SSF communities in Malaysia’s northern region. The livelihood vulnerability index (LVI) method and the LVI-IPCC framework methodology were used in this study to examine the climatic vulnerability of small-scale fishing livelihoods in Malaysia’s Northern region, which is regarded as one of the country’s primary open inland water sources. In addition, LVI is made up of seven key indicators, which can be broken down into three aspects of climatic vulnerability (exposure, sensitivity, and adaptive capacity). However, after computing the values of these three dimensions, the LVI-IPCC approach is utilized to determine the SSF community’s total climate vulnerability.

The overall objective of this study was to assess the impact of climate change on small-scale fishing communities of the northern region of Malaysia. They are surrounded by both climatic as well as non-climatic problems. These households face the adverse effects of climate change and extreme climate events such as floods, storms, rock rain, and cyclones, which become part of their life. Most of the households lost their physical assets during extreme climate events.

The findings of this study can be used to inform public policy. Households have been living in their homes for an average of 40 years, indicating that they have very limited options for moving. On the other hand, even though they have been living there for a long time, essentially all households experience health-related issues, such as chronic health problems, a lack of hygienic latrines, missing work or school due to illness, and so on. In addition, the average time spent travelling to the nearest healthcare facility is greater (average time 15 min). They also have limited access to financial capital assets, which they regard as the most important of the five capital assets.

Furthermore, the oral interview revealed that the majority of SSF households lack physical assets such as land, fishing gear, boats, and fishing nets. As a result, they were unable to obtain formal financing from banks or non-governmental organizations. Our advice to the government and local stakeholders is to ensure the construction of sanitary latrines and to monitor the health status of the SSF fishing villages through Community

Clinics (CC). Reduced fish catching, food scarcity, and everyday food shortages, on the other hand, are all threatening their livelihood. Our advice to the relevant authorities is to maintain a steady supply of water and safe drinking water for SSF villages. If this is accomplished, SSF families can be free of numerous water-borne illnesses.

Finally, natural calamities such as floods, rock rain, storms, and cyclones are common in the study areas. Extreme climatic occurrences caused households to lose their physical goods, and family members were harmed during natural disasters. Our advice to the government and all local stakeholders is to implement an early warning system for each SSF household. Furthermore, effective early warning systems (EWS), as well as proper post-disaster management, is required for SSF communities.

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