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Assessing local vulnerability to climate change by using Livelihood Vulnerability Index: Case study in Pahang region, Malaysia

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Abstract. The aim of this research is to test the Livelihood Vulnerability Index (LVI) in order to estimate climate change vulnerability to communities in Pahang. It will focus in particularly on two areas that are severely impacted by flooding namely Pekan and Temerloh. The data sample is taken from a survey of 402 households and it is based on their socio-demographics, livelihoods, social network, knowledge and skill, health, food, water security, housing, land, finances and income. This approach estimates vulnerabilities in term of exposure, sensitivity and adaptive capacity. While Pekan is more vulnerable in terms of social network, knowledge and skill but less adaptive in capacity to cope with climate and in contrast, Temerloh is the most vulnerable to natural disaster and climate variability, and sensitivity in term of health, food, finance and income and livelihood strategy. The research finding will allow a better planning of resources in terms of assistance in areas with limited support, enhanced evaluation for potential programs or current policy effectiveness, and provide access to reliable data by incorporating scenarios into the LVI model as a baseline comparison for future design management.

1. Introduction

Malaysia has had an annual increase in temperature per decade by 0.15-0.25°C which is lower than the predicated global average of 6°C by 2100 [1], but the rates of warming for the last 40 years were as high as 4°C per decade for several locations in Malaysia [2]. In addition, floods are associated with climate variability and will become more serious in the future, increasing in duration, number and frequency. A million people live in river basins world-wide and rivers flooding present a serious menace, often with the destruction of assets and the significant loss of human life due to the impact of climate change [3]. Increasing temperatures due to high rates of melting ice, glacial retreat, drought and floods, have all had a big impact on the livelihood of locals. If we look back at the historical records of Malaysia's climate change which is related to disasters and shocks it's even more prominent (Kelantan, Terengganu and Pahang) and it is often still unreported. It is now essential to identify socio-economic, health and well-being impacts on vulnerable places, communities and the magnitude and aspects of livelihood vulnerability in Malaysia. In order to do that, the research needs to encompass and study the various adaptations and vulnerability reducing projects in Malaysia. Flooding is a recurring seasonal event in Malaysia. About 29,800 KM2 or 9% of the land mass is located in the flood-plain and is affecting almost 4.82 million people which is circa 22% of the total population [4]. The most immediate and serious consequence of heavy rain is the flooding of river basins through both inundation and erosion. This not only displaces those locals affected, but it has an impact on their health and well-being as well as damaging the eco-system. Climate change not only effects a gradual change to the normal conditions it

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also has an effect on the frequency and intensity of extreme events such as heavy rainfall or drought or periods of extreme cold or heat [5].

The Pahang river Basin experiences flooding almost every year, but the 2014 flood was one of the worst flood disasters ever and caused the most devastation to Malaysia by a natural disaster. Flooding also exposes those affected by the event to stress and health related illness such as physical and mental, health problems and its related to negative impact. Very few qualitative vulnerability assessments or integrated vulnerability assessments have been done in Malaysia and is very much a new approach. This study aims to estimate the effect on people's livelihoods and their vulnerability in the flood-plains of Pekan and Temerloh districts using the Livelihood Vulnerability Index.

Vulnerability is also a function of the character, magnitude, and rate of climate change and the variation to which a system is exposed its sensitivity to climate change and its adaptive capacity. The IPCC definition views vulnerability as a function of exposure, sensitivity and adaptive capacity so the second category is largely associated with the Third and Fourth Assessment Reports (TAR and AR4, respectively) of the Intergovernmental Panel on Climate Change [5-6]. The approach differs from the natural hazards approach as it views vulnerability as a function of both 'internal' factors (sensitivity and adaptive capacity) and "external" factors (exposure to shocks and stresses). The latter are the various climate hazards associated with climate change and variability to which a system or population is exposed. The IPCC defines exposure as the nature and degree to which a system is exposed to significant climate variation [6], and sensitivity as the degree to which a system is affected either adversely or beneficially by climate related stimuli [6]. Adaptive capacity is defined as the ability of a system to adjust to climate change including climate variability and extremes to moderate potential damages to take advantage of opportunities or to cope with the consequences [6]. Vulnerability has traditionally had been determined through indices. For example, climate change vulnerability indices focused on agriculture [7-8], tourism [9-10] and health [11]. Most of the indices develop by socio-economic and biophysical indicator and transform to components of exposure, sensitivity and adaptive capacity. Recent studies point to the importance of vulnerability assessment when determining adaptation strategies for climate change adaptation strategies for climate change. Finally, the concept of vulnerability may include local geographical and environmental factors that mediate risks and outcomes. It is strongly rooted in social and political processes and tends to take an actor-oriented approach [12-14]. Consequently, the interpretation of an external hazard might be considered an undesirable outcome such as complex disaster) but is does however result from the interaction of, hazard and vulnerability. The people risk of flooding will also depend on its intrinsic ability to tolerate changing climate and its sensitivity.

This analysis was used to identify sources and forms of vulnerability that are specific to this context in order to design context-specific resilience measures which may help the governments to better understand communities' vulnerabilities in order to establish their resilience. This will provide development organizations and local policy makers with practical tools to understand demographics, social and other related factors contributing to the flood.

2. Material and method

2.1 Study area and household survey

The reference period for most of the survey is between 2007 and 2014 and the primary source of the data came from people residing in the Pekan and Temerloh districts. A questionnaire covering 42 key variables used in calculating the LVI was designed, tested and administrated at the household level. Pekan and Temerloh were selected for the study (locations in figure 1), as being the most flood affected area in Pahang. The Temerloh district is located in middle of Pahang and up stream of the Pahang river basin and is normally flooded from October. Whereas the Pekan district is located down-stream of the Pahang river basin and close to the South China Sea. Normally both areas face long term flooding because of the slow water to flow out from the river. A total of 402 of households were interviewed in June 2015 with approximately 200 residents in Pekan and 202 within Temerloh, respectively. The reference period for the climate events data was 2007 to 2014. A further criterion of the research was that the residents were living in the area most likely to flood and had a different social group.

2.2 Data analysis

To guide the assessment of livelihood vulnerability to floods, the study used the sustainable Livelihood framework. The impact of flood and climate variability is considered as a vulnerability, which is a major indicator of sustainability of livelihoods and assets which influence the livelihood strategies, the institutional process, and the livelihoods outcome of a community [15].This can be show in equation (1) below:

$$Index_{S_d} = \frac{S_d - S_{min}}{S_{max} - S_{min}} \quad (1)$$

Where S_d is the dimension value of each indicator, and S_{min} and S_{max} are the minimum and maximum sub-dimension values determined dimension respectively. After standardization, the values of each dimension are averaged using equations (2):

$$M_d = \frac{\sum_{i=1}^{n} index_{sdi}}{n} \quad (2)$$

Where M_d one of the ten major is dimensions for region d, $Index_{sdi}$ represents the sub-dimension value of each indicator i of major dimension M_d and n is the number of sub-dimensions in major dimension of M_d. The 11 major components are Socio-demographic profiles (SDP), Social networks (SN), Livelihood strategies (LS), Knowledge and Skill (KS), Health (H), Food (F), Water (W), Land (L), Housing (Hou), Finance and Income (FI) and Natural disaster and climate variability (NDCV). Once values for each of the 11 major components for a region are calculated , they are directly used in equation (3) to obtain the district level LVI:

$$LVI_d = \frac{\sum_{i=1}^{11} W_{Mi} M_{di}}{\sum_{i=1}^{11} W_{Mi}} \quad (3)$$

This can also be shown as follows:

$$LVI_d = \frac{w_{SDP}SDP_d + w_{SN}SN_d + w_{LS}LS_d + w_{KS}KS_d + w_H H_d + w_F F_d + w_W W_d + w_L L_d + w_{Hou}Hou_d + w_{FI}FI_d + w_{NDCV}NDCV_d}{w_{SDP} + w_{SN} + w_{LS} + w_{KS} + w_H + w_F + w_W + w_L + w_{Hou} + w_{FI} + w_{NDCV}} \quad (4)$$

Where LVI_d is the livelihood vulnerability index for the district *d*, and the weightings of the 11 major components, $W_{MI,}$ are determinants by number of subcomponents that each of the components, contribute equally to the overall LVI. In this study, the LVI is scaled from 0 (least vulnerable) to 1 (most vulnerable). Following the equations (1), (4), and [16] also calculated the new equation of vulnerability LVI-IPCC. This takes consideration of the IPCC vulnerability definition as a function of system expose, sensitivity and adaptive capacity. These approaches utilise household level primary data to quantify the subcomponents. Using the same data, the LVI is based on the IPCC vulnerability definition by grouping the eleven major components into each of these three categories. The three IPCC factors are calculated based on the equation (5):

$$CF_d = \frac{\sum_{i=1}^{n} W_{Mi} M_{di}}{\sum_{i=1}^{n} W_{Mi}} \quad (5)$$

Where district d CF_d is an IPCC-defined contribution factor (exposure, sensitivity or adaptive capacity) for the district d, M_{di} is the major components for the district *d*, indexed by i, W_{Mi} is the weightage of each major components, and n is the number of major components in each contribution factor. Once exposure, sensitivity and adaptive capacity were calculated, the three contributing factors were combined using equation (6):

$$LVI - IPCC_d = (e_d - a_d) * s_d \quad (5)$$

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Where $LVI - IPCC_d$ is the LVI for the district d expressed using the IPCC vulnerability framework, e_d is the calculated exposure score for the district d (equivalent to the natural disaster and climate variability major component) a_d is the calculated adaptation capacity score for district d (weighted average of the Socio-Demographic, Social Networks, Livelihood Strategies and Knowledge and Skill major components) and s is the calculated sensitivity score for district d (weighted average of Health, Food, Water, Land, Housing and Finance and Income major components). The LVI-IPCC is scaled for -1 (least vulnerable) to +1 (most vulnerable) and is the best understood as an estimate of the relative vulnerability of compared populations. A total of 37 component values were computed from scored responses of individuals in each community was treated scores taken from a set of scales ranging from minimum to maximum. All individual score was used for computing the variable components values for the community. The foregoing to this, scores were checked with their respective values and were all found significant at $p < 0.05$ using the three-standard deviation rule and a standard error of 0.1.

3. Result and Discussions

The initial readings of the finding suggest little difference between the two districts. Further detailed reading does however reveal several important differences between Pekan and Temerloh. These nuances are now discussed in greater detail by using the vulnerabilities indices of the major components which range from 0.10 to 0.85 as shown in table 1. The value index for the socio-demographic profile component of the LVI shows Temerloh to be the most vulnerable (0.257) and the Pekan district to be the least vulnerable (0.178). Furthermore, the Temerloh districts recorded the highest percentage of female headed households, lowest household income which is below the Poverty Line Income (PLI) of Malaysia in fact; they are also reported taking care of at least one orphan. The starts show that this area and its inhabitants are the most vulnerable to flooding. The indices are relative values and are compared across two districts in Pahang within the study sample only. The major component of Social Networks is made up of two sub-components which are borrowing money and do not involved in any organization. In term of social networks, Pekan is the most vulnerable (0.462) whereas Temerloh is (0.348). Households in Pekan reported receiving more help than giving help to others compared to households in the other districts. Help is a classed as small funding programs for small scale agricultural or other small business projects. This activity is recorded between themselves and their social network and this also includes assistance in kind. Households that borrow more money than they lend are more vulnerable. If the subcomponents were added together, the most reliant on their social network was the Pekan districts. These results indicated a need for strengthening community networks and local organizations such as Farmer Associations, Business Associations, and Youth Associations at village level to reduce social vulnerability. Most of the households are comfortable with borrowing from relatives and close friends rather than from community. Good social networking seems to lessen the impact of climatic stresses on individual households [17]. The third major component is livelihood strategies which are made up of three sub-components. Due to individual experiences, knowledge and exposure to natural disasters [18], the livelihood strategies of households were diverse. These strategies include no members migrating to others areas, depending solely on agriculture income and the diversification of agriculture. When the results of all the sub-components where aggregated, it was found that the Temerloh area was the most vulnerable (0.412) and Pekan slightly less (0.356). The results also revealed that Temerloh retained their members within the community and was less likely to diversify away from agriculture. The majority of them remained in catfish farming and thus they had the highest indices of vulnerability. In contrast, although Pekan households reported relying solely on agriculture income too, they were more likely to have diversification strategies such as growing crops, animal husbandry and farming natural resources which shows their livelihood diversification. When the three sub-components were averaged, the overall Livelihood Strategies vulnerability score was higher for Temerloh than for the Pekan districts. The finding also shows that the inhabitants of the Temerloh district where more likely to suffer health issues than the Pekan district. This is mainly due to issues arising from flooding such as cough and colds, flu, fever, sore throats and headaches and consequently it was taking an average of two weeks to return to work or school. Another impact was the time to reach a health facility due to flood related illness which was 13 minutes. Inadequate access to the health services tends to decrease the health status of households, thereby increasing their vulnerability to

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extreme climatic stresses. Sickness increases the vulnerability of households to other external stresses it was also revealed that 5.5% of households in the study area have post-traumatic stress disorder (PTSD).

The Pekan districts have a higher knowledge and skills than Temerloh. This shows that areas with lower levels of education and especially flood training are more vulnerable to disaster. Lower adaptation strategy without any training is less likely to cope with stress after a flood for the Pekan households. A Temerloh household also without enough skill to cope with shock and just recently left primary school. The food major component is made up by three sub components show that Temerloh is the highest again in food storage and grow the own crops and diversify rather than Pekan The overall food vulnerability score for Temerloh (0.745) was higher than Pekan (0.648). This is important as food security enhances a households' resilience to external stress and shock due to extreme climatic events.

Temerloh also had a lower vulnerability score (0.235) for the water component than Pekan (0.243). It was seen that they were much better prepared storing fresh water, and the Temerloh households reported less conflicts of water supply and accessibility of water resources compared to Pekan. The average number of liters water storage by Pekan residents during the flood is the lowest, coupled with the utilization of natural water resources which is more likely to expose them to the symptom of water borne disease. Land is the most important assets of inhabitants in the area and is a measurement of wealth. This major segment is made up of two sub components; one being landless and the other small farms linked or owned by the households. Nonetheless, they are considered more susceptible to flood damage and climate change. The land at Pekan registers as slightly more vulnerable (0.650) and more than fifty percent of households are reported are landlessness 57% and the percentage of small land packages is 73%. This was constructed by raising the vulnerability value for Pekan rather than Temerloh (0.625). Most of the residents rent or live in their ancestral home. The research also discovered that non-landowners have limited to access the formal safety nets and other entitlements which are seriously vulnerable.

In terms of natural resources, Temerloh has a higher index than Pekan (0.100) mainly because a larger percent of household does not receive a flood warning and a larger percent of injury or death due to flood. Additionally, the last seven years have seen severe flooding every year which also contributes in a small way to the higher index. The survey results also show the average water level of seven feet with sub component indices of about 0.347 and households affected by flood, partially to totally submerge was 68.0% and shows a higher percentage of households with non-solid houses in Temerloh district 18.0% and that the water levels that engulfed the houses is average. The combinations of these three sub-components provide a higher housing vulnerability index for Temerloh districts (0.403) than Pekan (0.378). In the Temerloh districts, households were affected by income loss during the flood and it was these households that needed to borrow money during the crisis. Furthermore, these residents are the ones on the lowest incomes RM 520 and are in the lowest band of 2%. When the results of all three sub-components are aggregated, the Temerloh district is found to be the most vulnerable (0.158) in term of finance and income. Overall, the aggregated score in table 1 shows that Temerloh was more vulnerable to climate change than Pekan, LVIs of 0.308 compared to 0.278. The results also suggest that Temerloh was more vulnerable in term of SDP, Health, NDCV, Housing and F&I. In contrast, Pekan was more vulnerable in SN (0.462), Knowledge and Skill (0.207), Water (0.243) and Land (0.650). Therefore, a further model 2, LVI-IPCC where the findings show that all of communities in all of these districts share a very similar degree of vulnerability -0.053 and -0.052, respectively and could be described as "mid-range" on the scale -1 to +1. The results do suggest that Temerloh is more sensitive (0.357) and was most affected by food, health, land and housing and that Pekan (0.326) which is less exposed than Temerloh 0.100 vs. 0.141, respectively. The adaptive capacity of the communities was most affected by their livelihood strategies which was 0.288 in Temerloh and 0.263 in Pekan were also the elements of social networks (0.462) were most affected and the indices is the lowest at 0.263.

Table 1 LVI-IPCC contributing factors calculation for Pekan and Temerloh districts, Pahang, Malaysia (IPCC, 2001)

Contributing factors	Major components	Major component values	Number of subcomponent per major component	Contributing factor values	LVI- IPCC value
Adaptive capacity	Socio-demographic profile	0.178 (0.257)	6	0.236 (0.288)	
	Livelihood strategies	0.356 (0.412)	3		
	Social Network	0.462 (0.348)	2		
	Knowledge and skill	0.207 (0.187)	3		
Sensitivity	Health	0.107 (0.170)	4	0.326 (0.357)	-0.053(-0.052)
	Food	0.648 (0.745)	3		
	Water	0.243 (0.235)	4		
	Housing	0.378 (0.402)	3		
	Land	0.650 (0.625)	2		
	Finance and income	0.140 (0.158)	3		
Exposure	Natural Disaster and Climate variability	0.100 (0.141)	4	0.100 (0.141)	

Noted: Values in the parenthesis are for Temerloh district.MIndex value should be interpreted as relative values to be compared within the study sample only. The LVI-IPCC is on a scale from -1(least vulnerable) to 1 (most vulnerable) [16].

Next, figure 1 below show the triangle diagram of the contributing factors at related places.

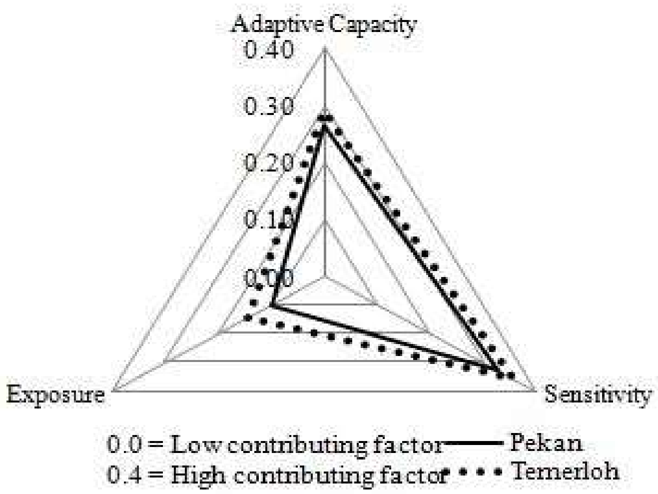

Figure 1: Vulnerability triangle diagram of the contributing factors of the Intergovernmental Panel on Climate Change livelihood vulnerability index (LVI-IPCC) for districts

The LVI-IPCC was calculated by grouping the 11 major components into three categories, namely, adaptive capacity, sensitivity, and exposure, which all differ across districts. The calculations show the high levels of exposure relative to adaptive capacity yield positive vulnerability scores while low values of exposure relative to adaptive capacity, yield negative vulnerability scores. Sensitivity roles as a multiplier such as that high sensitivity in a district for which exposure exceeds adaptive capacity will result in a large positive for example high vulnerability LVI-IPCC scores and vulnerability to other areas such as its socio-demographic profile, health , natural disaster and climate control variability components are impending. There was also found to be a disproportionate number of households with orphans, female breadwinners and a sole dependence on agriculture with little diversification with little awareness towards climate variability. It is also this socio-group which is impacted more with health problems consequently missed school and work due to flooding.

The majority of these groups received no warning about flooding and where the most severely affected by the loss of property including equipment. Over the last seven years, they were also the most exposed to injury and death, natural hazards and climate variability. It was revealing that those are living in natural disaster areas such as a river basin affected by flooding are exposed to the hazard [19]. Furthermore, flooding is one of the environmental shocks that are associated with poverty drivers [20] Thus; the government had to rescue the community in this district to reduce the risk of climate change. Medical assistance and visits from various health teams after the flooding should be enhanced so those affected can get back to normality and health as quickly as possible after the disaster. Additionally, Pekan was found to be most vulnerable districts in term of its adaptation capacity and this could be a major factor due to its enhanced social network. Furthermore, the results highlighted a definite need to strengthen community networks and associations such as farming, business and youth groups in an effort to reduce social vulnerability. This will also reduce the impact of climatic stress [17] and could also facilitate economic well-being and security for coping with climate variability and hazard [21]. The LVI is designed to provide development organization, policy-makers and practitioners with a practical tool to understand various livelihood assets contributing towards climate vulnerability. The index-scale can help development planners refine and focus their analysis of geography units.

4. Conclusion

The research performed some pragmatic analysis to assess and understand the local vulnerability to climate change and variability in two specific areas by using the livelihood and vulnerability index (LVI) as developed [16]. In addition, it also investigated the significant contributions of the index to the development and understanding of vulnerability indicators and the assessment tool for policy analysis. Additionally, it is a systematic means for comparing livelihood vulnerability in different socio-ecological circumstance. The presenting of LVI-IPCC as alternative methods for assessing relative vulnerability of community to climate variability impacts shows that Pahang river basin is most vulnerable to climate change due to the high exposure and relatively low level of adaptive capacity than Temerloh. Flood preparedness is a good strategy in order to limit the impact of extreme flooding in the future. In addition, the upgrading of communication system and strengthening of social institution networks are highly recommended to a community to deal with climate change and climate variability and can help identify and determine actions that can ameliorate adverse impacts of disaster, such as flooding. If the community improves their coping capacity, it could help to reduce the damage caused by extreme events or environmental degradation, especially in the Temerloh districts. In contrast, the community in the Pekan district was the most vulnerable and had the lowest financial support. It is recommended that they are the most likely to need assistance for small and medium enterprises, smallholders and producers to start-up production or enterprises to improve their living conditions.

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References

[1]. Tangang F.T., Juneng L., Salimun E., Sei K.M., Le L.J. and Muhamad H. 2012. *Climate change and variability over Malaysia*: Gaps in Science and Research Information. Sains Malaysiana. **41 11** 1355-1366

[2]. Tangang F.T., Xia C., Qiao F., Juneng L. and Shan F. 2011. *Seasonal circulations in the Malay Peninsula Eastern continental shelf from a wave-tide-circulation coupled model*. Ocean Dynamic. **61** 1317

[3]. Chan N.W. 2012. *Impacts of Disaster & Disaster Risk Management in Malaysia: The case of floods.* pp.503-551

[4]. Sani G., Gasim M.B., Toriman M.E., Abdullahi M.G. 2012. *Floods in Malaysia: Historical reviews, causes, effects and mitigation approach. International Journal of Interdisciplinary Research and Innovations*. **2 4** 59-65

[5]. IPCC 2007. Climate change 2007: *The physical science basis. Contribution of working group II to the Forth Assessment Report of the Intergovernmental Panel on Climate Change (Ch.9)*. Cambridge University Press, Cambridge, UK

[6]. IPCC,2001. Climate change 2001: *Impacts, adaptation and vulnerability. Contribution of working group II to the Third Assessment Report.* Cambridge University Press, Cambridge, UK.

[7]. Tao S., Xu Y., Liu K, Pan J. & Gou S. 2011. *Research progress in agricultural vulnerability to climate change. Advances in Climate Change Research.* **2** 4, 203-210

[8]. Millari A.E. 2016. *Climate change vulnerability assessment in the Agriculture sector: Typhoon Santi Experience. Procedia-Social and Behavioral Sciences*. **216** 440-451

[9]. Sabine L.P.-N. 2010. The *vulnerability of beach tourism to climate change- an index approach. Climatic Change.* **100** 3-4, 579-606

[10]. Raquel S.L., Clave S. A., Saladie O. 2017. *The vulnerability of coastal tourism destination to climate change: The usefulness of policy analysis*. *Sustainability.* **9** 11 2062

[11]. Malik S.M., Awan H., Khan N. 2012. *Mapping vulnerability to climate change and its repercussions on human health in Pakistan*. *Globalization and Health.* **8** 31

[12]. Cannon T., Muller-Mahn D. 2010. *Vulnerability, resilience and development discourses in context of climate change. Nat Hazards.* **55** 3 621-635

[13]. Miller F. H., Osbahr E., Boyd F., Thomalla S., Bharwani G., Ziervogel B., Walker J., Birkmann.S., Van der Leeuw J., Rockström J., Hinkel T, Downing C., Folke and D. Nelson. 2010. *Resilience and vulnerability: complementary or conflicting concepts?. Ecologyand Society*. **15** 3, 11

[14]. Wisner B., Blaikie P., Cannon T., Davis I. 2004. *At Risk: Natural Hazards, people's vulnerability and disasters.* London: Routledge

[15]. Chamber R., Conway G.R. 1992. *Sustainable rural livelihood: Practical concepts for the 21st century* discussion paper 296 Institute of Development Studies, Brighton

[16]. Hanh M.B., Riederer A.M., Foster S.O. 2009. *The livelihood vulnerability index: A pragmatic approach to assessing risks from climate variability and change-A case study in Mozambique. Global Environmental Change.* **19** 1, 17-88

[17]. Madhuri Tewar H.R., Bhowmick P.K. 2014. *Livelihood vulnerability index analysis: An approach to study vulnerability in the context of Bihar*. *Jamba: Journal of Disaster Risk Studies.* **6** 1, 1-13

[18]. Etwire P.M., Al-Hassan R.M., Kuwornu J.K.M., Owusu O.Y. 2010. *Application of livelihoodvulnerability index in assessing vulnerability to climate change and variability in Northern Ghana*. *Journal of Environment and Earth Science*. **3** 2 157-170

[19]. Fussel H.M. 2007. *Vulnerability: A generally applicable conceptual framework for climate change research*. *Global Environment Change.* **17** 2 155-167

[20]. Leichenko R., Julie A. S. 2014. *Climate change and poverty: vulnerability, impacts and alleviation strategies. WIREs Climate Change*. **5** 4 539-556

[21]. Adger W.N., Huq S., Brown K., Conway D., Hulme M. 2003. *Adaptation to climate change in the developing world. Progress in Development Studies*. **3** 3 179-195