Measuring the livelihood vulnerability index of a dry region in Indonesia

A case study of three subsistence communities in West Timor

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Abstract

Purpose – The purpose of this paper is to contribute to the study of sustainable rural livelihoods by developing a model to measure vulnerability of subsistence communities in dryland regions and identifying the major determinants that contribute to the livelihood vulnerability of these communities.

Design/methodology/approach – The author conducted a household survey across three subsistence communities in West Timor ($n = 627$), from June to November 2013. Based on the guideline of the OECD (2008), the author developed a series of indicators and constructed a composite index to measure the vulnerability of dryland communities. The author adapted the livelihood vulnerability index (LVI) measure from Hahn *et al.* (2009) but refined it by using Shannon's entropy method in deciding the weights of indicators and statistically tested the correlation between indicators using Kendall's correlations.

Findings – Six major determinants were identified: education (EDU), children's participation in agriculture (CPA), agricultural income (AI), subsistence food reserve (SUBSIST), social-cultural participation (SCP) and access to water, health clinic and market (ACC). LVI in all communities shows significant and strong relationships with SCP (0.594, $p < 0.01$), AI (0.545, $p < 0.01$) and CPA (0.434, $p < 0.01$). This signifies that constraints to engage in social gatherings, market the harvest and obtain additional labour input are currently the major contributor to the vulnerability in these communities.

Research limitations/implications – Shannon's entropy is one of the methods for assisting in making decision (ranking) objectively. The results may need to be tested further using other methods.

Practical implications – Using objective weight provides additional information useful for identifying and prioritising areas (sub-components) which require attention and appropriate solutions to prevent households from further impoverishment and increased vulnerability.

Social implications – Livelihood vulnerability of subsistence community in dry region is closely related to local survival skills and customs. Differences in the level of vulnerability across communities are due not only to geographical location and physical infrastructure, but also the leadership of local customary leaders and village government in looking for ways to improve the livelihoods of community members.

Originality/value – This paper is based on part of the results of a PhD thesis supported and approved by Griffith University. It has not been published before.

Keywords Sustainability, Drylands, Climate change, Rural, Livelihood diversification, Subsistence community

Paper type Research paper

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1. Introduction

In the era of global warming, communities in rural drylands are likely to be the most vulnerable group (Fraser *et al.*, 2011; Solomon *et al.*, 2007). This is because most of these communities live mainly at a basic subsistence level by performing subsistence farming combined with additional income from non-agricultural sources (Hunt, 1991; Food and Agriculture Organisation (FAO), 2004). Assistance for these communities to adapt to the effects of global warming and to sustain livelihoods is urgently needed.

This study attempts to contribute to the study of sustainable rural livelihoods. Through a household survey across three subsistence communities in dryland regions of West Timor ($n = 627$), we develop a model to measure livelihood vulnerability to drought and identify the major determinants of vulnerability in dryland communities. In the next section, this paper reviews literature on vulnerability of dryland communities to climate change and the socio-economic determinants of vulnerability. The study area and research method are described in the second section. The results and discussions are presented, respectively, in the third and fourth sections. The last section provides the conclusion of the paper.

1.1 Dryland communities' vulnerability to climate change

In adapting to changes (environmental, climatic, policy and political changes), resource-scarce communities generally choose to move to other resourceful communities to marry, or stay temporary to earn money, as supplementary income to feed their family. For example, the hardships resulting from to the drying river in the southern Murray-Darling Basin in Australia caused the local communities to leave the region for jobs and the number of students to decline as local schools could hardly retain teachers (Golding and Angwin, 2009).

Dryland communities are found to confront not just drought, but also the impact of marketisation of water, global financial crisis, declining commodities' prices, an ageing community and the declining interests of younger generation to continue family farm business (Kiem and Austin, 2013). Two farming communities in regional Victoria of Australia, Donald and Mildura, have actively taken initiatives to survive and sustain the community, but these people find it difficult to apply support schemes due to the declining number of skilled people in rural areas combined with limited finance and technological resources (Kiem and Austin, 2013).

Other studies also found that in some cases, livelihood resources of rural communities are altered by government policy processes rather than environmental changes. Among others are the UK policy in agriculture to reserve national security from 1915 to 1980 (Condliffe, 2008); the Integrated Rural Development Programme in Columbia from 1976 to 1981 (Escobar, 1995); the pricing policy in Malawi from 1970s to 1980s (Barbier, 2000); the forestry decentralisation in Latin American countries (Larson *et al.*, 2007); and the decentralisation programme in Vietnam (Vien *et al.*, 2005), Cambodia (Ehrentraut, 2011) and Indonesia (Duncan, 2007). All these studies found that these government policies have a negative effect on their resource-dependent communities including subsistence farmers, herders, forest-dependent poor and the ethnic minorities.

1.2 Socio-economic factors as determinant of vulnerability

In explaining vulnerability of a society, socio-economic factors play a more critical role than the exposure to climatic shock itself (Fraser *et al.*, 2011; Watts and Bohle, 1993; Turner *et al.*, 2003a, b; Ericksen, 2008). Freedom and capabilities to access a range of resources can help develop adaptive capacity of communities to extreme environmental changes (Sen, 1983, 2000). Collapse of social bonds (cooperative relationships) can lead to resource decline and increasing vulnerability as conflict arises among competing groups (McCay and Jentoft, 1998 cited in Li and Huntsinger, 2011).

Many studies also emphasise the role of socio-ecological resilience, for instance, social networks as key resource to sustainability in rural areas (Sabo, 1991; Reed *et al.*, 2008), resilience in rural communities (McIntosh *et al.*, 2008; Chitea, 2012; Daskon, 2010), indigenous knowledge in the disaster risk reduction policy (Shaw *et al.*, 2008, 2009), and adaptive capacity of indigenous culture to cope with change (Colombi, 2012).

In measuring the vulnerability of rural people to climate change, Schwarz *et al.* (2011) identified three variables of local governance which influence the perception of people about the ability of their community to cope with crisis in the future, among others: "household's participation in communal activities", "household's support and respect for community leader's decisions" and "household's perceived strength of the leadership". Similarly, Hahn *et al.* (2009) and Thomas *et al.* (2005) also agree that community bonds and high level of trust among resource-dependent communities can contribute to reducing vulnerability to extreme weathers. However, all these studies note that some factors that societies perceive as important for resilience are hard to measure and to integrate into the vulnerability model.

1.3 Measuring vulnerability: a composite index

Hahn *et al.* (2009) construct a composite indicator based on seven major variables to assess the vulnerability of rural communities in Mozambique to the impact of climate change. Individual variables are compiled into a single index to be used to describe the performance of a region in relation to the others (Miller *et al.*, 2012). Composite indicator summarises multi-dimensional issues into a big picture which allows practical interpretation (rather than an array of separate indicators).

The major disadvantage of composite indicator lies in the weights of each variable; the use of different weights to the variables can result in poor construction of index, thus misleading information (Miller *et al.*, 2012). By using weighted average method, Hahn *et al.* (2009) decided the weights on the basis of number of questions (sub-components); this implies that the weights are subjective (Angrist and Imbens, 1995; Lofti and Fallahnejad, 2010). Subjective weights may not be precise when the information is: unquantifiable; incomplete; unobtainable; or partial ignorance (Yeh and Deng, 1997, cited in Wang and Lee, 2009, p. 8981).

To overcome this problem, this study used objective weights (by solving mathematical models through methods such as Shannon's entropy) for assisting in making decision (Wang and Lee, 2009; Lofti and Fallahnejad, 2010; Zhang *et al.*, 2014) and statistically tested the level of correlation between variables using such as Pearson's or Kendall's τ correlations (Organisation for Economic Co-operation and Development (OECD), 2008). In developing the Dryland Community's livelihood vulnerability index (LVI), this study utilised both subjective weight and objective weight for comparison (see Tables VI and VII). The use of subjective weight is based on weighted average method adopted from Hahn *et al.* (2009), while the objective weight is based on Shannon's entropy method.

2. Methods

2.1 Study area

The study was conducted in three *Atoin Meto*[1] communities across two regencies of West Timor (Kupang and Timor Tengah Selatan (TTS) from June to November, 2013, as part of a doctoral research into rural livelihood sustainability, drought adaptation and decentralisation impacts by a research team from Griffith University. The three Meto communities comprised of: (i) one in a midland region of Kupang; (ii) one in upland of TTS; and (iii) one in lowland of TTS.

The three research sites were selected based on the gaps identified through the literature review and the consultation with local academics and practitioners in rural development areas, including Institute of Resource, Governance and Social Change and Forum Academia NTT. West Timor is a semi-arid island, located in East Nusa Tenggara (NTT), the fourth poorest province of Indonesia. Subsistence farming is commonly found in poor districts (*kecamatan*) of NTT where people grow corn or raise animals for domestic consumption (Barlow and Gondowarsito, 2007). The regional economy relies mainly on agricultural production (nearly 35 per cent of NTT regional-GDP in 2013) (BPS NTT, 2014), in which 61 per cent of its working population in 2013 made a living from agriculture (BPS NTT, 2015). Since decentralisation reform in 1999, this region has received increasing assistance from the government as well as non-government organisations, but the reform has also facilitated many large-scale development projects that are not effective for supporting the livelihoods of the grassroots (Tjoe, 2013).

From years 2008 to 2011, according to Regional Meteorology Bureau in Kupang, the average annual rainfall recorded in its capital city, Kupang was 1,785 mm (256 days/year without rain). On the other hand, for the same period, TTS Regency's Agricultural and Food Security Agency recorded an average of 2,134 mm annual rainfall (237 days/year without rain) in its capital city, SoE. In both regencies, the highest intensity of rainfall occurs between early December and mid-March, with the rest of the year being dry and hot. The increasing incidents of long droughts, landslides and extreme rainfalls have worsened the region's poverty issue to the extent where crop failure, clean water and food crises occurred in almost all districts (Muslimatun and Fanggidae, 2009; National Bureau for Disaster Management, BNPB, 2009).

2.2 Measuring the Dryland Community's LVI

We developed a series of indicators by following the guideline of the OECD (2008). The indicators reflected the five livelihood assets identified in Chambers and Conway (1992) and Department for International Development (DFID) (1999) on Sustainable Livelihoods Framework, among others are: natural resources, human capital, social capital, financial sources and physical infrastructure. We involved individual reviews to refine the draft of questionnaires and conducted field-testing so that the final version of survey questionnaire is place-and-culture specific to NTT region[2]. Table I shows the developed indicators of the Dryland Community's LVI for the subsistence communities in West Timor.

The measure of LVI in this study was adapted from Hahn *et al.* (2009) who assessed risks of two districts in Mozambique to future climate change impacts. LVI equation follows the simple average method as shown below:

$$\text{Average} = \frac{1}{n}\sum_{i=1}^{n} Component_i \tag{1}$$

where $Component_i$ = value of a major component of rural livelihood identified in this study, and n = the number of major components.

First, the answer of each question (sub-component) is standardised as an index (Index S_c). The equation used for this conversion was adopted from Hahn *et al.* (2009) which itself was adapted from the human development index[3] (UNDP, 2007):

$$\text{Index } S_c = \frac{S_v - S_{\min}}{S_{\max} - S_{\min}} \tag{2}$$

Major component	Sub-components	Explanation of sub-components	Source/adapted from
1. EDU (education of household members)	Education of household heads	% household where head of household never attended school	Indonesia Demographic and Health Survey, 2007 (BPS (Statistics Indonesia) and Macro International, 2008)
	Household heads' educational level	Head of household's last educational level	Human Development Report (UNDP, 2014)
	Literacy of household heads	% of household where head of household cannot read and (or) write	BPS (Statistics Indonesia) and Macro International (2008)
	Female members' education	$\frac{\text{No. of female members who never attend school}}{\text{Total no. of female members in the house}}$	UNDP (2014)
2. CPA (children's participation in agricultural activities)	Caring of livestock	% of households whose children never participate in the care of domestic animals	Developed for the purpose of this questionnaire
	Farm work	% of households whose children never participate in farm work	Developed for the purpose of this questionnaire
	Gathering of forest product	% of households whose children never participate in collecting resources in forest	Developed for the purpose of this questionnaire
3. AI (agricultural produce and animals that are sold for cash Income)	Average crops sold for cash diversity index	$\frac{1}{(\text{no. of crops})+1}$	World Bank (1997)
	Average livestock sold for cash diversity index	$\frac{1}{(\text{no. of livestock})+1}$	BPS (Statistics Indonesia) and Macro International (2008)
	Average forest produce sold for cash diversity index	$\frac{1}{(\text{no. of forest produce})+1}$	BPS (Statistics Indonesia) and Macro International (2008)
4. SUBSIST (subsistence food reserve)	Average crops-grown-for-domestic-consumption diversity index	$\frac{1}{(\text{no. of crops})+1}$	World Bank (1997)
	Households who do not save seeds	% of households that do not save seeds for next season	Hahn *et al.* (2009)
	Households who do not save foods	% of households that do not preserve corn for domestic use	Hahn *et al.* (2009)
5. SCP (social-cultural participation)	Invitation to social gatherings	% of households who are rarely or never invited to social/cultural gatherings	Schwarz *et al.* (2011)
	Attend gatherings	% of households who rarely or never attended gatherings	Schwarz *et al.* (2011)
6. ACC (access to water, health clinic and market)	Water sources	Average time spent each day collecting water (minutes)	ICF Macro (2011)
	Source of water	Where do households collect water from?	ICF Macro (2011)
	Village health centre	Average time to the closest health facility (minutes)	World Bank (1997)
	Marketplace	Average time to the nearest marketplace (minutes)	Developed for the purpose of this questionnaire

Table I. Indicators of Ddryland Community's LVI developed for three subsistence communities, West Timor

S_v, individual's value (sub-component) for a major component in community c; S_{min}, the minimum value of the specified sub-component in community c; and S_{max}, the maximum value of the specified sub-component in community c.

Second, after each sub-component is standardised, reliability statistics and confirmatory factor analysis are conducted using SPSS 22. Table II shows the reliability and adequacy statistics of our survey data, in which the values of Cronbach's α, KMO and Bartlett's test for all the 19 indicators indicate significant reliability and adequacy of our data. Next, the suitability of our data for a satisfactory factor analysis is presented in Figure 1 (Scree Plot), Table III (total variance explained) and Table IV (rotated component matrix). Using principal component analysis, six components are extracted from 19 indicators, in which these six components explain a cumulative of 68.9 per cent of the variance (Table III). All items are significantly loaded onto the expected latent factor (Table IV). The Cronbach's α values for all components are within the acceptable values (0.5 and above, Table V). From this procedure, six major components of rural livelihoods for this study are confirmed: education (EDU), children's participation in agriculture (CPA), agricultural income (AI), subsistence food reserve (SUBSIST), social-cultural participation (SCP) and access to water, health clinic and market (ACC).

Third, individual index per component are then averaged using Equation (3) to obtain the average value of each major component:

$$M_c = \sum_{i=1}^{n} \left(Weight_{indexS_{ci}}\right) \times \left(Value_{indexS_{ci}}\right) \quad (3)$$

Number of items	19
Cronbach's α	0.789
Cronbach's α based on standardised items	0.763
Bartlett's test of sphericity approx. χ^2	4,929.172
df	171
Sig.	0.000
Kaiser-Meyer-Olkin measure of sampling adequacy	0.758

Table II. Reliability and adequacy statistics

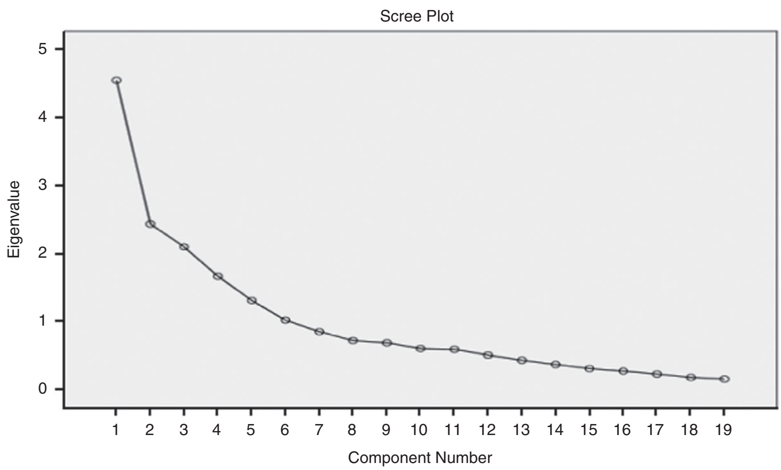


Figure 1. Scree plot (factor analysis)

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	4.552	23.957	23.957	4.552	23.957	23.957	2.706	14.243	14.243
2	2.437	12.826	36.782	2.437	12.826	36.782	2.408	12.671	26.914
3	2.102	11.066	47.848	2.102	11.066	47.848	2.364	12.444	39.358
4	1.669	8.783	56.631	1.669	8.783	56.631	2.065	10.867	50.226
5	1.311	6.902	63.533	1.311	6.902	63.533	1.838	9.676	59.901
6	1.020	5.369	68.902	1.020	5.369	68.902	1.710	9.001	68.902
7	0.850	4.476	73.378						
8	0.720	3.789	77.167						
9	0.686	3.610	80.777						
10	0.602	3.170	83.947						
11	0.590	3.107	87.054						
12	0.506	2.662	89.716						
13	0.432	2.274	91.991						
14	0.371	1.952	93.943						
15	0.311	1.635	95.578						
16	0.274	1.444	97.021						
17	0.229	1.207	98.228						
18	0.180	0.946	99.174						
19	0.157	0.826	100.000						

Note: Extraction method: principal component analysis

Table III.
Total variance explained (factor analysis)

	Component					
	1	2	3	4	5	6
HH never attended school	0.909					
Illiterate HH	0.864					
HHs last education level	0.791					
Uneducated female	0.585					
Children participation in farm		0.866				
Children participation in caring of livestock		0.864				
Children participation in forest		0.804				
Forest produce sold for cash			0.840			
Farm produce sold for cash			0.783			
Livestock sold for cash			0.742			
Households who save food				0.879		
No. of crops for domestic use				0.816		
Households who save seeds				0.757		
Often invited to gatherings					0.904	
Often attend gatherings					0.820	
Time spent collecting water/day						0.732
Type of water source						0.700
Time to reach market						0.607
Time to reach health facility						0.459

Notes: Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalisation. Rotation converged in six iterations

Table IV.
Rotated component matrixa (factor analysis)

Major components	M	SD	Cronbach's α	Cronbach's α based on standardised items
EDU (n = 4)			0.814	0.821
HHs never attended school	0.20	0.40		
HHs last educational level	0.71	0.22		
Illiterate household heads	0.25	0.43		
Uneducated female members	0.21	0.32		
CPA (n = 3)			0.838	0.839
Care of livestock	0.55	0.34		
Farm work	0.57	0.33		
Gathering of forest products	0.54	0.34		
AI (n = 3)			0.786	0.789
Livestock variety	0.60	0.38		
Crop variety	0.73	0.37		
Forest product variety	0.78	0.34		
SUBSIST (n = 6)			0.702	0.766
Crop variety for domestic use	0.15	0.13		
Do not save seeds for next season	0.07	0.26		
Do not preserve corn for domestic use	0.03	0.16		
SCP (n = 5)			0.878	0.879
Rarely/never invited to gatherings	0.19	0.40		
Frequency of attending gatherings	0.39	0.37		
ACC (n = 4)			0.535	0.543
Time spent each day collecting water	0.15	0.27		
Type of water source	0.56	0.29		
Travel time to the closest health clinic	0.18	0.28		
Travel time to the closest marketplace	0.29	0.31		

Notes: Total sample = 627. *M*, mean, SD, standard deviation

Table V. Means, standard deviations and Cronbach's α scores for all components

M_c, average value of one of the six major components for community c; *Index* S_{ci}, index (i) of a sub-component (S_c) that make up each major component; and n, the number of sub-components in each major component.

Then, a goodness-of-fit test is conducted through logistic regression; where independent variables include the six M_c, perceptions of respondents about the cause of disasters and their ability to cope with past disasters; while dependent variable includes perceptions of respondents about their ability to cope with future disasters.

Lastly, community – level LVI is calculated using the following equation:

$$LVI_c = \frac{1}{6}\sum_{i=1}^{6} M_{ci} \tag{4}$$

This can also be expressed as:

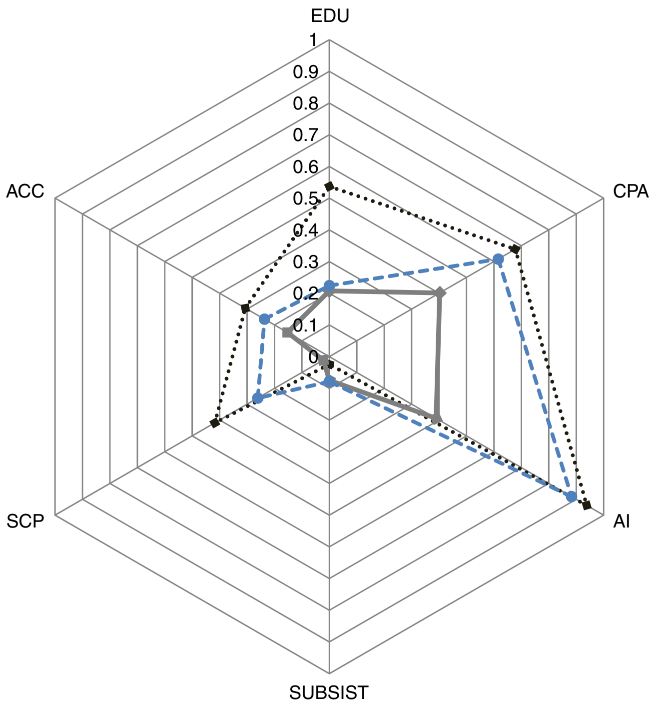
$$LVI_c = \frac{1}{6}(EDU_c + CPA_c + AI_c + SUBSIST_c + SCP_c + ACC_c) \tag{5}$$

where LVI_c, LVI for community c; M_{ci}, average value of a component (e.g. EDU_c, average value of component education); *EDU*, education of household's members; *CPA*, children's participation in agricultural activities; *AI*, agricultural produce and animals that are sold for cash income; *SUBSIST*, subsistence food reserve; *SCP*, social-cultural participation; and *ACC*, access to water, health facility and market.

LVI value is scaled from 0 (least vulnerable) to 1 (most vulnerable). The average value for each of the component is then plotted in a spider-diagram (Figure 2). All data analysis in this study was conducted using SPSS 22 and Microsoft Excel.

2.3 Calculating the weight of sub-components based on Shannon's entropy concept

Shannon's entropy is one of the most important metrics in the field of information theory (Lofti and Fallahnejad, 2010). It measures the uncertainty associated with a random variable, i.e. the expected value of the information in the message (in classical informatics it is measured in bits). It was introduced into information theory in 1948 by Claude E. Shannon who proposed the concept of information entropy to measure the level of system chaos or disorder (Shannon, 1948). Information flow is defined by Shannon as the reduction of uncertainty, which is inversely related to probability (Seligman, 2009). The concept of Shannon's entropy provides the average intrinsic



Notes: ◆······ UPLAND; ◆—— MIDLAND; ●- - - LOWLAND. 0.0 = Least vulnerable; 1.0 = most vulnerable; EDU, education; CPA, children's participation in agricultural activities; AI, agricultural produce and animals that are sold for cash income; SUBSIST, subsistence food reserve; SCP, social cultural participation; ACC, access to nearest market, water source and health facility

Figure 2. Spider diagram of the six components of LVI for the three communities

information by measuring the relative contrast intensities of individual attributes (Zeleny, 1996, cited in Wang and Lee, 2009, p. 8981).

According to Shannon, information content, h(E), of an event E is defined as a function which depends only on the probability P{E}, as expressed in the following logarithmic function:

$$h(\mathrm{E}) = \log \frac{1}{\mathrm{P}\{\mathrm{E}\}} = -\log \mathrm{P}\{\mathrm{E}\} \quad (6)$$

where:

- h(E) is information content of an event E; P{E} is the probability of E to occur;
- h(E) must be a decreasing function of P{E}: the more likely an event is to occur, the less uncertain we are about it occurring (hence the less information its occurrence brings to us);
- $h(\mathrm{E}) = 0$ if $\mathrm{P}\{\mathrm{E}\} = 1$, since if we are certain (there is no doubt) that E will occur, we get no information its occurrence brings to us;
- $h(\mathrm{E} \cap \mathrm{F}) = h(\mathrm{E}) + h(\mathrm{F})$ if E and F are independent; and
- $\log\left(1/p\{e\}\right) = -\log p\{e\}$ denotes a measure of uncertainty of an event and is expressed in bits (i.e. the unit of base 2 logarithm).

In the finite case, uncertainty about a source is defined as the sum of uncertainties about the source states, weighted according to their probability (Seligman, 2009), expressed as follows:

$$H(X) = -\sum_{i=1}^{n} p(\{x_i\}) \log_2 p(\{x_i\}) \quad (7)$$

where:

- $H(X)$ is the Shannon's entropy of a discrete random variable X taking values in $\{x_1, x_2, \ldots, x_n\}$.
- $p\{x_i\} = \mathrm{P}\{X = x_i\}$ is the average uncertainty in the outcomes $\{X = x_1\}$, $\{X = x_2\}$, …, $\{X = x_n\}$.
- n, number of outcomes; n can be infinite.
- $H(X)$ depends only on the probability distribution of X, not on the actual values taken by X.
- If n is finite, the maximum of $H(X)$ is achieved if and only if X is uniformly distributed over its values. In this case, we have $H(X) = \log n$.
- Entropy $H(X)$ is non-negative; it is between 0 and 1 when the events/outcomes are binary (e.g. Yes or No; Head or Tail); it is greater than 1 when the events/outcomes are not binary (e.g. always, sometimes, rarely, or never attend gatherings).

After obtaining the value of $H(X)$, the ratio of $H(X)$ to the maximum possible value in the source (log n) is quantified with the following equation, called relative entropy (Shannon, 1948):

$$\text{Relative entropy} = \frac{H(X_i)}{H_{(xi)max}} \quad (8)$$

To obtain the amount of information flow (i.e. reduction of uncertainty), Wang and Lee (2009) propose the following equation to calculate the degree of divergence:

$$d = 1 - H(X) \tag{9}$$

in which the equation for d in Wang and Lee (2009) assumes that 1 is the maximum possible value of the source, i.e. $\log n = 1$, thus $n = 2$ (outcomes are binary). For non-binary outcomes, d is expressed as follows:

$$d = \log\ n - H(X) \tag{10}$$

where d is the degree of divergence, representing the intrinsic information of the source (attribute or sub-component); the higher the value of d, the more important this source is for the component. The weight for each source can then be obtained using the following equation adopted from Wang and Lee (2009):

$$w = \frac{d_i}{\sum_{i=1}^{n} d_i} \tag{11}$$

where w, Shannon's objective weight of sub-component i in a component; d_i, degree of divergence of sub-component i in a component; and n, number of sub-components in a component (e.g. EDU has four sub-components, $n = 4$).

When the value of Shannon's entropy $H(X)$ for a particular sub-component is smaller, the value of its degree of divergence d will be greater which indicates that there is a greater reduction of uncertainty and a greater amount of information flow provided by this sub-component, hence this sub-component deserves a higher weight w in the decision making process (Wang and Lee, 2009, p. 8982). On the contrary, when the value of Shannon's entropy $H(X)$ is larger, the value of its degree of divergence d will be smaller which indicates that there is a less reduction of uncertainty (less amount of information flow) provided, hence this particular sub-component deserves a smaller weight w in the decision-making process.

2.4 Data collection – household survey

In each community, four native speakers of *Bahasa Indonesia* and *Meto* language[4] were recruited from respective regions and trained for surveys, including understanding the questionnaires, objective of each question and confidentiality protocol[5]. The training was conducted in 2013 on the 14 and 15 July in Midland (Kupang); 23 and 24 August in Lowland (TTS); and 31 August and 1 September in Upland (TTS).

The household survey used stratified random sampling adapted from Hahn *et al.* (2009). Based on a sample size calculation (World Health Organisation (WHO), 2005) at 95 per cent confidence interval, 50 per cent prevalence, 10 per cent precision and a design effect of 2 to account for cluster sampling, at least 200 households in each community were surveyed[6]. Research team divided each community into several sub-groups based on the number of *dusun* (sub-villages) in each community and interviewed a same percentage of households per *dusun* in each community as sub-samples to represent the total population per community. The team conducted survey with a total of 629 households[7]. This offers advantage that survey can cover the whole geographic area, save time and cost. Once the field team arrived in the site, community leaders were first consulted to explain the purpose of the study and to obtain permission to visit households.

The sampling followed the expanded programme on immunisation "random walk" methodology (WHO, 2005). Briefly, research team spread out to *dusun*s. The team began by standing in the centre of the *dusun* and spin a pencil in the air to randomly select a starting direction for the first interviewer (UNICEF, 2008). The other interviewers turned to face 120° angles from the first. Then a random number was selected from an Rp5,000 bill and the interviewers walk in their respective directions, counting houses until they reach the selected number. This was the first house to be interviewed. For the rest of the interviews, the interviewers moved to the next closest house by walking diagonally across the road until they had interviewed their quota for that *dusun*.

3. Results

3.1 LVI – comparison between objective weights and subjective weights

Our study finds that when using objective weight, each indicator has its own weight that is distinguishable from the other indicators. Table VI describes the objective weights for the three indicators of SUBSIST. The sum value of uncertainty (d) for Q3 is lower than Q1 and Q2, thus Q3 has a higher weight (Q3 = 0.495) than Q1 (0.133) and Q2 (0.372). This means that in the aspect of SUBSIST, in terms of food storing (Q3), the 97 per cent of total respondents who reported that they preserved corn for domestic use has zero vulnerability, and the remaining 3 per cent who do not preserve corn has an increased vulnerability of 0.495. On the other hand, in the indicator of seed saving (Q2), the 93 per cent of total respondents who saved seeds for next planting season has zero vulnerability, while the remaining 7 per cent who do not save seeds has an increased vulnerability of 0.372. Contrasting with the concept of subjective weight (weighted average); it assumes each indicator as having similar weight, i.e. assigning an increased vulnerability of 1 value for those who do not save corn or seed in Q3 and Q2.

Table VII shows that the mean values of each of the six components as well as the value of LVI generated based on objective weights are different and more precise than the values generated based on subjective weights.

3.2 Livelihood vulnerability in Upland, Midland and Lowland communities

Table VIII presents all the sub-component values for each community, the minimum and maximum values for all communities combined. The six major components and the composite Dryland Community's LVI for each community are depicted in Figure 2 and Table IX. Upland community exhibits the highest vulnerability index in all components, especially in the households' marketable agricultural products (AI = 0.938), children's participation in agricultural activities (CPA = 0.678) and education of household members (EDU = 0.537). Kendall's τ correlations (Table X) show that the overall vulnerability indices of Upland and Lowland are significantly and largely correlated to SCP (households' involvements in social-cultural events), while Midland's vulnerability index is significantly and mainly related to AI and CPA. Overall LVI in all communities shows significant and strong relationship with SCP (0.594, $p < 0.01$), AI (0.545, $p < 0.01$) and CPA (0.434, $p < 0.01$), indicating that constraints to engage in social gatherings, market the harvest and additional labour input from children are important determinants of vulnerability in these communities.

3.2.1 Educational level of household members. Refer to Table VIII, in Upland community, 59.5 per cent of the household heads are illiterate (26.5 per cent were aged between 22 and 45, and 33 per cent were aged 45 and above), compared to Midland (8.8 per cent) and lowland community (9 per cent). In census 2014, the illiteracy rate at NTT provincial average is 3.48 and 19.87 per cent, and at national average is

Table VI. Shannon's entropy and objective weights, example from component SUBSIST (subsistence food reserve)

Possible outcomes	Probability	Uncertainty	
Q1 (Number of crop types for domestic use)			
14 types	0.001595	9.29232	If all the 15 possible outcomes is uniformly distributed over its values (i.e. each has a 1/15 chance of occurring), then the maximum value of uncertainty is achieved, Max *e*(Q1) = log 15 = 3.91. Given the distribution of the 15 possible outcomes obtained from data collection in the research site, the sum value of uncertainty for this Q1 is 3.04, this approximately 77.69% of the max value of uncertainty. This provides about 22.31% of the intrinsic information (*d*) that is important of this indicator
12 types	0.011164	6.48497	
11 types	0.007974	6.97039	
10 types	0.017544	5.83289	
9 types	0.035088	4.83289	
8 types	0.044657	4.48497	
7 types	0.049442	4.33812	
6 types	0.114832	3.12240	
5 types	0.280702	1.83289	
4 types	0.207336	2.26995	
3 types	0.129187	2.95247	
2 types	0.057416	4.12240	
1 type	0.027113	5.20486	
0 type	0.014354	6.12239	
Max *e*(Q1), 15 outcomes	3.906891		
e(Q1)	3.035109		
Relative *e*(Q1)	0.776861		
d	0.223139		
Q2 (Do you save part of the harvest as seed for next planting term?)			
YES	0.926635	0.10993	If all the 2 possible outcomes is uniformly distributed over its values (i.e. 50% of HH say YES; 50% of HH say NO), then the maximum value of uncertainty is achieved, Max *e*(Q2) = log 2 = 1.00. Given the distribution of the outcomes (92.66% say YES; 7.34% say NO), the sum value of uncertainty for this question (Q2) is 0.38 (i.e. 38% of the max value of uncertainty). This provides about 62% of the intrinsic information (*d*) that is important of this indicator
NO	0.073365	3.76876	
Max *e*(Q2), 2 outcomes	1		
e(Q2)	0.378358		
Relative *e*(Q2)	0.378358		
d	0.621642		
Q3 (Do you save and preserve part of harvest for domestic consumption?)			
YES	0.974482	0.037293	Given the distribution of the outcomes (97.45% say YES; 2.55% say NO), the sum value of uncertainty for this question (Q3) is 0.17 (i.e. 17% of the max value of uncertainty). This provides about 83% of the intrinsic information (*d*) that is important of this indicator
NO	0.025518	5.292322	
Max *e*(Q3), 2 outcomes	1		
e(Q3)	0.171393		
Relative *e*(Q3)	0.171393		
d	0.828607		

Note: Based on the intrinsic information (d), the weight of individual sub-component in SUBSIST is Q1 = 0.133, Q2 = 0.372 and Q3 = 0.495

1.24 and 12.25 per cent, for age groups 15-44 and 45 and above, respectively (Statistics Indonesia, 2015a). In terms of the education of females per household, the mean value for Upland was 0.39, in other words, for every three females in a household, one was uneducated. Contrasting with the values in Midland (0.10) and Lowland (0.15), the education of Upland females is far behind the average females in these regions.

3.2.2 Food and water security. Refer to Table IX, in all communities, the index for SUBSIST is the lowest. This is largely due to their tradition of growing subsistence corn

Major components	Upland ($n = 200$)	Communities Midland ($n = 226$)	Lowland ($n = 201$)
EDU			
Ob	0.537	0.208	0.224
Sub	0.572	0.227	0.238
CPA			
Ob	0.678	0.402	0.616
Sub	0.680	0.400	0.611
AI			
Ob	0.938	0.389	0.883
Sub	0.918	0.373	0.859
SUBSIST			
Ob	0.024	0.074	0.079
Sub	0.047	0.091	0.109
SCP			
Ob	0.418	0.022	0.261
Sub	0.492	0.056	0.353
ACC			
Ob	0.306	0.153	0.237
Sub	0.374	0.220	0.304
LVI			
Ob	0.484	0.208	0.383
Sub	0.511	0.236	0.400

Notes: Ob, objective weight (based on Shannon's entropy); Sub, subjective weight (based on weighted average)

Table VII. Comparison of results between objective weights and subjective weights

and other foodstuff in their farmland and community forest. Households in these communities belong to a certain clan. Households as clan members inherit a certain block of farmland and are granted access to community forest as their rights for livelihood. When growing and preserving corn, these communities distinguish clearly between local corn and market corn. Local corn is reported as inherited from ancestor, storable and last longer, hence households preserve local corn as long-term food and seeds. Market corn is easily damaged by pest, so households have to consume it first within a month of harvest. In the survey, these communities reported that they experienced shortage of food every summer season (October-January) because most of their preserved corn has been consumed and sowed in the farm. During that period, they combine alternative foods found in their community forest into their daily diet including cassava, various types of beans, butternut squash, kent pumpkin, tomatoes and papaya.

In all communities, the index for ACC (Table IX) is not as vulnerable as the other components. In Upland, local households use jerry cans (5 L) and walk multiple trips from their house to water source. Each household spent an average of 62 minutes each day collecting water. Water is then stored in drum (100-200 L), tempayan, kumbang or gentong air (20-50 L). Majority of households collect water from a common well and reported that they have sufficient water. Those who use spring water (8 per cent) also reported that they always have sufficient water throughout the year although in the summer they reduce the number of water collections per day. Only 20 per cent of

Table VIII. Dryland Community's LVI sub-component values, maximum and minimum sub-component values for the three subsistence communities, West Timor

Major component	Sub-component	Unit	Communities: Upland	Communities: Midland	Communities: Lowland	Value in all three communities: Maximum	Value in all three communities: Minimum
EDU	Household heads never attended school	%	48.5	6.6	5.5	100	0
	Household heads' last educational level	Type	0.82 (none to primary)	0.65 (primary)	0.66 (primary)	1 (none)	0 (university)
	Illiterate household heads	%	59.5	8.8	9.0	100	100
	Uneducated female members	Ratio	0.39	0.10	0.15	1 (all)	0 (none)
CPA	Children's participation in:						
	Caring of livestock	Type	0.66 (rarely)	0.38 (often)	0.65 (rarely)	1 (never)	0 (always)
	Farm work	Type	0.66 (rarely)	0.42 (often)	0.66 (rarely)	1 (never)	0 (always)
	Gathering of forest products	Type	0.73 (almost never)	0.40 (often)	0.53 (sometimes)	1 (never)	0 (always)
AI	Livestock variety	1/no. of animals+1	0.85 (none)	0.31 (≤1 type)	0.67 (none)	1 (none)	0 (≥ 5 types)
	Crop variety	1/no. of crops+1	0.91 (none)	0.37 (≤3 types)	0.95 (none)	1 (none)	0 (≥ 8 types)
	Forest product variety	1/no. of products+1	0.99 (none)	0.43 (≤1 type)	0.96 (none)	1 (none)	0 (≥ 5 types)
SUBSIST	Crop variety for domestic use	1/no. of crops+1	0.12 (4-8 types)	0.13 (4-8 types)	0.20 (≤ 3 types)	1 (none)	0 (≤15 types)
	Do not save seeds for next season	%	1.5	10.6	9.5	100	0
	Do not preserve corn for domestic use	%	0.5	3.5	3.5	100	0
SCP	Rarely/never invited to gatherings	%	38	0.4	21.4	100	0
	Frequency of attending gatherings	Types	0.60 (rarely)	0.11 (often)	0.50 (sometimes)	1 (never)	0 (always)
ACC	Time spent each day collecting water	Minutes	61.95	22.37	38.21	180	< 15
	Type of water source	Types	1.8 (common well)	1.4 (own or family well)	1.6 (family well)	1 (river, forest)	0 (buy water)
	Travel time to the closest health clinic	Minutes	83	34	73	> 180	< 30
	Travel time to the closest marketplace	Minutes	69	81	72	180	< 30

Sub-components	Communities Up	Mid	Low	Major component	Communities Up	Mid	Low
HHs never attend school	0.119	0.016	0.013	EDU	0.537	0.208	0.224
HHs last educational level	0.173	0.137	0.140				
Illiterate HHs	0.096	0.014	0.015				
Uneducated female members	0.148	0.040	0.056				
Caring of livestock	0.184	0.108	0.181	CPA	0.678	0.402	0.616
Farm work	0.274	0.173	0.273				
Gathering of forest products	0.220	0.120	0.161				
Livestock variety Index	0.215	0.078	0.169	AI	0.938	0.389	0.883
Cash crops diversity Index	0.216	0.089	0.227				
Forest product diversity Index	0.507	0.222	0.487				
Crops diversity Index	0.016	0.017	0.026	SUBSIST	0.024	0.074	0.079
Do not save seeds	0.006	0.040	0.035				
Do not preserve corn	0.002	0.018	0.017				
Rarely/never invited	0.316	0.004	0.178	SCP	0.418	0.022	0.261
Frequency of attending	0.102	0.018	0.083				
Proximity to water source	0.104	0.016	0.051	ACC	0.306	0.153	0.237
Type of water source	0.050	0.035	0.042				
Proximity to health clinic	0.085	0.007	0.070				
Proximity to marketplace	0.068	0.095	0.074				
LVI	Upland community: 0.484 Midland community: 0.208 Lowland community: 0.383						

Notes: Value is scaled from 0 (least vulnerable) to 1 (most vulnerable). All values are based on objective weight

Table IX. Indexed sub-components, major components, and overall LVI for Upland, Midland and Lowland communities, West Timor

Variables	Upland ($n = 200$)	Midland ($n = 226$)	Lowland ($n = 201$)	All communities ($n = 627$)
EDU	0.344**	0.155**	0.287**	0.396**
CPA	0.326**	0.399**	0.334**	0.434**
AI	0.252**	0.413**	0.025	0.545**
SUBSIST	0.083	0.239**	0.210**	0.132**
SCP	0.585**	0.201**	0.465**	0.594**
ACC	0.163**	0.122**	0.262**	0.338**

Notes: *$p < 0.05$, two-tailed; **$p < 0.01$, two-tailed

Table X. *Kendall's τ correlations between LVI and all components in Upland, Midland, and Lowland communities, West Timor

households who shared a common well in the same hamlet (*dusun* 1) reported that water is not always sufficient.

Unlike Upland community, the average time spent each day collecting water is less in Midland (22 minutes) and Lowland (38 minutes). Due to proximity to urban area, Midland community can buy water from local company (Rp50-65 thousand per 5,000 L). For those who can afford to build a water cistern reported that it takes less than 15 mins to have the water delivered to their house. In Lowland community, there are households who set up temporary shelter close to the beach for collecting stones during the fallow season. These households did not have large water storage (they only stored 5-10 L each day), yet reported that water is always sufficient because they also use sea water for daily water needs. In average, Upland households store 10-14.5 L of water in their house for daily use, while Midland and Lowland store more water (60-85 and 14-20 L, respectively).

3.2.3 AIs, livelihood strategies and SCPs. Refer to Table IX, Upland and Lowland communities have very high AI index (0.938 and 0.883, respectively). Cattle (pig and cow) are not easily sold in these regions unless there is a buyer or *papa lele* who visits to look for good breed and price. Chickens were raised but mainly for domestic consumption. Seasonal farm crops and forest produce like candle nut, banana and tamarind were transported to the urbans but households in these two communities did not consider these produce as routine cash generator. Most of the time, they stored these produce in their house because the cost of transporting these produce is higher than the profit they can earn. The main cause is the poor roads and the distance to major marketplaces (it takes up to four to ten hours of travel to reach SoE Capital City of TTS Regency and Kupang Capital City of NTT Province).

Nearly 85 per cent of the Upland and Lowland respondents diversify their income sources to other activities, in addition to AI. This study found that income diversification in Upland tends to be more traditional and make use of local materials, for instance, up to 40 per cent of the Upland respondents generate additional incomes by producing handmade food and *ikat tenun* (weaved fabric); in Lowland there were only 6 per cent. About 25 per cent of Upland respondents also generate additional incomes by offering low-skilled labour in the village such as *ojek* (motorcycle-taxi driver); in Lowland there were nearly 62 per cent of respondents generate additional incomes from both being an *ojek* and collecting colourful stones at the beach. In terms of working outside of the village for cash incomes, Upland respondents tend to leave during fallow season (May-August) to work as low-skilled construction labour in Kupang or SoE (reported by 15 per cent of Upland respondents). On the other hand, Lowland respondents tend leave for longer period to work as plantation worker and contracted maids in Java, Kalimantan or Malaysia (reported by 16 per cent of lowland respondents). There were a small portion of respondents with stable incomes (7 per cent in Upland and 14 per cent in Lowland) where these respondents were either a small vendor owner or their children work as public school teacher and civil servant in the village.

As shown in Table IX, these two communities have a considerably higher index in SCP and CPA, i.e. less involvement in SCP and less additional labour input from their family members. This is expressed by the respondents in Upland and Lowland during household survey that their daily needs are increasingly dependent on money and they are struggling to allocate their time and energy into cash income activities, food growing and social gatherings, especially for those whose family members left village for work or study.

Compared to the other two communities, Midland community has the lowest AI index (0.389). Agricultural products are sold for cash generating purposes. Midland respondents said that the road development during the 1990s has facilitated the easy access to sell their produce (one hour of travel time to Kupang City). Cassava, banana, chillies, eggplant and green vegetables were reported as the most sellable cash crops, in which the women brought these produce to markets on a daily basis. Forest produces were another source of cash income, including bamboos and woods like *mahoni* (broad-leaf mahogany) and *jati* (teak or tropical hardwood), nuts and fruits like candle nut, cocoa and tamarind.

Nearly 30 per cent of the Midland respondents reported that they depend solely on agriculture as income source. There were 10 per cent of the respondents diversifying their income by producing handmade food or craft (e.g. cakes, traditional drink or *tenun ikat*) and another 11 per cent said that they have a stable income source from small vendor business or their family members worked in education and public sectors in the village. In terms of working outside of the village for cash incomes, nearly half of the total respondents (48.7 per cent) reported that their family members generated additional incomes from employments outside the village such as low-skilled construction worker, housemaid, shopkeeper and *ojek* (39.9 per cent), public school teacher or civil servant (5.3 per cent) and sharecropping (3.5 per cent).

Refer to Table IX, Midland community has a lower index in SCP and CPA, compared to Lowland and Upland communities, because the young adults or school children do not have to travel long hours away from family for job opportunity or education. According to the Midland respondents, the close distance to major marketplace in Kupang City and the accessible public transports has allowed the local people to easily travel in and out of village.

4. Discussion

This study finds that customary laws play a key role in the three communities. Customary laws shape the patriarchal system based on strong personal tie (kinship) among members and form a unique clan social unit in each of these communities. Customary laws also informally govern member's conducts and grant rights to access resources (farmland and community forest). Foodstuffs and resources found in the community forests provide the members with temporary support and relief during post-crisis periods. However, there are some barriers associated with this custom which limit these communities from improving their living standards.

One of the impacts of strong customary laws is the low awareness about drinking water for body maintenance. For daily social practice, these communities drink coffee and chewing *sirih pinang* (a tradition of chewing a combination of betel nut, betel leaf and limestone). Although the survey result shows that Midland community store sufficient amount of water per person for daily needs[8], yet, in reality these communities use water largely for cooking and washing dishes, not for drinking.

What is more, this study finds that local norms that require members to obey both the informal customary laws and the *Desa* (village government) have limited these communities from effective problem solving. For example, in Midland, *bak umum* (water cisterns) has been built for many years from Rural PNPM[9] development grants as part of the clean water facility projects. However, after completion of project, some water cisterns were left unattended and idled due to land issue. The old inhabitants whose land was used to build such facility intended to gain some share from the monthly fees paid by users. Local *Desa* did not act to correct the issue with the land owner as they have some family relationship and this land owner is a high ranking member in the clan.

Issue associated with unattended public facility in rural regions of Indonesia has been pointed out by Usman *et al.* (2008) as the result of the lack of monitoring and evaluation by local authority. This study finds that local authority (*Desa*) cannot solve this issue constructively because they are hampered by the local norms. Moreover, in all these communities, the general members do not go to see customary elders or *Desa* in person because it is considered inappropriate to raise individual concern or issue that only affects small number of people. Not until a big problem happens and affects the whole community, will the members feel the urgency to form a voice and endorse a relatively high ranking person in the community to visit the authority for solutions. This is also why SCP (engage in social-cultural gatherings) is an important component in the livelihoods of these communities, because it is through these gatherings that the ordinary members strengthen their connections, share information and support each other.

Given the strong customs in these communities, this study finds that the high vulnerability index in Upland and Lowland communities, compared to Midland, is because their customary elders and *Desa* lack the support from the skilled and educated people in assisting and improving their living standards. These two regions have serious shortage of human resources because their locations are more remote than Midland region, and the educational facilities for school children and the access to information for adults (on health, nutrition and basic "petty cash" management) are very limited.

Despite the promising investment on education sector (20 per cent national annual budget since decentralisation reform) (National Education System, Law No. 20/2003, Article 49), there is still huge gap in school-completion rates between wealthier and poorer regions. In 2014, poorer region such as NTT has 65.86 per cent of net enrolment ratio[10] in SMP (Secondary School) and 52.15 per cent in SMU (High School), which is below the national average of 77.53 per cent for SMP and 59.35 per cent for SMU (Statistics Indonesia, 2015b).

From 2003 to 2014, standard educational facilities in the villages of NTT have not yet proportionately distributed. According to Statistics Indonesia (2015c), in year 2014 there were 3,129 villages in NTT with standard SD (Elementary Schools) but only 1,391 villages have SMP and 428 villages have SMU. In other words, after completing six-year of SD, more than half of the village children have to travel out of the village to continue SMP and SMU. This is especially the case for remote areas such as Upland and Lowland in this study.

With limited human resources, the customary elders and *Desa* in Upland and Lowland communities seriously lack educational competency to write proposals or apply grants for development of their community. This explains why the government assistance for rural development (DAK or Specific Propose Grants) has not effectively promoted the living standards of regions that have low quality of clean water or rely on agriculture to maintain livelihood (Tjoe, 2013).

This study confirms with the conclusions of Schwarz *et al.* (2011), Hahn *et al.* (2009) and Thomas *et al.* (2005) that local governance plays a key role in the livelihood vulnerability and resilience of resource-dependent communities. This study finds that the leadership of the customary elders and *Desa* needs to be more conducive and constructive to improve the livelihoods of the traditional subsistence communities in West Timor.

The uncertainty in climates and the long procedure of linking and selling farm produce to buyers further rationalise the Meto households' decision to look for cash-employment, where many of them in the remote areas like Upland and Lowland communities in this study chose to migrate temporarily to work as TKI or TKW (migrant worker) to support family needs. The implications of this finding are clear for the government and policymakers; under global warming, unless the shortage of human resources in these communities is addressed and the quality of market access and educational facilities is improved, the livelihood of these subsistence communities is expected to become more vulnerable.

5. Conclusion

This study has developed a practical way to measure the livelihood vulnerability of three dryland communities in West Timor who practice traditional subsistence farming to sustain their livelihood. This study utilised Shannon's entropy for assisting in making decision (ranking) objectively and found that based on objective weights, the mean values of each livelihood components and the value of LVI are more precise than the values generated based on subjective weights. Hence, objective weights provide better information than subjective weight in identifying and prioritising areas which require attention and appropriate solutions to prevent households from further impoverishment and increased vulnerability. However, the results may need to be tested further using other methods.

This study found that communities are less vulnerable when they have better access, AIs, and when the members and their children can actively participate in local agricultural and ritual activities. A poorer access to market and schools is found to contribute to increasing vulnerability as the members have to leave for employment or educational purposes.

The finding of this study shows how the shortage of human resources and poor quality of market access and educational facilities in these communities have led to the declining number of educated people in these communities and the local authorities lacked of support to develop the region. For sustaining livelihoods and adapting to the effects of global warming, our study suggests that the leadership of local authority should be immediately improved and supported by educated people and investment is needed to attract these people as well as to improve educational facilities to retain the young people in the rural drylands.

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Notes

1. *Atoin Meto* (or the People of Dryland) is a major tribe in West Timor, accounted for 2/3 of the total population in West Timor Island (Fox, 1999). They mainly live in rural villages and support themselves through small-scale farming and animal husbandry, with corn as their staple food. According to the respondents in our study, they also receive external support through the national welfare enhancing programs such as BLSM (temporary direct cash-aid), *raskin* (rice transfer for the poor), chemical fertilizer, and market corn seeds. These aids are periodically collected from local officers (district and village) by showing evidence of identity as low-income earners.
2. Three groups of local key informants were involved: professional from local non-government organisation, academics (one professor from Universitas Indonesia and two scholars from local research institution IRGSC), and rural school teacher and *Meto* key informants.
3. In HDI, life expectancy index is the ratio of the difference of the actual life expectancy and a pre-selected minimum, and the range of pre-determined maximum and minimum life expectancy.
4. This is important because some of the household heads preferred using local dialect (*Bahasa Timor*).

5. This research was granted approval by the East Nusa Tenggara Local Government for conducting research and data collection in the three regions under study. Further to this, this survey was conducted with approval of the Griffith University Human Research Ethics Committee (HREC).
6. Sample size formula: $n = \text{DEFF} \times ((Z^2 \times p \times q)/e^2)$, where *n,* sample size, DEFF = 2; $Z = 1.96$ (95 per cent CI), $p = 0.5$; $q = 0.5$; $e = 0.10$. DEFF means design effect. DEFF = 2 means that the sample size is twice as large as that obtained from a simple sample size formula.
7. Two cases in Midland were deleted due to missing data. So in total, 627 of respondents were analysed (201 in Lowland, 226 in Midland and 200 in Upland).
8. According to World Health Organisation (WHO) (2011), the minimum amount of water needed for survival (drinking and food), cooking needs and sanitation per person is 7.5-15 L per day. With an average number of five to seven members per family in the three communities, individual households need at least 37.5-52.5 L of water per day. In the survey, Upland and Lowland communities indeed stored insufficient amount of water per person (10-14.5 L in Upland and14-20 L in Lowland), in contrast to 60-85 L in Midland community.
9. PNPM is a National Programme for Community Empowerment in Rural Areas, launched by the former President Susilo Bambang Yudhoyono in 2007. PNPM fund comes from APBN (national annual budget) and the programme aims to accelerate national poverty reduction through 12 poverty alleviation programs which are implemented based on community empowerment approaches and are managed by various ministries and institutions (TNP2K, 2015). Misappropriation of PNPM fund has been reported in local news in Sumatra, Java, and Kalimantan (See Detikriau.com, 2014; Berita Gresik, 2015; Antara Kalbar, 2015). Majority of these cases are related to misuse of rolling funds by the *Unit Pelaksana Kegiatan* (project implementation unit).
10. Net Enrolment Ratio (Angka Partisipasi Murni) is the proportion of school children at a certain age group who attend school at the level that officially corresponds to the age group (UNICEF, 2015). In Indonesia, the official age group corresponding to the given level of education is specified in the joint regulation by the Minister of National Education and the Minister of Religion No. 04/VI/PB/2011 and No. MA/111/2011; which states that age group for SD (Primary School) is 7-12 y-o; SMP (Secondary School) is 13-15 y-o; SMU (High School) is 16-18 y-o.

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