Measuring the livelihood vulnerability index of a dry region in Indonesia

Measuring the livelihood vulnerability index of a dry region in Indonesia: a case study of three subsistence communities in West Timor[1]

Abstract

Under global warming, it is expected that low yields in dry regions will cause the local communities to adapt to modern cash-employment in the urbans. Through a household survey across three subsistence communities in West Timor (N=627), we measured their livelihood vulnerability and identified six major determinants: Education (EDU), Children's Participation in Agricultural activities (CPA), Agricultural Income (AI), Subsistence Food Reserve (SUBSIST), Social-Cultural Participation (SCP), and Access to Water, Health facility and Market (ACC). Livelihood Vulnerability Index in all communities shows significant and strong relationships with SCP (.594, $p < 0.01$), AI (.545, $p < 0.01$) and CPA (.434, $p < 0.01$), signifying that constraints to engage in social gatherings, market the harvest and obtain additional labour input are currently the major factors of vulnerability in these communities. Unless local issues educational facility and human resources are addressed, impact of global warming will increasingly affect these communities.

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; FAO 2004). Assistance for these communities to adapt to the effects of global warming and to sustain livelihoods is urgently needed.

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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 & Angwin 2009).

Dryland communities are found to confront not just drought, but also the impact of marketization of water, global financial crisis, declining commodities' prices, an ageing community and the declining interests of younger generation to continue family farm business (Kiem & 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 & 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 1915-1980 (Condliffe 2008); the Integrated Rural Development Program (DRI) in Columbia from 1976-1981 (Escobar 1995); the pricing policy in Malawi from 1970s to1980s (Barbier 2000); the forestry decentralisation in Latin American countries (Larson et al. 2007); and the decentralisation program in Vietnam (Vien, Quang & Thanh 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

Many researchers have pointed out that in explaining vulnerability of a society, socio-economic factors play a more critical role than the exposure to climatic shock itself (see Fraser et al. 2011; Watts & Bohle 1993; Turner at al. 2003a; Turner et al. 2003b; 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 & Jentoft 1998 cited in Li & Huntsinger 2011).

There are also studies that 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, Shaw et al 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 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 summarizes 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 & Imbens 1995; Lofti & Fallahnejad 2010). Subjective weights may not be precise when the information is: (1) unquantifiable; (2) incomplete; (3) unobtainable; or (4) partial ignorance (Yeh & Deng 1997, cited in Wang & 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 & Lee 2009; Lofti & Fallahnejad 2010; Zhang, Wang & Wang 2014), and statistically tested the level of correlation between variables using such as Pearson's or Kendall's τ correlations (OECD 2008). In developing the Dryland Community's Livelihood Vulnerability Index, this study utilized both subjective weight and objective weight for comparison (see Tables 5 and 6). 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*[2] communities across two regencies of West Timor (Kupang and Timor Tengah Selatan (TTS), shown in Figures 1 and 2) from June to November, 2013, as part of a doctoral research into rural livelihood sustainability, drought adaptation, and decentralization impacts by a research team from Griffith University.

Insert Figure 1: Map of Indonesia, Part of Australia, and the Study Area West Timor (White Box)

Source: Google Earth

Insert Figure 2: Study area (West Timor) and the three subsistence communities:
B (Midland, Kupang Regency), A (Upland, TTS Regency) and C (Lowland, TTS Regency)

Source: Google Earth

The three research sites were selected based on the gaps identified through the literature review, consultation with local academics and practitioners in rural development areas,

[2] *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.

including IRGSC (Institute of Resource, Governance and Social Change) and FAN (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 & Gondowarsito 2007). The regional economy relies mainly on agricultural production (nearly 35% of NTT Regional-GDP in 2013) (BPS NTT 2014), in which 61% 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 [name deleted to maintain the integrity of the review process].

From years 2008 to 2011, according to Regional Meteorology Bureau in Kupang, the average annual rainfall recorded in its capital city, Kupang was 1,785mm (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 2,134mm 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 & Fanggidae 2009; National Bureau for Disaster Management, BNPB 2009).

2.2 Measuring the Dryland Community's Livelihood Vulnerability Index

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

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[3]. Table 1 shows the developed indicators of the Dryland Community's Livelihood Vulnerability Index (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:

$$\text{Average} = \frac{1}{\text{n}} \sum_{i=1}^{n} Component_i \qquad (1)$$

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

Firstly, the answer of each question (sub-component) is standardized 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[4] (UNDP 2007) and:

$$\text{Index } S_c = \frac{S_v - S_{min}}{S_{max} - S_{min}} \qquad (2)$$

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

S_{max}= the maximum value of the specified sub-component in community c

Secondly, after each sub-component is standardized, reliability statistics and confirmatory factor analysis are conducted using SPSS 22. Table 2 shows the reliability and adequacy

[3] Three groups of local key informants were involved: (1) professional from local non-government organization, (2) academics (1 professor from Universitas Indonesia and 2 scholars from local research institution IRGSC), and (3) rural school teacher and *Meto* key informants.
[4] 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.

statistics of our survey data, in which the values of Cronbach's Alpha, 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 3 (Scree Plot), Table 3 (total variance explained) and Table 4 (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% of the variance (Table 3). All items are significantly loaded onto the expected latent factor (Table 4). The Cronbach's Alpha values for all components are within the acceptable values (0.5 and above, Table 5). From this procedure, six major components of rural livelihoods for this study are confirmed: EDU, CPA, AI, SUBSIST, SCP, and ACC.

Insert Table 1 Major components and sub-components of the Dryland Community's Livelihood Vulnerability Index developed for the three subsistence communities, West Timor.

Insert Table 2 Reliability and adequacy statistics.

Insert Figure 3 Scree plot (Factor Analysis).

Insert Table 3 Total variance explained (Factor Analysis).

Insert Table 4 Rotated component matrix[a] (Factor Analysis).

Insert Table 5 Means, standard deviations and Cronbach's Alpha scores for all components.

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

$$\mathrm{M_c} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \left(Weight_{\mathrm{indexS_{ci}}}\right) \mathrm{x\ (Value\ indexS_{ci})} \qquad (3)$$

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

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 *Mc*, 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. Any outliers are removed.

Lastly, Community – Level LVI is calculated using Equation (4):

$$LVI_c = \frac{1}{6} \sum_{i=1}^{6} M_{ci} \quad (4)$$

This can also be expressed as:

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

Where

LVI_c= Livelihood Vulnerability Index for community *c*

M_{ci} = average value of a component (e.g. $\mathrm{EDU_c}$ = average value of component Education)

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

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 4). All data analysis in this study was conducted using SPSS 22 and Microsoft Excel.

2.2 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 & 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 information by measuring the relative contrast intensities of individual attributes (Zeleny 1996, cited in Wang & 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:

$$h(\mathrm{E}) = log\frac{1}{P\{E\}} = -logP\{E\} \quad (7)$$

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(E) = 0 if P{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(E∩F) = h(E) + h(F) if E and F are independent.
- $log\frac{1}{p\{e\}} = -logp\{e\}$ 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:

$$H(X) = -\sum_{i=1}^{n} p(\{x_i\})log_2\, p(\{x_i\}) \quad (8)$$

Where:

- $H(X)$ is the Shannon Entropy of a discrete random variable X taking values in $\{x_1, x_2, \ldots x_n\}$
- $p\{x_i\} = P\{X = x_i\}$ is the average uncertainty in the outcomes $\{X = x_1\}$, $\{X = x_2\}, \ldots \{X = x_n\}$
- 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):

$$Relative\ Entropy = \frac{H(X_i)}{H_{(xi)max}} \tag{9}$$

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

$$d = 1 - H(X) \tag{10}$$

in which the equation for d in Wang & 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:

$$d = \log n - H(X) \quad (11)$$

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 & Lee (2009):

$$w = \frac{d_i}{\sum_{i=1}^{n} d_i} \quad (12)$$

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

n = number of sub-components in a component (e.g. EDU has 4 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 & 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.

2.3 Data Collection – Household Survey

In each community, four native speakers of *Bahasa Indonesia* and *Meto* language[5] were recruited from respective regions and trained for surveys, including understanding the

[5] This is important because some of the household heads preferred using local dialect (*Bahasa Timor*).

questionnaires, objective of each question, and confidentiality protocol[6]. The training was conducted on the 14th and 15th July in Midland (Region B); 23rd and 24th August in Lowland (Region C); and 31st August and 1st September in Upland (Region A).

The household survey used stratified random sampling adapted from Hahn et al. (2009). Based on a sample size calculation (WHO 2005) at 95% confidence interval, 50% prevalence, 10% precision, and a design effect of 2 to account for cluster sampling, at least 200 households in each community were surveyed[7]. Research team divided each community into several sub-groups based on the number of *dusun* (sub-villages) in each community. A same percentage of households per *dusun* were interviewed in each community as sub-samples to represent the total population for each community. 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 Program on Immunization "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 120^0 angles from the first. Then a random number was selected from an Rp5000 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

[6] 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).

[7]Sample size formula: N = DEFF*[(Z2*p*q)/e2], where N = sample size, DEFF = 2; Z = 1.96 (95% 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.

interviewers moved to the next closest house by walking diagonally across the road until they had interviewed their quota for that *dusun*.

Insert Table 6 Sub-component values, maximum and minimum sub-component values for the three subsistence communities, West Timor.

Insert Table 7 Dryland Community's LVI* in Upland, Midland and Lowland, West Timor.

Insert Figure 4 Spider diagram of the six major components in the three communities.

Insert Table 8 Kendall's τ correlations between LVI and all components in Upland, Midland and Lowland communities, West Timor.

3. Results

Table 6 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 Table 7 and Figure 4. 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 8) 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 (.594, $p < 0.01$), AI (.545, $p < 0.01$) and CPA (.434, $p < 0.01$) indicating that social-cultural participation, agricultural incomes and additional labour input from children are important determinants of vulnerability in these communities.

3.1 Educational level of household members

In Upland community, 59.5% of the household heads are illiterate (26.5% were aged between 22 and 45, and 33% were aged 45 and above), compared to Midland (8.8%) and lowland

community (9%). In census 2014, the illiteracy rate at NTT provincial average is 3.48% and 19.87%, and at national average is 1.24% and 12.25%, 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 Lowland (0.15) and Midland (0.10), the education of Upland females is far behind the average females in these regions.

3.2 Food and water security

In all communities, the index for SUBSIST is the lowest. This is largely due to their tradition of growing subsistence corn 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.

The index for ACC in all communities is not as vulnerable as the other components. In Upland, local households use jerry cans (5L) 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%) 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% of 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 5000L). 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 - 10L each day), yet reported that water is always sufficient because they also use sea water for daily water needs. In average, Upland households store 10L – 14.5L of water in their house for daily use, while Midland and Lowland store more water (60L – 85L and 14L – 20L respectively).

3.3 Agricultural incomes, livelihood strategies, and social-cultural participations

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 candlenut, 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 far higher than the profit they can earn. The main cause is the poor roads and the distance to major marketplaces (it takes up to 4 to

10 hours of travel to reach SoE Capital City of TTS Regency and Kupang Capital City of NTT Province).

Nearly 85% of the Upland and Lowland respondents diversify their income sources to other activities. For instance, some households (40% of 200 upland respondents and 6% of 201 lowland respondents) produce handmade traditional food and craft work (weaved fabric *ikat tenun*). Some households (25 % of upland respondents and 62% of lowland respondents) performed both handmade food and craft as well low-skilled work in village such as motorcycle-taxi driver or collecting colourful stones at the beach). To support household needs, it is also common that the members migrated out of village to work as plantation worker and contracted maids in Java, Kalimantan or Malaysia (5% of upland respondents and 16% of lowland respondents), or left the village during fallow season (May – August) to look for low-skilled jobs such as construction labour in Kupang or SoE (15% of upland respondents). There were a small portion of respondents with stable incomes (7% in upland and 14% 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.

The rate of getting invited and attending social gatherings are considerably low, which constitutes to higher SCP index for these two communities. In average, Upland respondents reported they 'rarely attend' and 30% of them said they hardly received invitation. Lowland respondents said 'sometimes attend' and 21.4% of them reported they were rarely invited to social events. In sloped-region, respondents said 'often attend' and those who said they were rarely invited were only 0.4%. From the survey, respondents in Upland and Lowland admitted 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. Cassava, banana, chillies, eggplant, and green vegetables were reported as the most sellable cash crops, in which the women brought these produce to markets in Kupang City (1 hour of travel time) on a daily basis. Forest produces were another cash contributor, including bamboos and woods like *mahoni* (broad-leaf mahogany) and *jati* (teak or tropical hardwood), nuts and fruits like candle nut, cocoa and tamarind. According to the respondents, road development during the 1990s has facilitated the easy access to sell their products. The close distance to major market place in Kupang City and the accessible public transports has allowed the local people to easily travel in and out of village.

Nearly 30% of the total 226 Midland respondents reported that they depend solely on agriculture as income source. 10% of the respondents said they also performed handmade food or craft work (weaving, cakes, or traditional drink) as secondary income sources. 11% 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. Nearly half of the total respondents (48.7%) reported that their family members generated additional incomes from activities performed outside the village. These activities ranged from employments as public school teacher or civil servant (5.3%), unskilled labour or construction worker, housemaid, shopkeeper, and *ojek* (motorcycle-taxi driver (39.9%), and sharecropping (3.5%). The CPA index is lower than the other two communities, as the young adults or schoolchildren do not have to travel long hours away from family for job opportunity or education.

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.

[8] According to WHO (2011), the minimum amount of water needed for survival (drinking and food), cooking needs and sanitation per person is 7.5 to 15 L per day. With an average number of 5 to 7 members per family in the three communities, individual households need at least 37.5L to 52.5L of water per day. In the survey, Upland and Lowland communities indeed stored insufficient amount of water per person (10L–14.5L in Upland and14L–20L in Lowland), in contrast to 60L–85L in Midland community.

[9] PNPM is a National Program 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 program 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.org 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).

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 schoolchildren 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% national annual budget since decentralization 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% of net enrolment ratio[10] in SMP (Secondary School)

[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

and 52.15% in SMU (High School), which is below the national average of 77.53% for SMP and 59.35% 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 6-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 [name deleted to maintain the integrity of the review process].

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. Individual households in these three communities have gradually experiencing the declining social bonds and subsistence food preserving activities as they increase their activities for generating cash.

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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.

The uncertainty in climates and the long procedure of linking and selling farm produce to buyers further rationalize their decision to look for cash-employment, where many farmers 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. Communities are less vulnerable when they have better access, agricultural incomes, 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.

Insert Table 9 Shannon's objective weights and weighted average subjective weights.
Insert Table 10 Comparison of results between objective weights and subjective weights.

In Table 9, for example in major component SUBSIST, the sum value of uncertainty (d) for Q3 is lower than Q1 and Q2, in other words, the probability of respondents giving the same response in Q3 is higher, thus this sub-component is given a higher weight (Q3 = 0.495) than Q1 (0.133) and Q2 (0.372). This means that in the aspect of Subsistence Food Reserve, in terms of food storing, the 97% of total respondents who reported that they preserved corn for domestic use has zero vulnerability, and the remaining 3% who do not preserve corn has an increased vulnerability of 0.495. In terms of seed saving, the 93% of total respondents who saved seeds for next planting season has zero vulnerability, while the remaining 7% who do not save seeds has an increased vulnerability of 0.372. In contrast, subjective weight assigns an increased vulnerability of 1 value for those who do not save corn/seed in Q3 and Q2.

Table 10 shows that overall index value based on objective weight is smaller than that based on subjective weight, for example, EDU for upland community is 0.537 (instead of 0.572 when using subjective weight). Using objective weight, each indicator has its own weight that is distinguishable from other indicators hence this gives better information than subjective weight in identifying and prioritizing areas which require attention and appropriate solutions to prevent households from further impoverishment and increased vulnerability.

References

Angrist, JD & Imbens, GW 1995, 'Two-Stages Least Squares Estimation of Average Causal Effects in Models with Variable Treatment Intensity', *Journal of the American Statistical Association*, Vol. 90, No. 430, pp. 431 – 442.

Barbier, EB 2000, 'The economic linkages between rural poverty and land degradation: some evidence from Africa,' *Agriculture, Ecosystems and Environment,* Vol. *82*, pp. 355-370.

Barlow, C & Gondowarsito, R 2007, *Socio-economic Conditions & Poverty Alleviation in NTT*, ANU, Canberra.

BNPB 2009, *Peta Kejadian Bencana di Propinsi Nusa Tenggara Timur Tahun 2008* (East Nusa Tenggara 2008 Natural Disaster Incidence Map), Badan Nasional Penanggulangan Bencana (National Bureau for Disaster Management of the Republic of Indonesia), Jakarta.

BPS (Statistics Indonesia) & Macro International 2008, *Indonesia Demographic and Health Survey 2007,* BPS and Macro International, Calverton, Maryland, USA. Available from: <http://www.measuredhs.com/pubs/pdf/FR218/FR218[27August2010].pdf>. [7 August 2012].

BPS NTT 2014, *NTT in Figures year 2013* (NTT in Figures year 2013), Badan Pusat Statistik NTT (NTT Provincial Central Bureau of Statistics), Kupang City, Nusa Tenggara Timur (NTT), Indonesia.

BPS NTT 2015, *Produk Domestik Regional Bruto Menurut Lapangan Usaha, 2004-2013* (Gross Regional Domestic Product by Industrial Origin, 2004-2013). Badan Pusat Statistik NTT (NTT Provincial Central Bureau of Statistics). Available from: <http://ntt.bps.go.id/linkTableDinamis/view/id/41>. [20 March 2015].

Chambers, R & Conway, G 1992, '*Sustainable Rural Livelihoods: Practical Concepts for the 21st Century', Discussion Paper 296,* Institute of Development Studies, University of Sussex, Brighton, UK.

Chitea, L 2012, Interfunctionality of natural, social, and economic factors in the Romanian rural community – Case study: Clopotiva village', *Agricultural Economics and Rural Development*, New Series, Year IX, No. 1, pp. 123-133.

Colombi, BJ 2012, 'Salmon and the Adaptive Capacity of Nimiipuu (Nez Perce) Culture to Cope with Change', *American Indian Quarterly* 36 (1), 75-98.

Condliffe, I 2008, 'Policy Change in the Uplands', in *Drivers of Environmental Change in Uplands*, eds A Bonn, T Allott, K Hubacek & J Stewart, Routledge, Florence, USA, pp. 59 – 89.

Daskon, CD 2010, 'Cultural Resilience – The Roles of Cultural Traditions in Sustaining Rural Livelihoods: A case study from rural Kandyan Villages in Central Sri Lanka', *Sustainability*, Vol. 2, pp. 1080-1100. Doi:10.3390/su2041080.

DFID (Department for International Development) 1999, *Sustainable Livelihoods Guidance Sheets.*

Duncan, CR 2007, 'Mixed Outcomes: The impact of Regional Autonomy and Decentralization on Indigenous Ethnic Minorities in Indonesia', *Development and Change* 38 (4), 711-733.

Ehrentraut, S 2011, 'Decentralization and the promise of indigenous peoples' empowerment: the case of World Bank in Cambodia', in *The Pacific Review,* Vol. 24, No.1, pp. 89-113

Ericksen, P 2008, 'Conceptualizing food systems for global environmental change research', *Global Environmental Change,* Vol. 18, pp. 234 – 245. Available from: <http://dx.doi.org/10.1016/j.gloenvcha.2007.09.002>.

Escobar, A 1995, *Encountering Development: The Making and Unmaking of the Third World*. Princeton University Press, New Jersey.

FAO (Food and Agriculture Organization) 2004, *Carbon sequestration in dryland soils,* World Soil Resources Reports No. 102, Rome.

Fox, JJ 1999, 'Precedence in Practice among the Atoni Pah Meto of Timor' in *Structuralism's Transformations: Order and Revisions in Indonesia and Malaysia,* eds LV Aragon & SD Russell, Center for Southeast Asian Studies, Arizona State University, Tucson, pp. 1 – 36.

Fraser, ED, Dougill, AJ, Hubacek, K, Quinn, CH, Sendzimir, J & Termansen, M 2011, 'Assessing Vulnerability to Climate Change in Dryland Livelihood Systems: Conceptual Challenges and Interdisciplinary Solutions', *Ecology and Society,* Vol. 16, No. 3.

Golding, B & Angwin, J 2009, 'Bearing the risk: Learning to be drier mid-river, *Australian Journal of Adult Learning,* Vol. 49, Issue 3, pp. 472 – 496.

Hahn, MB, Riederer, AM & Foster, SO 2009, 'The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change— A case study in Mozambique', *Global Environmental Change*, Vo. 19, Issue 1, pp. 74 – 88.

Hunt, D 1991, 'Farm system and household economy as frameworks for prioritising and appraising technical research: a critical appraisal of current approaches' in *Rural households in emerging societies: technology and change in sub Saharan Africa*, ed DHM Haswell, Oxford, UK, Berg, pp. 49–76.

ICF Macro 2011, *Demographic and Health Survey Interviewer's Manual. MEASURE DHS Basic Documentation No.2*, ICF Macro, Calverton, Maryland, USA.

Kiem, AS & Austin, EK 2013, Drought and the future of rural communities: Opportunities and challenges for climate change adaptation in regional Victoria, Australia, Global Environmental Change, Vol. 23, pp. 1307 – 1316.

Larson, A.M., Pacheco, P., Toni, F., and Vallejo, M. (2007) 'The Effects of Forestry Decentralization on Access to Livelihoods Assets', in *Journal of Environment Development*, Vol. 16, No. 3, pp. 251-268.

Li, WJ & Huntsinger, L 2011, 'China's Grassland Contract Policy and its Impacts on Herder Ability to Benefit in Inner Mongolia: Tragic Feedbacks', *Ecology and Society*, Vol. 16, Issue 2, Article 1. Available from: <http://www.ecologyandsociety.org/vol16/iss2/art1/>.

Lofti, FH & Fallahnejad, R 2010, 'Imprecise Shannon's Entropy and Multi Attribute Decision Making', *Entropy*, Vol. 12, No. 1, pp. 53 – 62.

McIntosh, A, Stayner, R, Carrington, K, Rolley, F, Scott, J & Sorensen, T 2008, *Resilience in rural communities: Literature review*, Centre for Applied Research in Social Science, University of New England, Armidale.

Miller, HJ, Witlox, F & Tribby, CP 2012 'Developing context-sensitive livability indicators for transportation planning: a measurement framework,' *Journal of Transport Geography*, Vol. 26, pp. 51-64. Available from: <http://dx.doi.org/10.1016/j.jtrangeo.2012.08.007>.

Muslimatun, S & Fanggidae, S 2009, *A brief review on the persistent of food insecurity and malnutrition problems in East Nusa Tenggara Province, Indonesia*, *Working Paper 12*,

Institute of Indonesia Tenggara Timur Studies (NTT Studies), IITTS Publications (Open Sources).

OECD (Organization for Economic Co-operation and Development) 2008, *Handbook on Constructing Composite Indicators: Methodology and User Guide*, OECD Publication. Available from: < www.oecd.org/publishing/corrigenda>. [10 November 2012].

Schwarz, AM, Béné, C, Bennett, G, Boso, D, Hilly, Z, Paul, C, Posala, R, Sibiti, S & Andrew, N 2011, 'Vulnerability and resilience of remote rural communities to shocks and global changes: Empirical analysis from Solomon Islands', *Global Environmental Change*, Vol. 21, pp. 1128 – 1140.

Seligman, J 2009, 'Channels: From Logic to Probability' in *Formal Theories of Information: From Shannon to Semantic Information Theory and General Concepts of Information,* ed G Sommaruga, Springer-Verlag Berlin Heidelberg, Germany, pp. 193 – 233.

Shannon, CE 1948, 'A mathematical theory of communication', *The Bell System Technical Journal*, Vol. 27, pp. 379 – 423.

Statistics Indonesia 2015a, *Persentase Penduduk Buta Huruf menurut Kelompok Umur, 2011 – 2014* (Percentage of illiteracy according to age group, 2011 – 2014). Available from: <http://bps.go.id/linkTableDinamis/view/id/1056>. [12 May 2015].

Statistics Indonesia 2015b, *Angka Partisipasi Murni (APM) menurut Provinsi, 2011 – 2014* (Net enrollment ratio by province, 2011 – 2014). Available from: <http://www.bps.go.id/linkTableDinamis/view/id/1052>. [10 December 2015].

Statistics Indonesia 2015c, *Jumlah Desa yang Memiliki Fasilitas Sekolah Menurut Provinsi dan Tingkat Pendidikan, 2003 – 2014* (Number of villages having educational facilities by province and educational level, 2003 – 2004). Available from: <http://www.bps.go.id/linkTableDinamis/view/id/905>. [10 December 2015].

Thomas, D, Osbahr, H, Twyman, C, Adger, N & Hewitson, B 2005, *ADAPTIVE: adaptations to climate change amongst natural resource-dependent societies in the developing world: across the Southern African climate gradient.* Tyndall Centre for Climate Change Research Technical Report 35.

Turner, BLI, Kasperson, RE, Matson, PA, McCarthy, JJ, Corell, RW, Christensen, L, Eckley, N, Kasperson, JX, Luers, A, Martello, ML, Polsky, C, Pulsipher, A & Schiller, A 2003a, 'A framework for vulnerability analysis in sustainability science', *Proceedings of the National Academy of Sciences of the United States of America* 100 (14): 8074-8079.

Turner, BLI, Matson, P, McCarthy, JJ, Corell, RW, Christensen, L, Eckley, N, Hovelsrud-Broda, GK, Kasperson, JX, Kasperson, RE, Luers, A, Martello, ML, Mathiesen, S, Naylor, R, Polsky, C, Pulsipher, A, Schiller, A, Selin, H & Tyler, N 2003b, 'Illustrating the coupled human-environment system for vulnerability analysis: Three case studies', *Proceedings of the National Academy of Sciences* 100 (14): 8080-8085.

UNDP 2007 *Human Development Reports*, Nations Development Programme (UNDP). Available from: <http://hdr.undp.org/en/>. [10 November 2012].

UNDP 2014, *'Technical Notes: Calculating the human development indices'* in *Human Development Report 2014. Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience*, UNDP (the United Nations Development Programme), New York, USA, 10 pp. Available from: <http://hdr.undp.org/sites/default/files/hdr14_technical_notes.pdf>. [20 November 2015].

UNICEF 2008, *MICS3 Manual* (Multiple Indicator Cluster Survey). Available from: <http://mics.unicef.org/files?job=W1siZiIsIjIwMTUvMDQvMDIvMDgvMDAvMTIvMTQwL01JQ1MzX0NoYXB0ZXJfM19fX0Rlc2lnbmluZ190aGVfUXVlc3Rpb25uYWlyZXNfMDYwMjE5LnBkZiJdXQ&sha=1d936219141dc9eb>. [10 December 2012].

UNICEF 2015, *Education: Definitions of the indicators*. Available from <http://www.unicef.org/infobycountry/stats_popup5.html>. [10 December 2015].

Usman, S, Mawardi, S, Poesoro, A, Suryahadi, A & Sampford, C 2008, *The Specific Allocation Fund (DAK): Mechanisms and Uses*, The SMERU Research Institute, Jakarta.

Vien, TD, Quang, NV & Thanh, MV 2005, *Decentralization of Forest Management and Impacts on Livelihoods of Ethnic Minority Groups in Vietnam's Upland.* Agricultural Publishing House, Hanoi, 124 pp.

Wang, TC & Lee, HD 2009, 'Developing a fuzzy TOPSIS approach based on subjective weights and objective weights', *Expert Systems with Applications*, Vol. 36, Issue 5, pp. 8980 – 8985.

Watts, MJ & Bohle, HG 1993, 'The space of vulnerability: the causal structure of hunger and famine', *Progress in Human Geography* 17, 43 – 67.

WHO (World Health Organization) 2005, *Immunization Coverage Cluster Survey—Reference Manual,* WHO Document Production Services, Geneva, Switzerland.

WHO (World Health Organization) 2011, *Technical Notes on Drinking-Water, Sanitation and Hygiene in Emergencies*. Available from: <http://www.who.int/water_sanitation_health/publications/2011/tn9_how_much_water_en.pdf?ua=1>. [10 October 2014].

World Bank 1997, *Survey of living conditions: Uttar Pradesh and Bihar, Household Questionnaire, December 1997 – March 1998,* World Bank. Available from: <http://siteresources.worldbank.org/INTLSMS/Resources/3358986-1181743055198/3877319-1190214802624/slc-hh97.pdf>. [12 August 2012].

Yeh, CH & Deng, H 1997, 'An algorithm for fuzzy multi-criteria decision making', *IEEE International Conference on Intelligent Processing Systems*, pp. 1564 – 1568.

Zhang, Y, Wang, Y & Wang J 2014, 'Objective Attributes Weights Determining Based on Shannon Information Entropy in Hesitant Fuzzy Multiple Attribute Decision Making', *Mathematical Problems in Engineering*, Article ID 463930, Vol. 2014, 7 pp. Doi: 10.1155/2014/463930.