NJAS - Wageningen Journal of Life Sciences 92 (2020) 100324

Contents lists available at ScienceDirect

NJAS - Wageningen Journal of Life Sciences

journal homepage: www.elsevier.com/locate/njas

Research paper

Climate change resilience and adaption of ethnic minority communities in the upland area in Thừa Thiên-Huế province, Vietnam

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ARTICLE INFO

Keywords:
Climate change
Resilience
Adaptation
Ethnic
Uplands
Thua Thien Hue province

ABSTRACT

Changing climate patterns and increases in climate extremes pose new challenges to livelihoods of ethnic communities in the upland area in Thừa Thiên-Huế (TTH) province. Unpredictability and extreme events have had adverse effects on both farming and income of many ethnic minority households who are already more likely to be vulnerable due to socio-economic and cultural marginalization. Promoting household resilience to climate extremes has emerged as a key development priority for those living in this area. Using data from a household survey conducted in two upland districts of TTH province (Nam Đông and A Lưới), this study employed FAO's resilience framework to measure household climate change resilience of different ethnic groups and a Poison regression model to identify determinants of household adaptation. Results showed that ethnic minority households had relatively low resilience to climate change and variability with the resilience index only 0.428. Due to geographic isolation, agriculture-dependent ethnic minority households in A Lưới were least resilient to climate change. Results suggest that interventions aimed at promoting climate resilience for ethnic minority households should focus on increasing people's knowledge of climate change and associated impacts and risks; and improving household income, savings and strengthen household asset base. Almost all households in the study areas have adopted adaptation measures, such as adjusting the seasonal calendar for crop production; using local crop varieties; practicing mixed cropping; and mulching. Education level, climate change awareness and risk perception of the household head, household income source and ability to access credit were key elements of households' choice of adaptation strategies.

1. Introduction

Climate change has become an indisputable fact (Vermeulen et al., 2010). It affects economies world-wide, especially in low- and middle-income countries owing to the heavy dependency on nature-sensitive sectors such as agriculture and forestry. Many low and middle income countries are experiencing higher risks from unusual changes in climate phenomena compared to high income countries due to both their location and geography (Bojo, 2011; Maharjan and Joshi, 2013). Vietnam is among the top 10 countries in the world most affected by climate change impacts and the Vietnamese Government has been considering climate change as a threat to the national economy and people's livelihoods (VGO - Vietnamese Government Office, 2011). Climate change impacts considerably on production, the environment and livelihoods. Higher temperatures and changes in rainfall patterns, including increased severity of storms, can bring about negative effects on agriculture and high risks to industry and socio-economic systems in the future. Climate change has been and will continue leading to comprehensive and deep changes in global development and security, especially energy, water, food, employment, diplomacy, culture, economy and trade (IPCC, 2014, 2017).

The mountainous areas of Thừa Thiên-Huế province are among the most vulnerable to climate change in Vietnam, given their degraded forests, steep slopes and barren hills that have low water holding capacity, are susceptible to severe erosion and landslides (Nguyen Tham and Nguyen Hoang Son, 2010; Le Duc Ngoan et al., 2013; Son Tran Van

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https://doi.org/10.1016/j.njas.2020.100324
Received 8 August 2019; Received in revised form 31 January 2020; Accepted 30 April 2020

et al., 2015; Le Thi Hong Phuong et al., 2017). The area is predominantly inhabited by ethnic minority communities who tend to have a much lower education level and higher poverty rates compared to ethnic majority Vietnamese (Kinh) within the province (PSO, 2017). There is increased pressure to protect or ensure their livelihoods because of forest degradation in combination with policies restricting access to natural forests, in addition to the impacts of climate change and variability (Truong Quang Hoang et al., 2017). Poor and smallholder farmers with limited capital and resources to invest in adaptation activities and those who make poor decisions regarding type and timing of adaptation measures seem to be the most vulnerable.

To minimize the negative impacts of climate change, it is important to evaluate how communities and individuals can better prepare and adapt for future climate change and extreme climate events to understand individuals' and communities' level of resilience (Romac, 2014). Increasing a community's resilience level is to increase its ability to cope with the changes that affect it (Romac, 2014; Laurie, 2015). Resilience is a complex concept, a latent variable that is difficult to quantitatively assess (Tambo, 2016), and a term which has historically been used in different ways (Klein et al., 2003). We view resilience as systems-orientated, where ecological and social systems are interrelated (Nelson et al., 2007), and considered at multiple scales. Recent research has focused on measuring resilience of either households or communities and focuses on a view of resilience as inclusive of preparation, mitigation and adaption (Cox and Hamlen, 2015). This is in support of local authorities, policy makers and related stakeholders to design both appropriate interventions and training. This paper adapts the resilience framework proposed by (FAO, 2010) to measure different ethnic groups' climate resilience at the household level and employs a Poison regression model to analyse households' adaptation choices. The study focuses on the upland areas of Thừa Thiên-Huế province to explore how dimensions such as culture, social networks, natural resource dependency, and location influence a community's resilience to climatic shocks such as storms, floods and drought. The aim of this study is to promote the inclusion or 'mainstreaming' of climate resilience considerations in policy and planning, which is often disconnected, particularly in countries with a lack of technical ability or governance transparency (Friend et al., 2014). We now consider the resilience framework.

The concept of resilience is widely applied with varied definitions. Generally, resilience implies the ability to respond to disturbances or change. In the context of climate change, resilience is frequently defined as the capacity for a socio-ecological system to: (1) absorb stresses and maintain function in the face of external stresses imposed upon it by climate change and (2) adapt, reorganize, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared (Marshall, 2008; Damhofer, 2014; Romac, 2014; Laurie, 2015). The resilience framework proposed by the FAO (2010) was originally developed and validated to measure households' resilience to food insecurity (Alinovi et al., 2010; Ciani and Romano, 2014), but it is a flexible framework that can be used in analysing households' capacity to absorb unpredictable shocks and stresses, such as extreme weather and climate events. It has been adapted in the literature, for example to measure climate induced shocks in north-east Ghana and the central highlands of Ethiopia (Tambo, 2016; Asmamaw et al., 2018). This resilience tool consists of six major components, including shocks (S), income and food access (IFA), access to basic services (ABS), social safety nets (SSN), assets and technology (AT), and adaptive capacity (AC) (Fig. 1). A household or a community with higher average values of each component is assumed to be more resilient to climate change-induced shocks. Each of the six major components has a set of indicators that can specifically measure households' resilience.

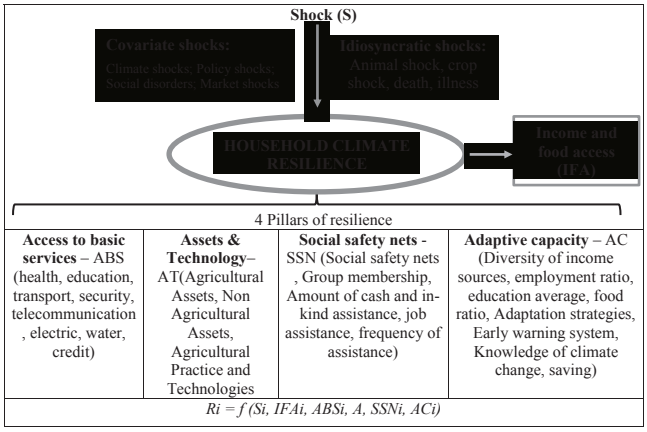

Fig. 1. Resilience framework.
Source: Adapted from FAO, 2010.

2. Methods

2.1. Study site and data collection

The study was conducted in Nam Đông and A Lưới, the two upland districts of Thừa Thiên-Huế province. The districts are sparsely populated with approximately 40 persons per km^2 (PSO, 2017) and these communities are among the poorest in the province, with a poverty rate of approximately 25% in 2017. The ethnic minority population includes Kơ Tu, Vân Kiều, Paco and Tà Ôi. Agricultural production and collection of forest products are their predominant livelihood activities (Le Van An, 2006; Truong Quang Hoang et al., 2017; Tran Nu My Linh, 2018).

The districts are in the upland agro-ecological zone adjacent to large areas of protected forests including Bạch Mã national conservation area, Saola (*Pseudoryx nghetinhensis*) conservation area and Phong Điền Nature Reserve. The farming systems are mainly steep slope land cultivation systems, dominated by small land holdings, degraded soil, low return on labour, and heavy dependence on the natural environment for economic benefit (Truong Quang Hoang et al., 2017). It is among the highest rainfall areas in the country, however rainfall patterns are erratic (Nguyen Tham and Phan Van Trung, 2011). In recent years, the number of rain days has decreased but rain intensity has increased leading to irregular seasons (Government Portal, 2018). Heavy rain during summer or late winter causes serious flash floods and landslides. In this context, the implementation of government policies on restricting access to natural forest has seriously affected livelihoods, particularly those dependent on forest resources (Truong Quang Hoang et al., 2017).

This study is based on data obtained through a household survey, two group discussions and in-depth interviews with key informants, undertaken between December 2018 and May 2019 in A Lưới and Nam Đông districts. Eleven communes of the two districts that are adjacent to natural forest and have a high percentage of ethnic population were selected for our case study. Households were randomly selected from the list of ethnic residents provided by the Commune People's Committee. The total sample size is 328 households, the location of studied districts is shown in Fig. 2.

Interviews were conducted in Vietnamese with the support of pretested questionnaires. Very few cases needed the support of commune staff with local languages. The majority of respondents were male heads of households. The questionnaires were used to obtain data on household characteristics, crop and livestock production, forestry, off-farm income earning activities, innovation-generating activities, access to infrastructural services, information and social interventions, household experiences with shocks, climate change adaptation strategies, risk, and livelihood capitals indicators.

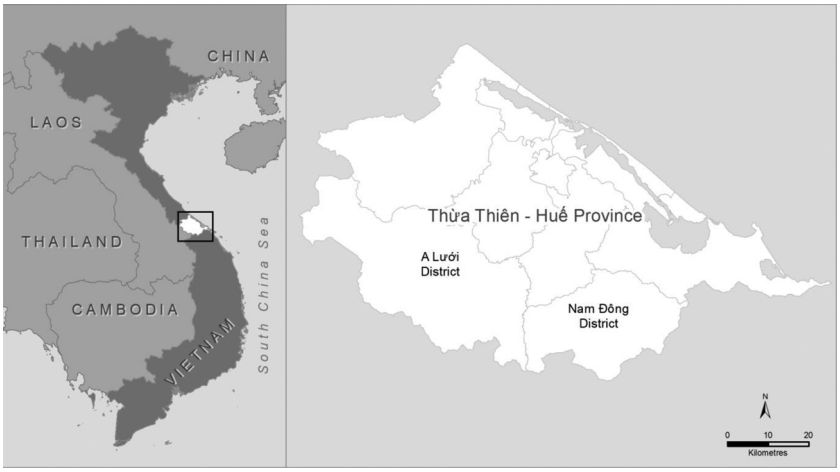

Fig. 2. Location of the districts included in this study.

Among the 328 households interviewed, 98 households are poor; 58 households are near poor and the remainder (172 households) are the better-off households according to the Ministry of Labour, Invalids and Social Affairs classification (Decision No 59/2015/QĐ-TTg dated 19/11/2015) used by the Commune People's Committee. Timber and non-timber collection from natural forests had been one of the main income sources for more than 87% of the ethnic communities in the two districts prior to the implementation of forest policy regarding the allocation of forests for community management in 2005 and 2011 (Tran Nu My Linh, 2018).

2.2. Measuring climate resilience

Stakeholder consultation with district extension staff, staff of the Department of Agriculture and Rural Development and Department of Natural Resources and Environment, and commune chairpersons and a literature review (see Table 1) were used to develop indicators suitable for the socio-economic and natural conditions of the study sites. The study used household-level data on these indicators to measure Climate Resilience Indexes (CRI) for different ethnic groups. Results of initial stakeholder consultation indicated that climate resilience of an individual or a community in the study sites can vary among wealth groups, different levels of forest resource dependency, and geographical location groups (Nam Đông and A Lưới proximity to larger town). Therefore, surveyed data included information about households' wealth classification, natural forest dependency, and location, and CRI was calculated and analysed for each group. The CRI consists of 41 indicators (Table 1). Eighteen out of 41 indicators were drawn from the FAO resilience tool. However, as these 18 indicators were not sufficient to measure CRI, an additional 23 indicators relevant to building resilience to extreme events were sourced from the literature or stakeholder consultation.

This study applied the balanced weighted approach to calculate CRI. With this approach each indicator is assumed to contribute equally to the resilience index despite each major component having an unequal number of indicators (Hahn et al., 2009). Based on the literature, indicators were measured with different units and scales. In the standardization, the functional relationship between resilience and the indicators was taken into account by ensuring that resilience increases with an increase in the value of each indicator (Hahn et al., 2009; Tambo, 2016). Due to the different in units and scale among indicators, values of all indicators must be standardized to obtain a uniform unit and scale (Tambo, 2016; Asmamaw et al., 2018). There are two ways to standardize indicators (Asmamaw et al., 2018). Those that are expected to have a direct relationship with resilience, such as education level; levels of awareness; income; food access; diversity of income sources; and coping strategies were standardized using equation (1),

$$I_a = (S_r - S_{min})/(S_{max} - S_{min}) \quad (1)$$

where I_a is the standardized value for the indicator a, Sr is the observed (average) value of the indicator for the household r, min and max are the minimum and maximum values of the indicator across all surveyed households, respectively. Indicators expected to have an inverse relationship to resilience, such as household food insecurity and access score, distance to the nearest health care station, distance to the nearest school, shock events (e.g. flooding and landslides), were standardized using equation (2),

$$I_a = (S_{max} - S_r)/(S_{max} - S_{min}) \quad (2)$$

After the standardization, values of different indicators under each component were averaged to derive a score for each of the six components.

The *CRI* was then obtained from a weighted average of the six components using equation (3),

$$CRI_i = \frac{w_s S_i + w_{ifa} IFA_i + w_{abs} ABS_i + w_{ssn} SSN_i + w_a A_i + w_{ac} AC_i}{w_s + w_{ifa} + w_{abs} + w_{ssn} + w_a + w_{ac}} \quad (3)$$

where CRI_i is the Climate Resilience Index for farmers' group i. The variables S, IFA, ABS, SN, A and AC, refer to the six major components: shocks, income and food access, access to basic services, safety nets, assets, and adaptive capacity respectively. w is the number of indicators in each component.

2.3. Identifying the determinants of household adaptation measures

The impacts of climate change have been increasingly felt by upland communities in central provinces, including Thừa Thiên-Huế (Truong Quang Hoang et al., 2017). In response to this, the majority of farmers decided to take action to reduce its impacts either pre-emptively before climate change occurs to avoid its impacts, or by adjusting their systems to adapt after realizing climate change impacts (Schluter and Herrfahrdt-Pahle, 2011). Some farmers decided to make many adaptation changes, or profound changes, while others decide to make few or no changes (Asmamaw et al., 2018; Solomon and Edet, 2018). Therefore, to determine factors influencing the household decision to respond to climate change impacts, it is appropriate to use the Poisson regression model for the count dependent variable. The Poisson regression model is specified by the equation 4.

$$Y_{ni} = \beta_i X_i + \varepsilon \quad (4)$$

Where Y_{ni} indicates the number of adaptation options adopted by household i, X_i is a vector of socio-economic and institutional variables

Table 1
Indicators of the climate resilience index.

Components	Sub-components	Explanation of sub-components	Units	Sources
Shocks (S)	**Idiosyncratic shocks**			
	Animal shock	Value-loss due to stolen or dead livestock	VND	Alinovi et al. (2010)
	Crop shock	Value lost due to low yield	VND	Alinovi et al. (2010)
	Other shocks	Value lost due to other shocks	VND	Alinovi et al. (2010)
	Covariate shocks			
	Climate shock	Such as droughts, heat, floods, rainfalls and storms	Dummy	FAO (2010)
	Policy shock	Limit to access forest resources policy	Dummy	Stakeholder consultation
	Conflict shock	Social disorders; different tribes	Dummy	FAO (2010)
	Market shock	Input and output price fluctuations	Dummy	FAO (2010)
Income and Food access (IFA)	Per capita income	Average income per person per year	VND	Alinovi et al. (2010)
	Per capita expenditure	Average expense per person per year	VND	Alinovi et al. (2010)
	Household food access score	Household Food Access Score	Index 0 to 27	FAO (2010) Coates et al. (2007)
Access to basic services (ABS)	Access to health services	Quality of health care services	1-5	FAO (2010) Tambo (2016)
	Quality of educational system	Quality of education system	1-5	FAO (2010)
	Perception of security	Household has perception of security	Dummy	FAO (2010)
	Mobility and transport constraints	Quality of transportation system	1-5	FAO (2010)
	Access to safe water	Household has access to safe water for living	1-5	FAO (2010)
	Access to electricity	Household has access to electricity	Dummy	Alinovi et al. (2010)
	Access to telecommunication	Household has access to telecommunication	1-5	Tambo (2016)
	Access to credit	Household's ability to access to credit	Dummy	Alinovi et al. (2010)
Social safety nets (SSN)	Social safety nets	Number of social safety net programmes household involved	Count	Tambo (2016)
	Group membership	Household members belong to formal or formal associations	Dummy	Tambo (2016)
	Amount of cash and in-kind assistance	Amount of cash and in-kind assistance per year	VND	Stakeholder consultation
	Frequency of assistance	Times received assistance in the last 5 years	Count	FAO (2010)
Assets and technology (A&T)	Poultry holding	Number of poultries kept by household per year	Count	Alinovi et al. (2010)
	Cattle holding	Number of cows, pigs, goats kept by household per year	Count	Alinovi et al. (2010)
	Land holding	Total area of land owned by household (hectares)	ha	Alinovi et al. (2010)
	House value	The value of the house in which the interviewed household lives	VND	(FAO, 2010); Tambo (2016)
	Durables value	Values of all durable assets	VND	FAO (2010) Tambo (2016)
	Other assets	Values of other household's assets	VND	
	Organic fertilizers	Used organic fertiliser for crops	0-5	Alinovi et al. (2010)
	Inorganic fertilisers	Used inorganic fertilisers for crops	0-5	Alinovi et al. (2010)
	Veterinary	Household applied veterinary services over the last 5 years	0-5	Alinovi et al. (2010)
	Pesticides	Household applied any types of pesticides over the last 5 years	0-5	Alinovi et al. (2010)
	Artificial insemination	Household used artificial insemination services over the last 5 years	0-5	Alinovi et al. (2010)
	Agricultural inputs	Costs per ha of all agricultural inputs	VND	Alinovi et al. (2010)
Adaptive capacity (AC)	Diversity of income sources	Number of household income sources	Count	FAO (2010)
	Educational level	Education level of household head	0-12	FAO (2010)
	Household labour force	Number of members aged to 15-64		FAO (2010)
	Available coping strategies	Number of available climate change adaptation strategies	Count	Tambo (2016)
	Early warning system	Household receives early warning system notices	Dummy	Tambo (2016)
	Knowledge of climate change	Household members are aware of climate change and its impacts	Dummy	Tambo (2016)
	Savings	Household has savings with a bank or saving group	Dummy	Tambo (2016)

that affect the adoption of the adaption options, and the β_i is the regression coefficient, and ε is a constant. There were sixteen independent variables, which were identified based on focus group discussions and the literature review (Tambo, 2016; Asmamaw et al., 2018; Solomon and Edet, 2018). Table 2 presents the description of these independent variables and their mean values.

3. Results

The results of random sampling for this study showed that approximately 25% of households were dependent on natural forests for their livelihood, and about 24.3 % collected non-timber forest products during the crop off-season. This collection was for household consumption and limited amounts for market. About 50% of households no longer depend on natural forest for their livelihoods. They stopped collecting forest products and increased farm production, shifted to small business or took up non-farm labour on acacia plantations or carpentry in the neighbouring communities. In this section we present results in relation to the CRI and then household adaptation and strategies.

3.1. Results of climate resilience index

The CRI of the ethnic minority communities in uplands of Thừa Thiên-Huế is relatively low (0.428) indicating relatively poor resilience to climate change induced shocks (Table3). Among the main components, components S and ABS had moderate and high CRI scores while SSN and the remaining three components had relatively low or very low scores.

All types of shocks were reviewed as low in both frequency and

Table 2
Description and mean value of the independent variables.

Variable	Description	Mean	Median	SD
Age	Age of household head	43.8	40.0	14.7
Gender	Gender of household head (dummy, 1 = male)	80.4		
Education level	Education level of household head (grade)	6.10	5.0	4.03
Awareness of climate change and climate risks	Climate change awareness of household head (dummy, 1 = have heard or aware of climate change)	47.8		
Household labour force	Total labour of household	2.48	2.0	1.07
Household's wealth ranking	Poor = 0	22.9		
	near poor = 1	17.6		
	better off = 2	59.5		
Cattle holding	Total number of cattle being kept by household	3.32	2.0	5.39
Poultry holding	Total number of poultries being kept by household	12.1	3.0	15.2
Assets	Total values of physical assets of household in VND	137	85.5	174
Social networks	Household participation in community associations or networks (Number of associations)	1.94	2.0	0.88
Land holding	Total land area owned by household (hectares)	49.4	34.0	76.6
Access to credit	Household accessibility to credit (dummy, 1 = accessible)	35.9		
Income per capita	Total income per household capita (thousand VND/person/year)	18,630	14,140	17,912
Income sources	Number of household income sources	4.24	4.0	1.85
Risk perception	Household consider climate change a risk (dummy, 1 = considered a risk)	49.1		
District	Household is located in Nam Đông district (= 1)	41.2		

Table 3
Resilience component and indicators for ethnic communities.

Indicators	Indicators' value	Main components	Score
Climate shock	0.578	Shocks (S)	0.693
Policy shock	0.806		
Conflict shock	0.809		
Market shock	0.625		
Animal shock	0.776		
Crop shock	0.627		
Other shocks (sickness, job lost)	0.627		
Per capita income	0.160	Income and Food access (IFA)	0.165
Per capita expenditure	0.082		
Household food access score	0.252		
Quality of health services	0.593	Access to basic services (ABS)	0.635
Quality of educational system	0.702		
Perception of security	0.698		
Mobility and transport constraints	0.726		
Access to safe water	0.537		
Access to electricity	0.685		
Access to telecommunication	0.601		
Access to credit	0.542		
Social safety nets	0.568	Social safety nets (SSN)	0.451
Formal group membership	0.429		
Informal group membership	0.532		
In cash and in-kind assistance	0.385		
Frequency of assistance	0.339		
Land holding	0.076	Assets and technology (A&T)	0.264
Cattle holding	0.042		
Poultry holding	0.686		
House value	0.087		
Durables value	0.345		
Other household assets (TV, Motorbike, etc.)	0.055		
Organic fertilisers	0.479		
Inorganic fertilisers	0.371		
Veterinary	0.298		
Artificial insemination	0.088		
Pesticides	0.401		
Other agriculture inputs	0.238		
Diversity of income sources	0.402	Adaptive capacity (AC)	0.320
Educational level	0.555		
Household labour force	0.227		
Available coping strategies	0.567		
Early warning system	0.354		
Knowledge of climate change	0.030		
Savings	0.105		
		Climate resilience index (CRI)	**0.428**

intensity, except for climate shocks because both frequency and intensity of climate change and variability seemed increasing over time and it influenced the whole system from income to living environment, human health and people's perceptions. It was revealed that there was no conflict within their communities. A village leader expressed the general sentiment this way: *"Our culture is to live and help each other, one community is being treated as one big family so we don't have conflicts"*.

Access to basic services (ABS) has a moderately high score (0.635). This reflects the true picture of the two districts where basic services (education, health care and telecommunication) were quite well developed due to the government's priority in developing these remote areas, focusing on infrastructure and public services. Local people felt they were able to easily access these services. However, most respondents reflected that while health services are available in every commune they were not well equipped and treatment techniques and skills were not deemed satisfactory. Some people gave a low score for healthcare because of their personal preferences. Trust in local 'traditional treatments' seems to be greater than in modern medicine. Some had no knowledge about health care provision or chose not to use it.

Access to credit is the indicator with the lowest score among indicators under the ABS component. Government as well as Community Based Organizations have both been instrumental in promoting credit services at local level to enhance small-scale economic opportunities. Unfortunately, more than 55% of respondents were excluded from accessing credit, because they already had a debt burden averaging VND 40 million per household. This is a result of a local government program promoting rubber plantations where farmers were offered loans through formal credit channels. With insufficient information, farmers in the two districts studied here adopted and rapidly expanded their plantations.

Receiving the lowest score in the CRI index was the IFA component. Low income and low per capita expenditure were the main reason for the low IFA score. It was expressed by most households that they have diversified income sources but due to poor resources (small land size, sloping land; rain-fed and poor fertile soils) and low investment, the return was just enough for household consumption. The majority of households had no savings and had less than 1 million VND cash (less than USD50) in hand at the time of surveying.

The Assets and Technology (A&T) component also had a very low score. The ethnic monitory communities had very poor asset portfolio. More than 70% of respondents had temporary houses that were very easily damaged during heavy rains or storm events. Most households did not have any valuable assets and as such were not concerned about theft.

About half of all respondents were not aware of the concept of

climate change. While they had not heard about it, they definitely spoke of their experiences of changing weather patterns. About 6% of respondents believed that changing weather patterns was due to God, as one respondent explained: "*he decides what he wants, it does not relate much to human action such as deforestation/ forest clearing…*". This would explain why some households had not taken any action to adapt to or cope with climate change and variability. Information about changing climate and weather conditions are available from a number of sources such as television, public loudspeakers, telephone or local officers. Almost all respondents stated that they did not use these channels. Public media such as television or radio, did not provide timely information and provided large volumes of information in a short time making it difficult for ethnic minority people to understand (because of the language barrier as well as their limited understanding of climate change). In addition, few households had television or radio and the geographical conditions (mountainous region) caused very low quality of radar/waves so it was not easy for them to get information from these channels.

For the direct sources such as training workshops and meetings organized by the agriculture department, extension departments or community-based organizations, it was difficult for local people to get sufficient and continuous information. Village leaders in A Lưới district said that some staff came for only one or two days and talked about climate change, disaster risks and introduced them to coping strategies. Yet their visits were too infrequent sustained and those who participated were unable to remember the content from one workshop to another. Commune staff were also trained disseminate information amongst local residents, but, according to our survey they only had limited capacity to teach what they had learned and therefore provided low quality training.

Technology used in agriculture, including fertilizers, machinery and other inputs were used by very few households and at a low level compared what was recommended by extension services. Due to financial constraints, fertilizer was not used extensively and few people invested in seedlings or new seed varieties from seed banks. Around 80% of farmers in our sample still keep seed or borrowed seeds from relatives, neighbours instead of buying seeds from commercial seed banks. While seed retention may be considered an adaptation strategy, in this case the quality of the seeds is low and not considered climate-tolerant.

Social safety nets (SSN) has a relative high score and reflects the rich values of culture and norms of diversified ethnic minority groups in the area. Cultural norms mean they support each other in livelihood activities as well as in coping with climate and variability. Alongside formal community organizations, established and managed by local authorities, local communities also set up various groups to help each other, such as goat keeping groups; acacia groups; non-timber collection groups; and some households at the same time participated in several groups. Respondents considered these groups as the most influential in their decisions about which livelihood activities to adopt.

The values of the Climate Resilience Indexes (CRIs) computed for each district are presented in Fig. 3 and for household groups in Fig. 4 and Fig. 5. These figures show that there was not a significant difference in CRI score among poor, near poor and better off groups and among districts, although, A Lưới had a lower CRI score than Nam Đông and the poor group had relatively lower CRI score than the other two groups.

3.2. Households' adaptation to climate change

Both externally introduced and local adaptation measures were evident in the case study areas. Although few people were aware of climate change and the causes, the majority (more than 94% of respondents) changed their practices in order to adapt. In responding to this, the chairmen of both communes expressed that people learned from each other and mostly they used their experiences and local

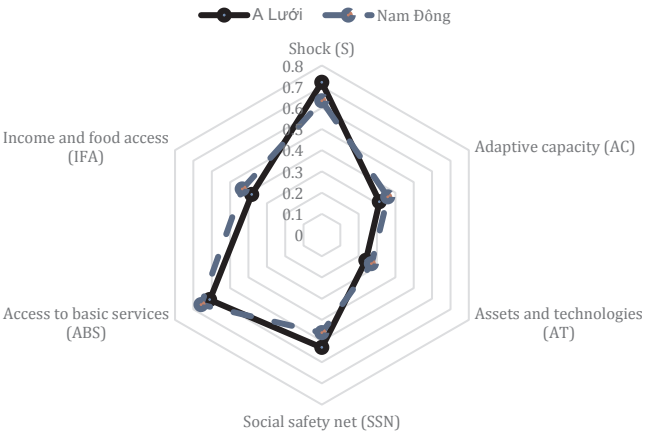

Fig. 3. Resilience components by districts.

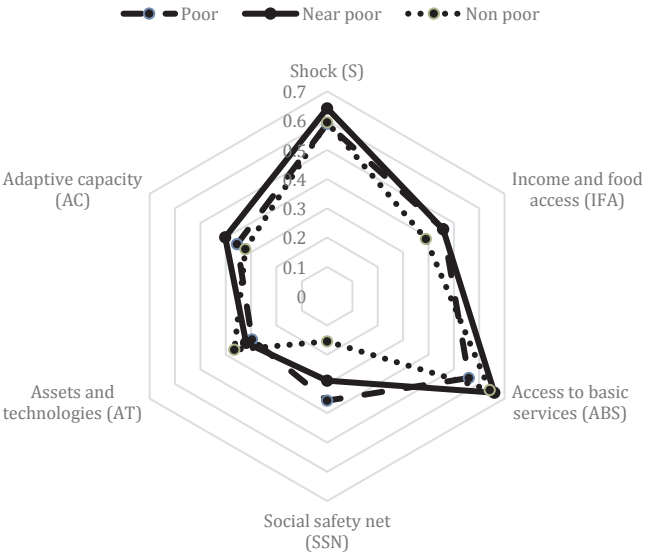

Fig. 4. Resilience components by wealthy groups: Poor, near poor and better off groups.

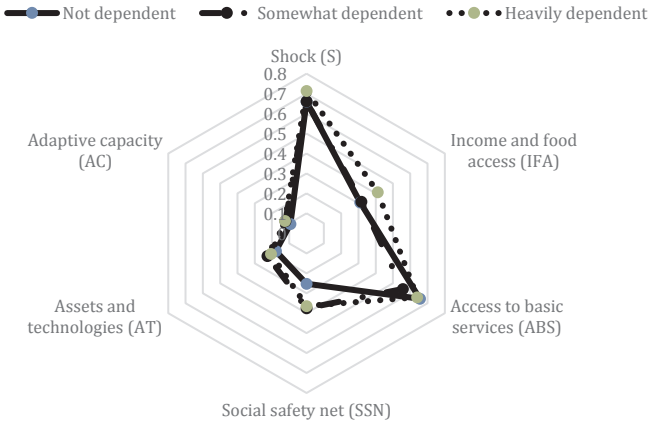

Fig. 5. Resilience components by forest dependency groups: Heavy forest dependency; somewhat dependency on forest and non-forest dependency groups.

Table 4
Households' adaptation measures.

Adaptation measures	Adoption rate (%)
Non-adopter, did not do anything and wait for favourable conditions	5.49
Using tolerate variety/breed	54.49
Mulching	36.28
Mix cropping	56.71
Crop rotation	31.10
Adjustment of seasonal calendar	62.50
Change to new crop	27.74
Change to new livestock	24.39
Water saving	32.93
Irrigation	33.84
Soil conservation	48.48
Off farm earning	46.04
Tree planting	17.07
Food storage for livestock	53.35

knowledge to adapt to climate change and variability.

Adjustment of the seasonal calendar was the most popular measure adopted by households in the studied area (Table 4). One respondent stated that "*due to changing weather extreme events, particularly the unusual distribution of rainfall patterns that causes floods, landslides, and drought, the seasonal calendar should be flexible. We have to use our indigenous knowledge to predict the weather conditions to decide the crop calendar. We experienced lots of losses of crop and fisheries due to climatic problems*". Mixed cropping; using tolerant varieties/breeds and storing feed for livestock during winter were also widely applied adaptation measures. Responses indicated that mulching had been the most popular adaptation measure a few years ago in the area, but it has fallen out of favour due to the spreading of pests and diseases, especially mice.

Various soil conservation techniques were adopted to protect land from soil erosion, landslides and enhance soil fertility, such as making different types of terraces; planting nitrogen-fixing crops; and applying organic fertilizers. The majority of arable land is sloping land and subject to problems of land degradation due to climate change, and a relatively high percentage of households applied these soil conservation techniques. To avoid risks from climate change and income losses due to sharply reducing access to natural forests, nearly half of households interviewed (46%) diversified income sources and shifted towards off-farm activities as a way to adapt. The only issue highlighted by our respondents and commune chairmen was the low wages paid to labourers. Many of ethnic minority farmers were paid only two thirds or even half in the case of female labourers) when compared to the earnings by majority Kinh people for doing the same work. Tree planting was an adaptation measure normally employed by households who kept livestock or had fish ponds. Planting trees around the garden or the fish pond reduces heat stress and water evaporation during the summer time. Few households choose to plant trees to enhance their resilience.

3.3. Determinants of households' adaptation strategies

Factors affecting the intensity of households' adaption are presented in Table 5. The results showed that education level of the household head; awareness of climate change; household perception about climate risk; number of household income sources; and household's ability to access credit were significant determinants of the number of household adaptation measures used. The results indicated all being equal, an increase of one year of education of the household head would lead to an increase of 0.117 more adaptation measures being adopted. Household heads who have heard about climate change were likely to adopt more adaptation options than those who have not heard of climate change. Household heads who perceived climate change as a risk to their livelihood were likely to adopt about three times more measures than those who did not.

Table 5
Determinants of numbers adaptation measures adopted by households.

Variables	Coefficients	S.E	t value
Age of household head	0.001	0.011	0.075
Gender of household head	0.577	0.420	1.373
Education level of household head	0.117***	0.044	2.656
Awareness of climate change	0.919***	0.304	3.021
Household labour force	0.082	0.144	0.566
Poor household	0.162	0.379	0.429
Near poor household	−0.638	0.402	−1.585
Cattle holding	−0.031	0.029	−1.046
Poultry holding	0.002	0.011	0.154
Assets	0.000	0.001	-.370
Social networks	0.207*	0.118	1.759
Land holding	−0.001	0.003	-.516
Income per capita	0.010	0.009	1.122
Income sources	0.560***	0.100	5.591
Access to credit	0.526***	0.114	4.622
Risk perception	2.619***	0.313	8.370
District	−0.961**	0.389	−2.468
Constant	0.325	0.862	0.377
R square	0.517		

***,**,*represent 99; 95; and 90 percent significant levels, respectively.

With a significance level of 99%, the diversification of income source indicated the importance of a household's income stability to the adaptation decision. Households who had one additional income source tended to adopt 0.526 more adaptation measures. Key informant interviews confirmed that household who are diversified are better able to manage and stabilise cash flow and minimize losses due to risks of climate and market changes.

Access to credit also has a very high significance level. Access to credit was a big issue in the two districts. As mentioned above, many farm households in the two districts were in debt because of their failure in rubber project, and thus they lose their interests in investment on adaptation. Those who were not in debt and able to access credit are likely to adopt 0.526 times more measures than those who were not able to access credit. However, as explained by respondents, most of adaptation measures are indigenous and low financial requirement, therefore, households' financial capacity did not decide the number of adaption measures adopted but their accessibility to financial resources and interests of investment in adaptation did. It's also the reason why household wealth group, and household assets and income did not relate to the number of adaptation measures adopted by households. Among the two districts, although Nam Đông had more favourable socio-economic conditions, people in A Lưới district are likely to adopt (0.96 times) more measures.

4. Discussion

The findings showed that different wealth groups (poor, near poor and better off) had almost similar CRI scores, however scores were different for those dependent on forest resources. The forest dependency group had a relatively higher CRI score, particularly in relation to income and adaptive capacity than the other groups. It was explained by key informants that "*households depending heavily on forests for livelihoods often had a good labour force with good life skills and good health. Therefore, they easily find other jobs (hired labour on acacia or rubber plantations; or wage labour for carpenter or other private enterprises) and they could adapt very well to the changing environment*". For households that have never been collecting forest products or households who only collect forest products during agricultural off-seasons, their livelihoods depended more on agriculture. They were locally named as 'agricultural households'. These households have been facing various difficulties in earning, including limited arable land, land degradation due to landslide, droughts, soil erosion, expensive production inputs

and costly adaptation measures introduced by outsiders. Therefore, the 'agricultural households' had lower income, lower food availability and faced more shocks than the forest-dependent households. It could be argued however, that these agricultural households are indeed dependent on forests, not predominantly for income, but for the ecosystem services that forests provide, such as soil conservation and stabilizing stream flows and water runoff (Jenkins and Schaap, 2018), which are highly relevant to the study area.

Despite forest restrictions, forest-dependent households were able to use their experience in harvesting forest products (such as rattan, herbs, medicinal plants, honey), social networks and labour force to generate alternative forest income or off-farm income. A Lưới is a more isolated area and has unfavourable topographical conditions compared to Nam Đông, creating barriers to access both information and markets and therefore limited adaptation options. Compared to A Lưới, in Nam Đông we find that there were closer connections with markets for inputs and production outputs. Our findings show a higher percentage of the labour force in Nam Đông moving from on-farm earning activities or forest harvesting activities to non-farm earning as wage-labourers than in A Lưới. As a consequence, people in A Lưới tend to be more dependent on both natural forest resources and agriculture and thus their culture and Indigenous knowledge play crucial roles in their livelihood decisions. Other studies have found that rural households move into off-farm employment as a long-term strategy to climate change rather than a short-term coping mechanism (Mathenge and Schirley, 2015) and our study supports this whereby geographic and structural factors enable Nam Đông residents to access off-farm opportunities more readily. However, most respondents acknowledge that adaptation is necessary and expressed that both agriculture production and collection of non-timber products means higher livelihood risks, because of unpredictable and irregular weather conditions, the degradation of natural forest and restricted access to natural forests. Thus, off-farm earning was the soundest option for ensuring frequent cash flow for households. One respondent mentioned that "*Working off farm, we are paid daily. With this payment we could ensure food for our family*". The trend for many households is therefore a shift to off-farm earning, although this may look different in each location. In A Lưới, the shift was to wage labour on acacia plantations within the district, with few people leaving the district to work as a carpenter or mason. In contrast, people in Nam Đông have more options available, such as starting a small business or becoming a middleman for the selling of local produce. The study also found potential bias against both study site residents where ethnic minority labourers are paid half-two thirds less than Kinh Vietnamese. This could be explained by the A Lưới and Nam Đông residents potentially lacking relevant technical skills but this needs to be explored further. Due to increased off-farm activity, people in Nam Đông depended more on market transactions whereas people in A Lưới were more dependent on each other for support. These were the reasons why some components' scores, such as SSN and shocks, are relatively higher in A Lưới district than Nam Đông district.

A lack of savings intensified the dependence on natural resources and agriculture and showed the vulnerability of these households to climatic shocks. The results show that household's everyday livelihood activities only just met the daily demands for food and other basic expenditure. This also highlights why the storms in both 2013 and 2015 had such deleterious effects on households in this study area. These storms destroyed households' crops and combined with a drop in latex price in 2013-2014, farmers were unable to recoup their investment and without adequate savings they were unable to repay their debt. The majority of households in the two districts are therefore not able to secure any further credit to invest in adaptation measures and potentially enhance their resilience. Storm damage to rubber plantations is not restricted to Thừa Thiên-Huế province with other rubber farmers in Quảng Trị province were also affected by storms in 2013 and 2017 (VietNamNet, 2017). The precarious nature of rubber is also felt by smallholders around the world where the interval time of approximately seven years between planting and harvest can be difficult for smallholders to recover (Kramer, 2009) and climate change is likely to exacerbate environmental marginalisation of these plantations (Ahrends et al., 2015). Therefore, choice of agricultural enterprise will influence household vulnerability.

Studies have shown that extension and training can have positive influence on adaptation to agricultural-specific climate shock coping strategies (Mehar et al., 2016). However, our results showed that the majority of farmers did not know any extension staff in the area, and as a result, local people depended more on their local knowledge and experience for adaptation rather than strategies from extension staff. Observational data showed that some adaptation techniques already practiced by farmers appeared to be more suitable to the environment and changing conditions than what the extension training by commune staff could provide. Further, the well-developed local support network is crucial in explaining why we find a relatively large gap in adaptation practices as advocated by local and national authorities (policy) and a reliance on local practices (Huynh Anh Phuong and Resurrección, 2014). Our findings show that despite improved socioeconomic conditions in Nam Đông, people in A Lưới were likely to adopt more coping measures. This can be explained by the geographical conditions which make A Lưới more vulnerable to climate change, the larger agricultural plots and greater dependence on agriculture in A Lưới, which means they had to adopt more measures to make their farm more resilient.

Our study confirmed the results of previous research that awareness and risk perception played important roles in adaptation decision-making (Marshall et al., 2010, 2013; Tambo, 2016; Le Thi Hong Phuong et al., 2017). Those who are more aware of climate change are able to access more diversified sources of information and able to better analyse the potential application on their farm. Our study was also consistent with results found by Truong Quang Hoang et al. (2017) in A Lưới and Nam Đông and Le Thi Hoa Sen and Dang Thu Phuong (2017) in Quảng Trị province who found that rural people have diversified their income sources in order to adapt to climate change. If one source is affected they still get income from other sources. Our study also supports the findings of Mehar et al. (2016) that a prominent coping mechanism, in this study enacted or desired, is to find off-farm employment, Vietnamese government policies (Decision No 106/2006/QĐ-BNN and Decree No 99/2010/NĐ-CP) have been introduced promoting alternative livelihood options to provide security of income in the context of increasing impacts of climate change, forest resource degradation, and restricted forest harvesting.

5. Conclusion

This paper aimed to exploring climate resilience and adaptation strategies of different ethnic groups in upland areas of Thừa Thiên-Huế province. We used the climate resilience framework developed by FAO in 2010 to compute households' Climate Resilience Index of the ethnic groups in Nam Đông and A Lưới districts. The household resilience index (CRI) had six major components that contained 41 indicators. A Poisson regression model was also employed to analyse determinants of a household's number of adaptation measures adopted.

The survey results indicated that ethnic minority groups in upland areas of Thừa Thiên-Huế province are increasingly affected by extreme climate events, particularly drought and irregular rainfall distribution which has caused significant crop loss, soil erosion and landslides. Results of computed CRIs showed that communities dominated by ethnic minority groups of the two districts had a low resilience to climate change and those in A Lưới district have relatively lower resilience than those in Nam Đông. Among the six CRI's components, ethnic minority households were shown to be moderately resilient in terms of social safety nets (SSN), access to basic services (ABS) and shocks (S), while they were shown to be weakly resilient regarding income and food access (IFA); assets and technology (A&T) as well as adaptive capacity (AC). Household assets, savings and knowledge about climate

change showed households' weakest resilience aspects. Formal information channels did not work effectively in the study sites and this led to an extremely high percentage of people, even commune and village leaders, who haven't heard of climate change nor fully understood climate change and its causes.

Climate resilience of different ethnic minority groups (with differentiation among wealth and natural forest dependency categories) were not significantly different, however, it seems that households closer to the town centre are more resilient because of more favourable conditions allowing for the build-up of better assets, access to information and services; technologies and adaptive capacity. The agriculture and non-forest-dependent group had the lowest CRI, indicating it was the least resilient group in the upland communities.

Results from the analysis of household adaptation showed that almost all ethnic minority households in the upland area of Thừa Thiên-Huế province adopted adaption measures to enhance their resilience to climate change. Most adaptation strategies were formed by local knowledge and experience rather than knowledge transfer from extension staff. The measures most widely applied by households were adjusting the seasonal calendar for crop production to avoid heavy rains and floods; using both short duration and tolerant crop varieties and practicing mixed cropping to reduce the risk of total crop failure. Various techniques of soil conservation and land protection were adopted, although mulching was not adopted by many households since it was not as effective as in the past. Trees were planted around gardens or fishponds to reduce heat stress for livestock and fish but it was the adaptation measure least adopted in the study sites.

The Poisson model used to analyse the determinants of the number of adaption measures adopted by households found that education level, climate change awareness and risk perception of the household head, household income source and ability to access credit were the key determining elements. Household participation in community social networks was also important for accessing information and supports from their network members to practice adaption measures. Ethnic households in A Lưới district were likely to adopt more adaptation measures than in Nam Đông. Further in-depth investigation into which adaptation measures can lead more resilience would be a useful next step.

The above findings are essential for policy makers as well as scientists in the efforts to enhance climate resilience for ethnic communities in the uplands of Thừa Thiên-Huế province, especially those living close to natural forests. **First**, it is important to have activities and policies to increase people's knowledge about climate change, impacts and climate risks. The policies should focus on strengthening capacity and consolidating the existing information channels in the area, including formal and informal extension networks, community groups, social networks and early warning systems. These will provide understandable, timely and sufficient information about climate change and variability for farmers. **Second**, policies formulated to improve household income, savings and build household assets, should give priority to the poor, ethnic minority and agriculture-dependent households (including both forest-dependent and nonforest-dependent households). They should promote the strengthening of capacity and technical skills to gain higher wages in off-farm earning and introduce and demonstrate adaptation livelihood models that suit the socio-economic conditions of each group of farmers. **Third**, the research successfully developed a tool to compute CRI of a community and it could serve as a tool for monitoring climate change resilience of the community, supporting scientists and policy makers to formulate appropriate actions to enhance communities' climate resilience. **Finally**, since this study only used cross-sectional data to compute CRI, these data could only reflect the situation over a very short period of time (one year). Conditions are rapidly changing due to climate change and are exacerbated by inadequate policies, such as restricting access to natural forests, possibly hampering local adaptation efforts. In addition, the study employed the balanced weighted approach in computing CRI instead of unbalanced weighted techniques such as AHP (Analytic Hierarchy Process) or PCA (Principle Component Analysis). Therefore, future research that considers all of these elements could be undertaken to more fully explore community resilience and opportunities to enhance climate resilience for all ethnic groups.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

Acknowledgment

This research was funded by the Vietnam National Foundation for Science and Technology Development (NAFOSTED) under grant number 504.05-2018.300. Thanks to our respondents for giving up their time to speak with us. Thanks also to Deanna Duffy (CSU) for developing the field site map.

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