Application of livelihood vulnerability index to assess risks from flood vulnerability and climate variability - A case study in the Mekong Delta of Vietnam

Nguyen Duy Can[1], Vo Hong Tu[1] and Chu Thai Hoanh[2]

[1]*College of Rural Development, Cantho University, Vietnam*
[2]*International Water Management Institute (IWMI), Vientiane, Lao PDR*

Abstract

An Giang of the Mekong Delta is one of the most vulnerable provinces to flood and climate variability impacts, and that by annual flood, thousands of households are being at risks due to severe flood. Current management interventions remain a challenging task for decision makers and less understanding people livelihoods that leads to more vulnerable to flood and poverty. This study applied the livelihood vulnerability index (LVI) that developed by Hahn et al. (2009) to estimate flood vulnerability in two villages, Phu Huu (An Phu district) and Ta Danh (Tri Ton district) of An Giang province. We surveyed 120 households in each village to collect data on socio-demographics, livelihoods, health, social networks, physical and finance, natural resources, natural disasters and climate variability. Gathered data were calculated for LVIs using a composite index and differential vulnerabilities were compared. Results show that the overall LVI of Phu Huu is higher than overall LVI of Ta Danh village. The result is also suggested that this practical method may be applied for other purposes, to monitor vulnerability, evaluate potential program or policy effectiveness by introducing scenarios into the LVI model for baseline comparison.

Key words: An Giang, livelihood, vulnerability index, flood vulnerability and climate variability

1. Introduction

In the Vietnamese Mekong Delta, flood is a recurrent seasonal event, about 2.7 million ha are subjected to flood-prone areas, and thousands of villagers are vulnerable to floods (MRC, 2005; 2006; Sanh and Can, 2009). An Giang is located in upstream of the Vietnamese Mekong Delta and as one of most province suffer from flood. For instance, the 2000's flood killed 134 inhabitants, destroyed 151,867 houses, and caused damage in economic at about US$ 42 million (CFSC, 2000). Since after the 2000's flood, despite many efforts from local governments, especially efforts in "structural measures"/ or "concrete measures", including investments in dikes but still suffer (MARD, 2007). Recently, the flood in 2011 had been continuous causing heavy losses in infrastructure and agriculture (CFSC, 2001; 2011). Most of the An Giang population is engaged within agricultural systems that typically involve in cultivation of rice, and over 20% of the population who living in flood-prone areas survive below the poverty line (CFSC, 2011). Therefore, it is feared that flood will cause of rural poverty as it poses a major threat to people's livelihoods and properties through destructive impacts on infrastructure and environment as well as disturbance to livelihood activities of people living in flood-prone areas. In relation to the flood, floods are associated with climate variability and flooding in the region would be more serious in the future, with expecting to increase in duration, timing and frequency (MRC, 2009; Wassmann et al., 2004).

This study aims to improve better understanding people livelihoods and sources of livelihood vulnerability in flood-prone villages of An Giang province. It is based on an empirical study of livelihood assets and application of livelihood vulnerability index (LVI). The LVI is designed to provide development organizations and local policy makers with a practical tool to understand demographic, social and other related factors contributing to flood vulnerability at the community or district levels.

2. Methodology

2.1 Constructing livelihood vulnerability index (LVI)

This study adopted the Sustainable Livelihood Framework (Birkmann, 2006) to guide the assessment of livelihood vulnerability to floods. The Sustainable Livelihood Framework (SLF) where *Vulnerability Context* is major determinant of sustainability of livelihood assets as it directly influences livelihood strategies, institutional process and livelihood outcomes of community (Chambers and Conway, 1992; DFID, 2000). The effects of floods and climate variability have been considered under the vulnerability context of SLF. The level of vulnerability of community determines the impacts of floods and climatic conditions on people‘s livelihood assets, strategies and outcomes. This study aimed at calculating level of vulnerability to the impacts of those extreme floods and climate variability in two different flooded villages of An Giang - a Mekong Delta Province of Vietnam by applying a LVI that developed by *Hahn et al.* (2009). The components that are the indicators of vulnerability of community to flood impacts are presented in Table 1. These components are classified under 5 different livelihood assets in SLF: human, physical, social, natural, financial. The sub-components have been developed as indicators under a single component which are showed in Table 1.

Table 1. Capitals, major component and sub-component comprising the livelihood vulnerability index.

Capitals	Major component	Sub-component (Indicator)
Human	Health	Percent of HHs with family member with illness
		Percent of HHs with family member get illness due to flood
	Knowledge & skills	Percent of HHs head unlettered
		Percent of HHs head just passed primary school
		Percent of HHs head that not receive any training to cope with flood
	Livelihood strategy	Average agric. livelihood diversity [1/ (no. of agric. activities + 1)]
		Percent of HHs dependent on agric as major source of income
		Percent of HHs reported no non-farm activities as affected by flood
		Percent of HHs with no jobs (during flood season)
		Percent of HHs exploring NR (during flood season)
		Percent of HHs do fishing (during flood season)
Natural	Land	Percent of HHs with landless
		Percent of HHs with small land (0.1-0.5 ha)
	Natural resources	Percent of HHs that not cultivate the 3rd crop
		Percent of HHs that depend on (exploit) natural resources
		Percent of HHs that depend on (do) fishing during flood
	Natural disasters and climate variability	Average number of most severe flood in the past 10 years
		Average of death/injury as result of most severe flood in past 10 years
		Percent of HHs did not receive a warning about flood
		Mean standard deviation of monthly average of average water level in Tan Chau (earlier flood zone; years: 2007-2011)
		Mean standard deviation of average precipitation by month (ave. 5 years)

Social	Socio-demographic	Dependency ratio
		Percent of female head HHs
		Average family member in a HHs
		Percent of poor HHs
	Social networks	Percent of HHs receive helps due to flood
		Percent of HHs that have not been membering of any organizations
Physical	Housing & prod. means	Percent of HHs that with non-solid house
		Percent of HHs that with housing affected by flood (partially to totally submerged)
		Percent of HHs that report no access to production means
Financial	Finance and incomes	Percent of HHs borrow money
		Percent of HHs with net HHs income lower 1000 USD
		Percent of HHs with non-income within flood season

2.2 Calculating the livelihood vulnerability index (LVI)

The LVI encompasses ten major components: Health, Knowledge & skills, Livelihood strategy, Land, Natural resources, Natural disasters and climate variability, Socio-demographic, Social networks, Housing and production means, and Finance and incomes. Each major component is included several sub-components or indicators (Table 1). These were developed based on available data that collected through household surveys from studies on flood sector of An Giang and the Mekong Delta of Vietnam.

The LVI constructs a balanced weighted average approach (Sullivan et al., 2002; Hahn et al., 2009) where each subcomponent contributes equally to the overall index even though each major component of different livelihood assets is comprised of a different number of sub-components (Table 1). Because this study intended to develop an example of assessment tool accessible to a diverse set of users in resource-poor settings, the LVI formula uses the simple approach of applying equal weights to all major components. This weighting scheme could be adjusted by future users as needed. Because each of the sub-components is measured on a different scale, they are therefore first standardised as an index. The equation used for this conversion was adapted from that used in the Human Development Index to calculate the life expectancy index (UNDP, 2007), and in Livelihood Vulnerability Index to assess risks in Mozambique (Hahn et al., 2009):

$$index_{sv} = \frac{S_v - S_{\min}}{S_{\max} - S_{\min}} \quad \text{Eq. (1)}$$

where S_v is the original sub-component for representative village *v;* S_{min} and S_{max} are the minimum and maximum values, respectively, for each sub-component determined using data from both villages of An Giang Province.

After each was standardized, the sub-components were averaged using equation (2) to calculate the value of each major component:

$$M_v = \frac{\sum_{i=1}^{n} index_{svi}}{n} \quad \text{Eq. (2)}$$

where M_v is one of the ten major components for village *v; index*$_{svi}$ represents the sub-components, indexed by *i*, that make up each major components; and *n* is the number of sub-components in each major component.

After the ten major components for a village were calculated, major components that make up each livelihood assets were average using formular (3) to obtain vulnerability value for each livelihood assets or capitals. One values for each livelihood assets [Human capital (H), Natural capital (N), Social capital (S), Physical capital (P) and Financial capital (F)] for a village were calculated, they were averaged using the same this formular (3) to obtain the village-level LVI:

Error! Bookmark not defined. $$LVI_v = \frac{\sum_{i=1}^{5} w_{M\,i} M_{vi}}{\sum_{i=1}^{5} w_{Mi}} \qquad \text{Eq. (3)}$$

which can also be described as

$$LVI_v = \frac{w_H H_v + w_N N_v + w_S S_v + w_P P_v + w_F F_v}{w_H + w_N + w_S + w_P + w_F} \qquad \text{Eq. (4)}$$

where LVI_v is the vulnerability index for one of the five livelihood assets of village *v*, equals the weighted average of major components which form that livelihood asset; w_{Mi} : the weights of each major component, are determined by the number of sub-components that make up each major components/ or each capitals. In this study, the LVI is ranged from 0 to 1; 0 denoting least vulnerable and 1 denoting most vulnerable.

2.3 Calculating the LVI-IPCC

This study also adopted an alternative method for calculating LVI that incorporated the Intergovernmental Panel on Climate Change (IPCC) vulnerability which used by Hahn et al. (2009). The LVI-IPCC diverges from LVI when the major components are combined. They are combined according to the categorization scheme in Table 2, using the following equation:

$$CF_v = \frac{\sum_{i=1}^{n} w_{Mi} M_{vi}}{\sum_{i=1}^{n} w_{Mi}} \qquad \text{Eq. (5)}$$

where CF_p is an IPCC defined contributing factor (exposure, sensitivity, or adaptive capacity) for village *v*, M_{vi} are major components for village *v* indexed by *i*, w_{Mi} is the weight of each major component, and *n* is the number of major components in each contributing factor. One exposure, sensitivity, and adaptive capacity were calculated, the three contributing factors were combined using the formula that developed by Hahn et al. (2009):

$$LVI - IPCC_v = (e_v - a_v) * s_v$$

where LVI-IPCC$_v$ is the LVI for village *v* expressed using the IPCC vulnerability framework, *e* is the calculated exposure score for village *v*, *a* is the calculated adaptive capacity score for village *v*, and *s* is the calculated sensitivity score for village *v*. The LVI-IPCC is scaled from -1 (denoting least vulnerable) to 1 (denoting most vulnerable).

Table 2. Categorization of major components into contributing factors from IPCC.

IPCC Contributing factors to vulnerability	Major components
Exposure (e)	Natural disasters and climate variability
Adaptive capacity (a)	Socio-demographic
	Livelihood strategies
	Social networks
Sensitivity (s)	Health, knowledge & skills
	Land and natural resources
	Financial

Source: Adapted from Hahn et al. (2009).

2.4 Study area and household surveys

The study was carried out at two villages namely: Phu Huu (An Phu district) and Ta Danh (Tri Ton district) of An Giang (Fig. 1). An Giang, a Mekong Delta province of Vietnam, is located in upstream and one of most flood affected province in the Vietnamese Mekong Delta. The province has total area of 353,676 ha, in which 297,872 ha are agricultural lands with mainly rice growing. The population of the province is of 2,273,150 people in which 72% of population living in rural areas, and people who live in flood-prone areas of the province are very poor. The two villages selected for surveys are situated in different zones. Phu Huu village is considered as earlier flooding zone with seasonal flooding occurs during early July to October, whereas Ta Danh village is considered as a later flooding zone with seasonal flooding occurs late July to November. Phu Huu is a big village with 4,460 households, but more than 26% of total households are subjected to poor households. The village has a total natural area of about 4,000 ha, in which 3,555 ha are used for agricultural production. Major land use is for rice, groundnut and beans. The village is characterized as richest of natural resources, especially fish from river during flooding season. Recently flood often arrives uncertainly, causing huge damage in both economic and non economic sectors. Ta Danh village has a total of 1,805 households, of which 450 households are subjected to poor households and 115 households resettled in the flood protected residential cluster (a safety place from flood). The village has a total natural area of about 5,040 ha, in which 969 ha are used for rice production with triple crops per year. Livestock keeping are mainly cattle, pig, chicken, especially duck grazing in paddy fields after harvesting rice, or during flood. Ta Danh village is one of the predominant village for rice production in the flood-prone areas.

For households (HHs) survey, respondents from sample HHs were selected purposively, approximately 120 HHs (40 respondents of poor HHs, 40 medium HHs and 40 better-off HHs) in each village were surveyed. The sample for survey was taken based on 2 main criteria, which were households living in area with most vulnerable to flood and households of different social groups. Interviews were conducted by field staff from Cantho University and local partners. Survey question was based on the sub-components or indicators as presented in Table 1. We also conducted at least 10 focus group discussions (FGDs) in two villages with each group including 7-10 household heads from different social groups to gather information at community level.

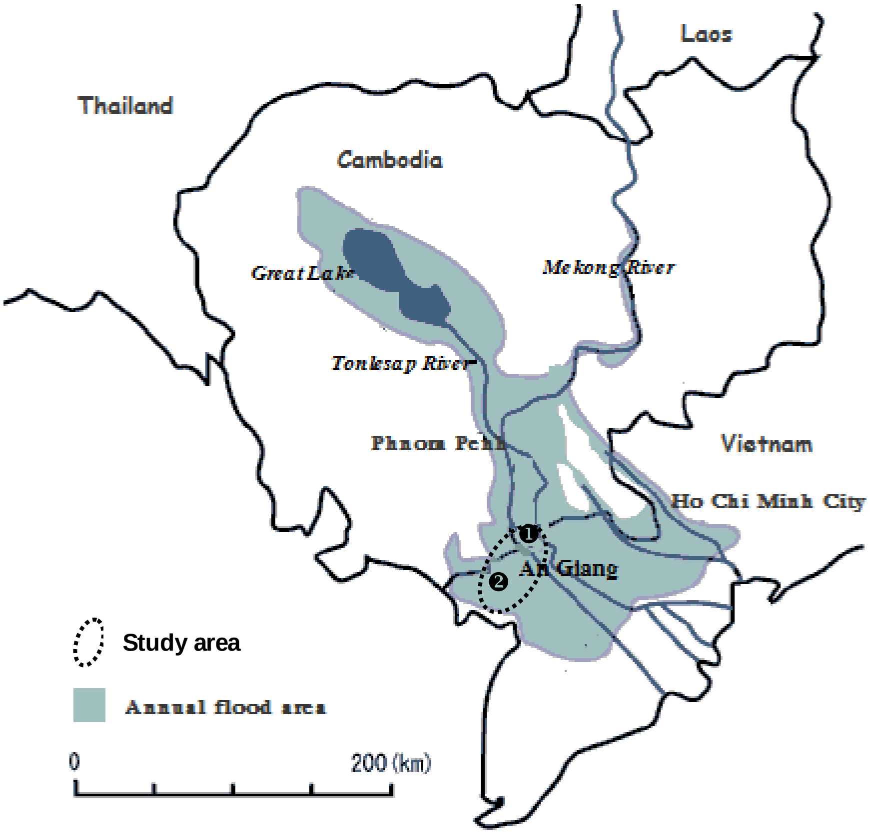

Fig. 1 Map showing the study area in An Giang, Vietnam.

Note: Study areas: (1) Phu Huu village (An Phu district) - study area at "earlier flooding zone"; (2) Ta Danh village (Tri Ton district) - study area at "later flooding zone".

3. Results and Discussion

The flood in year 2011 was also the most worse in An Giang Province, it caused serious damages to human and properties. An estimation of damage in economic by 2011's flood was US$ 49 million, killed 23 people (of which 19 were children), and agricultural damage was US$10.5 million. However, we conducted surveys two villages Ta Danh and Phu Huu in An Giang before the serious flood occurred, therefore some indicators might not reflect by respondents.

The LVI values for all 31 sub-components, 10 components and 5 capitals are presented in Table 3. The overall LVI of Phu Huu was found to be 0.488 which is making Phu Huu's livelihoods moderately vulnerable to the possible impacts of flood and climate variability, and is higher than the overall LVI of Ta Danh which was 0.432. Results vulnerability assessments for all 5 capitals and respective components are discussed below distinctly.

3.1 Human Capital Vulnerability

The vulnerability in term of Human capital of Phu Huu is higher than for Ta Danh due to its slightly higher levels of Health vulnerability, Knowledge and skills vulnerability, and Livelihood strategy vulnerability (Table 3). The greater vulnerability on the Health component index of Phu

Huu is caused by high proportion of households with family member got illness due to flood (Phu Huu 6%; Ta Danh 3%). Phu Huu also showed greater vulnerability on the Knowledge and skills component (0.664) than Ta Danh (0.588), this was caused by a higher household heads unlettered score for Phu Huu (0.419) than Ta Danh (0.194), and a higher household heads just passed primary school index for Phu Huu (0.653) than Ta Danh (0.630). Data from households surveys was also showing that there were a higher proportion of household heads unlettered for Phu Huu (42%) than Ta Danh (19%); and proportion of household heads just passed primary school for Phu Huu (65.3%), Ta Danh (63%). In terms of Livelihood strategy, Phu Huu showed higher vulnerability index than Ta Danh on this component (Phu Huu 0.443; Ta Danh 0.386). Looking at sub-components, the higher vulnerability of Phu Huu is caused especially by high levels of households dependent on agriculture as major source of income, no non-farm activities and no jobs during flood.

When the three components were averaged, the overall Human vulnerability was determined, and was higher for Phu Huu (0.428) than Ta Danh (0.374).

Table 3: Summary of the LVI result for all sub-component values, major components and capitals for TA DANH (TD) and PHU HUU (PH)

Sub-component	TD	PH	Major component	TD	PH	Capitals	TD	PH
Percent (%) of HHs with family member with illness	0.031	0.057	Health	0.016	0.029	Human (H)	0.374	0.428
% of HHs with family member get illness due to flood	0.000	0.000						
% of HHs head unlettered	0.194	0.419	Knowledge & skills	0.588	0.664			
% of HHs head just passed primary school	0.630	0.653						
% of HHs head that not receive any training to cope with flood	0.940	0.921						
Average agric livelihood diversification [1/(number of agric. livelihood activities + 1)]	0.063	0.063	Livelihood strategy	0.386	0.443			
% of HHs dependent on agric as major source of income	0.842	0.951						
% of HHs reported no non-farm activities as affected by flood	0.752	0.829						
% of HHs with no jobs (during flood season)	0.330	0.350						
% of HHs exploring NR (during flood season)	0.008	0.106						
% of HHs do fishing (during flood season)	0.320	0.358						
% of HHs with landless	0.395	0.269	Land	0.294	0.277	Natural (N)	0.286	0.339
% of HHs with small land (0.1-0.5 ha)	0.193	0.285						
% of HHs that not cultivate the 3rd crop	0.752	0.825	Natural resources	0.384	0.430			
% of HHs that depend on (exploit) natural resources	0.080	0.106						
Percent of HHs that depend on (do) fishing during flood	0.320	0.358						
Average number of most severe flood in the past 10 years	0.030	0.040	Natural disasters and c. variability	0.224	0.309			
Average number of death or injury as result of most severe flood in the past ten years	0.059	0.089						
% HHs did not receive a warning about flood	0.072	0.095						
Mean standard deviation of monthly	0.395	0.758						

average of average water level in Tan Chau (5 years)								
Mean standard deviation of average precipitation by month (ave. 5 years)	0.562	0.562						
Dependency ratio	0.257	0.309	Socio-demographic	0.372	0.408	Social (S)	0.484	0.554
Percent of female head HHs	0.493	0.485						
Average family member in a HHs	0.348	0.486						
% of poor HHs	0.391	0.350						
% of HHs receive helps due to flood	0.554	0.772	Social networks	0.708	0.846			
% of HHs that have not been membering of any organizations	0.861	0.919						
% of HHs that with non-solid house	0.592	0.626	Housing and production means	0.414	0.618	Physical (P)	0.414	0.618
% HHs that with housing affected by flood (partially to totally submerged)	0.126	0.732						
% of HHs that report no access to production means	0.525	0.496						
% HHs borrow money	0.488	0.515	Finance and incomes	0.519	0.616	Financial (F)	0.519	0.616
% HHs with net income lower 1000 USD	0.683	0.829						
% HHs with non-income within flood season	0.385	0.505						
Overall LVI (Weighted of H, N, S, P, F)								
LVI-Ta Danh	**0.409**							
LVI-Phu Huu	**0.488**							

Note: Index values were interpreted as relative values to be compared within the study sample only. The LVI is on a scale from 0 (least vulnerable) to 1 (most vulnerable).

3.2 Natural Capital Vulnerability

Land is an important household asset and indicator of wealth. In this study, landless and small land area owned by farmers are considered as indicators to measure vulnerability. Phu Huu showed slightly lower vulnerability on land ownership index than Ta Danh (0.277 vs. 0.294). Data from household surveys showed a higher proportion of households with landless for Ta Danh (39%) than Phu Huu (27%). In terms of natural resource, Phu Huu showed higher vulnerability on this component index than Ta Danh (0.430 vs. 0.384, respectively). This was due to a higher proportion of households that not cultivate third rice crop (Phu Huu 83%; Ta Danh 75%), a higher proportion of households that depend on (exploit) natural resources (Phu Huu 11%; Ta Danh 8%), and a higher proportion of households that depend on fishing (Phu Huu 36%; Ta Danh 32%). Phu Huu showed greater vulnerability on Natural disasters and climate variability than Ta Danh (Phu Huu: 0.309; Ta Danh: 0.224). Phu Huu is located in earlier flood zone of An Giang and more suffered from flood compared to other villages within district. The major contributing factors for a higher vulnerability on Natural disasters and climate variability for Phu Huu are more number of severe flood (Phu Huu: 4; Ta Danh: 3), more number of deaths (Phu Huu: 12; Ta Danh: 8), and higher percentage of household did not receive a warning about flood (Phu Huu: 9.5%; Ta Danh: 7.2%). By taking the weighted average of the above three components indices (land, natural resources, and natural disasters and climate variability), we obtained the overall Natural vulnerability index, and it was higher for Phu Huu (0.339) than Ta Danh (0.286).

3.3 Social Capital Vulnerability

Phu Huu had a higher dependency ratio index (0.309) than Ta Danh (0.257). In Phu Huu, average household size was 4.43, higher than Ta Danh (3.74), however Phu Huu had a lower percentage of female household head (48.5%) than Ta Danh (49.3%), and a lower percentage of poor household (Phu Huu: 35%; Ta danh: 39%). These four indicators contributed to make socio-demographic component index of 0.408 for Phu Huu and 0.372 for Ta Danh. Phu Huu also showed a higher vulnerability on the social networks component (0.846) than Ta Danh (0.708), which were relative high. This was due to Phu Huu had a higher proportion of households receive helps from flood (Phu Huu: 77.2%; Ta Danh: 55.4%), and a higher percentage of households not been membering of any organizations (Phu Huu: 91.9%; Ta Danh: 86.%). These results could be suggested that there is a need for strengthening community networks/ or local organizations such as Woman Union, Farmer Association, Red Cross, etc. at village level in functioning of coping with flood. Weighted average the two components (socio-demographic and social networks), the overall Social vulnerability index was identified to be higher for Phu Huu (0.554) than Ta Danh (0.484).

3.4 Physical Capital Vulnerability

Results from survey showed an average of percentage households with non-solid houses of 62.6% for Phu Huu and 59.2% for Ta Danh. Households with their houses affected by flood (partly to totally submerged) were recorded by 73% for Phu Huu and 13% for Ta Danh. About 49.6% of Phu Huu households reported that they had no access to production means (such as water pump, sprayer, boat, bike and fishing nets) compared to 52.5% for Ta Danh households. These three indicators, non-solid houses, housing affected by flood, and households no access to production means, contributed in making overall Physical vulnerability index for Phu Huu at 0.618, which was higher than that for Ta Danh at 0.414.

3.5 Financial Capital Vulnerability

In Phu Huu, 51.5% of households reported borrowing money during flood season, while Ta Danh reported 48.8%. Phu Huu households also reported non-income during flood season of 50.5% whereas Ta Danh reported of 38.5%. According to household surveys, percentage of net household income less than US$ 1000 was recorded by 82.9% for Phu Huu and 68.3% for Ta Danh. These three indicators, percentages of households borrowing money, households with non-income during flood season, and households with net income less than US$ 1000, contributed in making overall Financial vulnerability index for Phu Huu at 0.616, which was higher than that for Ta Danh at 0.519.

Table 4. Flood effect indicator values by household capital and social groups of TA DANH (TD) and PHU HUU (PH).

Household assets	Effect index for social groups in TD			Effect index for social groups in PH		
	Better-off	Medium	Poor	Better-off	Medium	Poor
Human	0.267	0.374	0.393	0.298	0.428	0.435
Natural	0.244	0.286	0.295	0.295	0.339	0.355
Social	0.347	0.484	0.495	0.402	0.554	0.555
Physical	0.332	0.414	0.441	0.583	0.618	0.648
Financial	0.369	0.519	0.562	0.442	0.616	0.621
Overall effect index	**0.309**	**0.409**	**0.428**	**0.378**	**0.488**	**0.499**

When examining LVI value for different social groups, it was apparent that the poor group was most affected and the better-off group was least vulnerable for both Phu Huu and Ta Danh (Table 4). In Phu Huu, overall effect index for better-off, medium and poor groups were at 0.378, 0.488 and 0.499, respectively, indicating poor and medium households had a higher vulnerability indices than better-off households. The same result was found for Ta Danh, overall effect index for better-off, medium and poor groups were at were at 0.309, 0.409 and 0.428, respectively. In practice, better-off households were experiencing of migration, having jobs and high levels knowledge and skills, whereas poor households face financial deficits, landless, less access to production means and possess lower quality physical capital (housing) more prone to be damaged by flood.

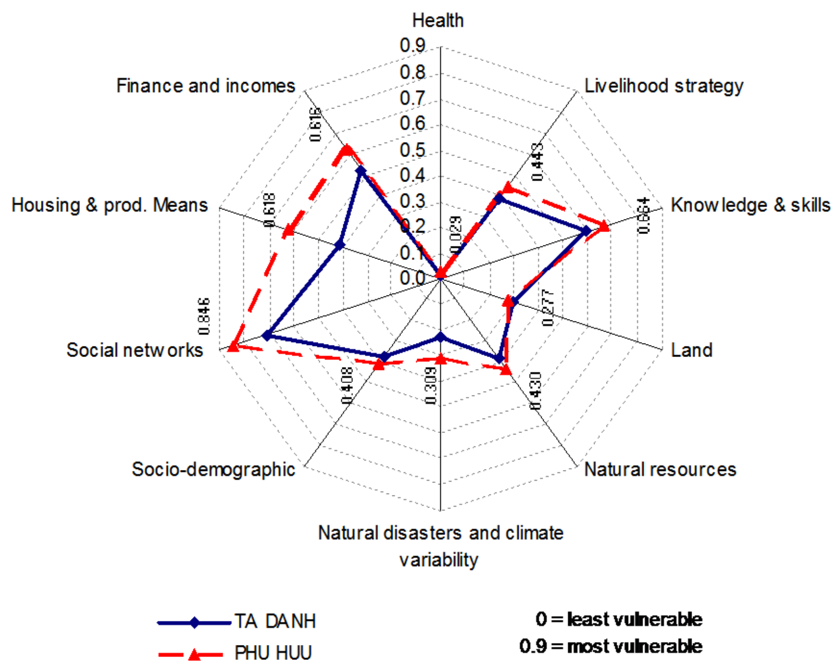

Fig. 2. Vulnerability diagram of the major components of LVI for TADANH and PHUHUU

Overall, Phu Huu had a higher LVI than Ta Danh (0.488 vs. 0.409, respectively), indicating relatively greater vulnerability to flood and climate variability impacts. The results of ten major component calculations are presented collectively in a spider diagram (Fig. 2). The scale of the diagram ranges from 0 (less vulnerable) at the center of the web, increasing to 0.9 (more vulnerable) at the outside edge in 0.1 unit increments. Fig. 2 reflects that Phu Huu is more vulnerable in terms of knowledge and skills, financial and incomes, housing and means, and social networks; whereas Ta Danh is more vulnerable in terms of knowledge and skills, and social networks. The same trend, Fig. 3 also shows that Phu Huu is more vulnerable in terms of financial, physical and physical capitals, while Ta Danh is more vulnerable in terms of financial and social capitals. These results should be taken into account for improving livelihood strategies by strengthening these livelihood capitals.

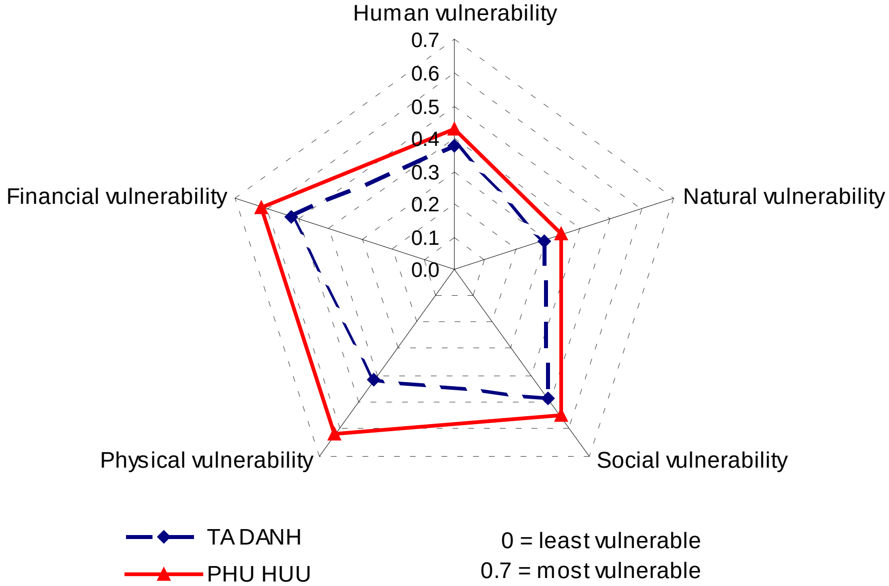

Fig. 3. Vulnerability diagram of five capitals of SLF for LVI of TADANH and PHUHUU village.

3.6 LVI-IPCC: Phu Huu versus Ta Danh

Under the consideration of similar indicators calculating on their respective methods, the LVI-IPCC analysis yielded consistence results (LVI-IPCC for Phu Huu: −0.089; LVI-IPCC for Ta Danh: −0.069) (Table 5). Fig. 4 showed a vulnerability triangle, which plots the contributing factor scores for exposure, adaptive capacity, and sensitivity [with the function LVI-IPCC = (Exposure − Adaptive capacity) * Sensitivity]. The triangle indicates that Phu Huu may be more exposed to flood and climate variability impacts than Ta Danh (Phu Huu: 0.309; Ta Danh: 0.268).

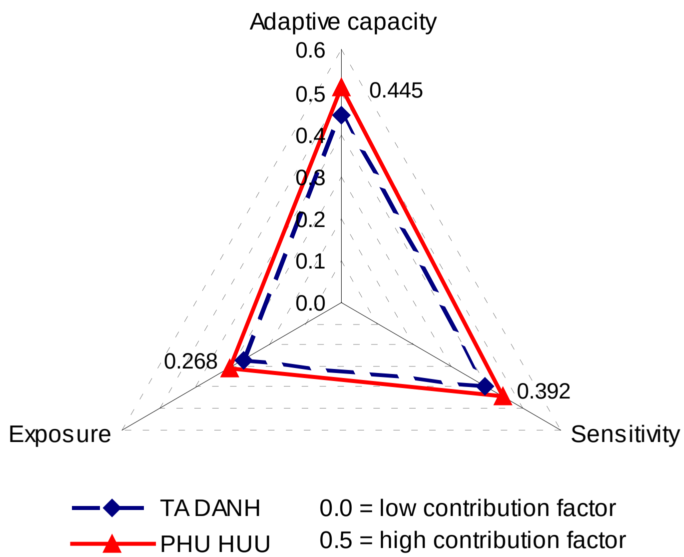

Fig. 4. Diagram of vulnerability triangle of the contributing factors of the LVI-IPCC for TADANH and PHUHUU.

The following Table 5 illustrates the major components to respective contributing factors of LVI-IPCC (exposure, adaptive capacity and sensitivity) and the result indices of them for Phu Huu and Ta Danh. Based on socio-demographic, livelihood strategies and social networks, Phu Huu showed a higher adaptive capacity than Ta Danh (0.510 vs. 0.445, respectively). When taking into account for health, knowledge and skills; land and natural resources, and financial, Phu Huu may also be more sensitive to flood and climate variability impacts than Ta Danh (0.442 vs. 0.392). The overall LVI-IPCC scores indicated that Phu Huu households may be more vulnerable than Ta Danh households (−0.089 versus −0.069, respectively).

Table 5. Calculation of contributing factors of LVI-IPCC for TADANH and PHUHUU.

Contributing factors	TA DANH	PHU HUU
Exposure	0.268	0.309
Adaptive capacity	0.445	0.510
Sensitivity	0.392	0.442
LVI-IPCC = (Exposure - Adaptive)*Sensitivity	**−0.069**	**−0.089**

3.7 Practical implications of assessing livelihood assets

Practically, assessment of livelihood vulnerability is too complicated to be covered all because there are many aspects, dimensions and factors that relating to livelihood vulnerability, e.g. economic, political, demography, etc., and it was certainly mentioned in some reports (Carney, 1998; Adger et al., 2001; Sullivan, 2002). This research only focuses on some major risk factors (major components) that influences livelihood assets of households due to floods affect and climate variability. The sub-components we used to construct the LVI in this study were selected based on the available data which mainly from household surveys for our particular study sites and may not apply to other communities, and other sub-components/ indicators may not be included. Thus, our LVI estimates in this study implies some degrees of interest regarding assessing livelihood vulnerability as affected by flood, and need to improve in future studies.

The LVI and LVI-IPCC come to the same trend of result regarding the relative vulnerability of the two flood-prone villages and follows the pattern provided from key informants through FGDs. Phu Huu is located in the earlier flood zone wherefore people living there is more suffered from flood, while Ta Danh is located in the later flood zone and therefore having less problems. Hence, the LVI could arguably capture main characteristics of the validly situation, and develop a comparable index for other villages/districts could be useful to priorities where support is most needed to improve effects of flood and climate variability.

Additionally, this study examined LVI value for different social groups and was found that the vulnerability is different amongst social groups, poorer was most suffered while the better-off group was least suffered. To measure this, we did not do wealth ranking but based on the lists from local authority to distinguish different social groups for interviewing that may fail to sampling bias. Thus, it is likely that the wealth ranking should be taken into account for sampling rather than selection bias.

Somehow use of sub-components/ indicators and indices in these approaches simplify a complex reality and there is no easy way to validate indices encompassed of unrelated indicators. Directionality of indicators is also arguable, for instance, in this study, higher percentage of female household head increase or decrease community's vulnerability to flood impacts; higher percentage of household with landless or small land increase or decrease community's vulnerability to flood effects. In terms of data interpretation, separating the effects of the flood and climate variability from other influencing factors is difficult. Therefore, the interpretation of LVI should be done carefully.

4. Conclusions and Recommendations

Based on results from a case study in An Giang - Mekong Delta of Vietnam, we presented the results of measuring livelihood vulnerability, and LVI and LVI-IPCC were used as alternative methods for assessing relative vulnerability of people's livelihood to flood and climate variability impacts. The LVI and LVI-IPCC come to the same conclusion regarding the vulnerability of the two pilot villages tested. Phu Huu had a higher LVI than Ta Danh. Vulnerability indices to flood were different amongst social groups and the poor faced most vulnerable.

This study applied two vulnerability assessment approaches (LVI and LVI-IPCC) in Phu Huu and Ta Danh villages of An Giang Province. Both indexes were evaluated to validly and therefore both could usefully form the basis for a provincial/national applicable index. These approaches could be applied as a practical tool for the governments, policy makers and development organizations to identify vulnerable communities, understand factors contributing to vulnerability at village/ or district level and also to prioritise the potential areas of intervention.

The LVI and LVI-IPCC could be used to assess the impact of a program or policy by substituting the value of the indicator that is expected to change and recalculating the overall vulnerability index. Similarly, the LVI might be used to project future vulnerability, for example under simple climate change scenarios in the Mekong Delta.

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