SOCIAL-ECONOMIC MODALITIES, NON RICE FARMING ACTIVITIES AND THEIR ROLES ON THE VULNERABILITY OF CLIMATE CHANGE OF VILLAGES SURROUNDING KERINCI-KERINCI SEBLAT NATIONAL PARK, LEBONG, BENGKULU

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Abstract

The impacts of global warming are easily recognized by the extreme change of the climate at a given region. Moderate changes such as the shifting onset of rainy and dry seasons could also generate the hardship for rice farmers in areas which were known to have stable climatic regimes. The distortion of rainfall from its normal pattern will influence the grain production through the increasing failures of pollination processes and diseases. The determination of magnitude and vulnerability will assist to policy makers to provide proper interventions to render the impacts of climate change. The study was aimed to determine the vulnerability of Rice farming dominated villages near the Kerinci-National Park, and the role of social-economic modalities and non-rice farming practices to the vulnerability. Data used were social-economic profiles of 9 villages within Lebong Sakti district, Lebong Regency. Landuse types, the percentage of rice farmer households to the total household population, and the types of rice field were included as indicators for potential impacts for climate change, while education backgrounds, the type of household income, farmer group, and supporting infrastructures for rice farming, coffee production, and livestock were considerd indicators for adaptive capacity. Scoring and weighting processes of the indicators were carried out through focused group discussion with twelve experts from various government agencies. We followed Saiffudin et al (2017) to define the five vulnerability categories. The results showed that of 9 villages, Ujung Tanjung I, Ujung Tanjung II and Magelang Baru were respectively cotegorized as very high and high vulnerability. Only one village, Lemeupit was low vulnerability, and the rest were categorized as very low vulnerability. Villages that have their landuses dominated by simple and semi-irigated rice field would likely become high or very high vulnerabilities. The vulnerability even became greater, if the sensitivity as expressed by the high dependency of the population to rice agriculture was higher. Education backgrounds did not play determinant roles on adaptive capacity of the villages. The number of farmer groups, the agriculture infrastructures, and coffee productions made the majority of the villages categorized as very low vulnerability. The type household incomes and the animal husbandary substantially influenced the adaptive capacity as well as the vulnerability of the villages.

BACKGROUND

Communities nearby tropical rain forests experience good and stable environmental services provided by the ecosystems. Such stable environments make communities develop its unique agriculture practices, which result from long term interactions between human and the ecosystems, and are characterized by well suited and neatly adapted practices to the mild variation of environments. Eventhough, the extreme climatic events may less occur to the nearby tropical rain forests compared to places more distant to the forest, the moderate variation of climate such as delaying on set of rainy season can generate problems on rice agricultural communities. In many cases, the moderate alteration on stable environments can produce impacts comparable to the strong alteration on less stable environments on the rice farming. The impacts can be traced back by the fact that rice varieties are adapted to the mild variation of environments, and that communities are used to practice agriculture accordingly to this rice varieties. Any disturbances on the normal climate pattern will result in the disruption of rice production and further farmer's lifehood.

Any variation to the normal climate patterns whether unsual drought, heavy rain or delayed onset of rainy season will effect on the rice production. In general, the increase of temperature will induce the outbreaks of pest and deseases, the failure of grain-filling processes, and low grain quality (Morton 2007, Phnong, 2016). During vegetative stages, rice is more tolerant to drought than during regenerative stages (Stigter and Winanto 2013), therefore, eventhough there is no extreme climatic events, the delayed onset of the seasons will affect on the rice productons. Moreover, many scenarios of the future climate show the increase of the average of temperature, and the events of earlier and later onsets of dry and rainy seasons. With regard to the southern part of the equator of Indonesia, it has been predicted that the area will be exposed to longer dry season, shorter, but heavier rain fall at rainy season (Syaukat, 2011). In southeast Asia, the moderate estimation shows that the increase temperature by 1^0 C will decrease the crop yield by 10 %, while the increase by 2^0 C could decreased yield as high as 20 % (Ariff and Romsden, 2016). The impact of the unusual drought does not only reduce rice yield productions, but also increases rice production costs, low price of poor quality grains, transportation cost after harvestings, and disturbs the livehood of rice farmers (Harvey et al. 2014).

Such future scenario should make all related institutions to be aware and to anticipate the impact of climate change to rice farming culture. In facing the failure of crop yield due to climate change, local farmers often rely on the existency of social modalities and network, and spread the risk of the failure of crop production through farm diversification. Harvey et al. (2014) showed that social networks and modalities become a pivot player in coping the unproductive period due to climate change. Local institution serving to communities becomes an alternative way to reduce the magnitude of the impacts through food giving mechanisme, borrowing money, and establishing social aids to the farmers. In general, local farmers have local wisdoms to carry out diversifications such as raising cattles and poultry, and practicing coffee plantation to get additional household incomes. These types livestocks will be treated as a way to do resources saving mechanism that will be used in the case the failure of rice production and food scarcity. Rohaeni (2015) showed that cattle alone can contribute up to 24 % of the total income of rice farmer households. The study was aimed to know the vulnerability of vilages nearby Kerinci Seblat Nasional Park, and the role of social modalities and non rice farming activities on the vulnerability.

METHODS

The focus of the study was Ujung Tanjung I, II, III, Muning Agung, Magelang Baru, Lemeupit, Tabeak Kauk, Tabeak Depoa, and Suka Bumi. All these nine vilages came from Lebong Sakti Distict, Lebong Regency, Bengkulu, and had border with Kerinci-Seblat National Park. Climatic records from nearby wheather station, Air Dingin from 2005-to 2015 showed that May to October were months with recieving less monthly rainfall than the total average of monthly rainfalls, while April, November, and December recieves more than the monthly rainfall. The anomaly of annual rainfall was also recorded, where 2005, 2008, 2009, 2010, 2013 and 2013 were known to be much, while 2006, 2011, 2012, and 2015 were drier wetter than the average of annual rainfall. Eventhough, the averagee of monthly rainfall of the area was never be classified as dry month (< 100 mm/month) within 10 years periode, the extreme low monthly precipitation respectively occured at June 2009 (32 mm), August 2012 (26 mm), July 2015 (33 mm) and September 2015 (38 mm). Compared to low precipitations, unusual wet months were more frequent, and respectively to occured at January (414 mm), February (433 mm), October 2005 (492 mm), April (433 mm), December 2009 (418 mm), July 2010 (513 mm), and November 2014 (455 mm). Data used for the research were based on the profile of Villages of Lebong Sakti District issued in 2016 by Lebong Sakti District government (Kec. Lebong Sakti, 2016). To develop vulnerability, index of Potential impacts (PI) consisting of exposure and sensitivity componens, and of adaptive capacity (AC) was calculated. Table 1 showed criteria and subcriteria of each components. To score criteria and subcriteria (S_i), questioners were distributed to 18 experts with various educational backgrounds. The results of the scoring then were used to calculated the values of each criterium at a villages (X_i), which then were further normalized.

Value of each criterium (i) at each village (j) $Ix_{ij} = S_i X_{ij}$

Normalized Value $NIx_{ij} = (X_i - X_{min}) / (X_{max} - X_{min})$

Index of Potential impact at each village (PI_j) $PI_j = Nx_{1j} + NIx_{2j} + Nix_3j$

Index of Adaptive capacity (AC) at each village AC_j) $AC_j = Nx_{4j} + Nx_{5j} .....+ Nx_{9j} + Nx_{10j}$

To determine vulnerability of each village, the approach by Saiffudin et al. (2017) was used. The Cartesius diagram was developed, where X and Y axises were respectively PI and AC indices. The fist quadrant showed high indices of PI and AC of villages, then was classified high vulnerability (HV). The second quadrant showed the low index of PI and High Index AC of villages, and then was grouped as very low vulnerability (VLV). The third quadrant showed the low indices of AC and PI, and was considered as low vulnerability (LV). The fourth quadrant showed the high index of PI and low index of AC, and was considered as very high vulnerability (VHV).

RESULTS AND DISCUSSIONS

The landuse of villages around Kerinci-Seblat National Park is generally dominated by coffee, Rubber trees, Palm trees, or Cinammon plantations, and rice field does not not become the dominant one. Some districts at Lebong Regency within Ketahun River Valley have relatively flat terrains, which are utilized as rice fields. Among them is Lebong District that has the rice field becoming a dominant landuse of its villages. The proportion of rice field to the total village's area varies among the villages from 30.69 % at Tabeak Dipoa to 54.62 % of the total villages of Magelang Baru. The other dominant landuse is upland, dry land outside of the villages, where non rice farmings such as Coffee, Rubber trees, and other multiple trees plantations are practiced (Table 2). With regard to rice-field, not all rice field has irrigation systems, those with irrigated and semi-irrigated systems become dominant categories. Both altogether contribute to 76 % at Magelang baru and up to 95 % of the total rice field area at Tabeak Kaut (Table 3). This also indicates that rice farming culture

potentially suffer less impact from the climate change, and one of aspects to make the majority of the villages becomes very low vulnerability categoory (VLV, Fig. 1). Eventhough, the water supply appears to be available year around, the farmers strangely only raise paddy once a year, because of their beliefs that raising paddy more once a year could triger the rat outbreaks.

The results indicated that majority of the villages, 5 of 9 villages appears be categorized as very low vulnerability (VLV). Two of them Murning Agung and Ujung Tanjung III most likely fall into medium vunerability category in the near future, if there is no intervention to mitigate the impact of the climate change. Both have higher values of PI Index than the other very low vulnerability villages. Lemeupit, Ujung Tangjung II and Magelang Baru, and Ujung Tanjung I respectively categorized as low vulnerability (LV), high vulnerability (HV), and very high vulnerability (VHV), respectively (Fig. 1). Three villages with high score on PI (Fig. 2), Magelang Baru (0.76), Ujung Tanjung I (0.75), and Ujung Tanjung II (0.60) were included to HV and VHV categories. Ujung Tanjung I becomes VHV because it had the high index on PI and the lowest index on adaptive capacity (AC). It does mean that Ujung Tanjung I have low scores on sosial economic modalities as well as non farming activities. The high index on PI does not determined by a single criterium, but by at leat two criteria that have relatively high value. Magelang Baru has high index of PI because of high scores its landuse and the type of rice field. Meanwhile the high index of PI's Ujung Tanjung I is a result of the high score of its landuse and the percentage of farmers to its total population. The High index of Ujung Tanjung II is due to combination of high score its landuse, the percentage of farmer, and type of rice field. With regard to landuse, it appears that if rice field is more than 48 % of the total area of the village, then, the village will tend to have high PI. High PI index of a village indicates that the village is prone to the impacts of the climate changes. Rice farmers have to prepare to the events of outbreaks of pest and deseases, and extreme wheather, which further can reduce rice production and incomes (Harvey et al. 2014). The high dependency to rice farming as indicated by the high percentage of rice farmers to the total population can increase the potential impact on Ujung Tanjung I. However, it does necessarily generate a similar impact to the other villages. Lemeupit, low vulnerability village, has the third highest dependency to rice farming, but has low index of PI. Rice field at Lemeupit is dominated with irrigated and semi-irrigated system (> 90 %, Table 3). The effect of the high dependency to rice farming at Lemeupit is moderated by its good irrigation system. As long as rice field is dominated by irrigated and semi-irrigated systems, then the sensitivity to the cilmate change of the high depency of population to rice farming agriculture is reduced. Both irrigated and semi-irrigated system are known to be les sensitive to the impacts of the climate change (Yuliawan et al. 2016). However, Harvey et al. (2014) warns that vulnerability influenced by the high dependency to rice farming could also increase food insecurity in the near future, if rice production is disturbed.

Lemeupit having the highest percentage of irrigated and semi-irrigated rice filed becomes an interesting case of LV villages. Among 4 social economic modalities constributing to adaptive capacity of Lemeupit, two of them, the level of education and the farmer group, have the lowest values among the other villages. However, it has the most complete supporting infrastructures for rice farming system, and raises more livestocks than that of the other villages. It seems odds that education level and farmer groups do not much influence on AC. In general, the higher education level and more farmer groups at i village will increase its adaptive capacity, and reduce vulnerability (Rochmayanto 2015). However, it is not the case of Lemeupit. Jiri et al (2015) stated that education may only play indirectly on applying adaptation technology on agriculture. Adaptive capacity is strongly influenced by farmers' experiences as well as their traditional technologies of agronomic practises.

Three villages with similiar high index of PI, Ujung Tanjung I, II, and Magelang Baru fall into very high and high vulnerability categories. Ujung Tanjung I has the lowest scores of its household income and supporting infrastuctures for rice farming system, and low scores

at the other five criteria for AC. In the constrast, Ujung Tanjung II and Magelang Baru can not fall into the VHV category because of their higher values on various social modalities and non rice farming practices. Ujung Tanjung II is a village with the high scores of the education level, the supporting infrastructure for rice farming , and livestock criteria. Meanwhile among the villages in Lebong Sakti, Magelang Baru has the high scores on the source of household income, farmer group, and supporting infrastucture for rice farming. It appears that high scores on sosial modalities and non rice farming practices can lower vulnerability.

Five villages with very low vulnerability have similar index of AC, ranging from 0.60 to 0.67 (Fig. 1). The similarity of these vilages, each of them has similar scores of the famer groups ranging from 0.63 to 1.0, means that the villages have relatively good percentage of number and member of farmer group to the total farmer population. Farmer group is generally considered as local institution where farmers can access to the information related to rice farming, fertilizers, and extension services. The important presence of such institution is emphazied by McDowel and Hess (2012). They stated that farmers have limited capacity and sources to cope the climate change. In facing the hardship due to the impacts of the climate change farmers seek alternatives to cope the hardship through social network. The presence of local institution to serve as social networks, and to provide services in the hardship events will increase adaptive capacity and reduce vulnerability of the community (Morton, 2007). Another similarity among them is the high scores on supporting infrastructure for rice farming. It does mean that all these villages have more available rice farming-related equipments as well as the presence of small vendors providing various items for rice productions .

Besides similarity, the five villages have differences that further will determine their vulnerability categories. Tabeak Kauk and Suka Bumi have the highest values at three various criteria of AC, and likely remain in very low vulnerability category in the future. Tabeak Kauk has the highest score on the level of education, the source of household incomes, and supporting infrastructure for rice farming. The high score on the source of household income of Tabeak Kauk indicates that the most of its population has stronger financial supports, thus becomes less dependent to rice farming practises. Therefore, they likely are less vulnerable to climate change. On the other hand, Suka Bumi have far lower values on the level of education as well the source of household incomes than Tabek Kauk. In fact, Suka Bumi is one of the villages that have lowest values at both criteria. However, it has the high scores on non rice farming activities such as coffee plantations and livestock. It appears that both non rice farming activities are able to compensate the low values of the level of education as well as the source of household incomes. Raising livestocks seem to be proper alternatives to cope the impact of climate changes. However, livestocks alone will not substantially mitigate the impacts. In many rural communities, combination between livestock and agriculture practises is a common strategy to cope the climate change (Jiri et al. 2015). Non rice farming practises provide diversifications that are basically common adaptation measures to reduce the risks, and to secure the household incomes.

Ujung Tanjung III and Muning Agung have high scores on various two criteria of AC (Fig. 2). Ujung Tanjung III has high scores on supporting infrastructure of rice farming and livestocks. Muning Agung has high scores on the source of household income and farmer groups. These two villages with will likely fall into medium vulnerability, both have lower values of AC than the other five villages with VLV. This can be prevented, if proper interventions are applied for these two villages. Of 4 criteria of adaptive capacity, only two that have high score, therefore, there are good possibilities to increase the index of adaptive capasity through interventions to improve the values of the rest two criteria. Agriculture extention will likely play important roles on increasing adaptive capacity measures. This issue has been raised by Boissiere et al (2013) and Takamo et al (2014). Extention will mitigate the impacts through provide technical supports and agronomic alternatives. Takamo et al (2014) further the extention servives will increase rice grain production by 12 %..

CONCLUSIONS

Majority of villages nearby Kerinci-Seblat National Park are categorized as very low vulnerability. Two of them are grouped by high vulnerability. One village, Ujung Tanjung I fall into very high category. Villages with rice field more than 40 % of their area mostly have high index of potential impacts. High dependancy to rice farming does not always to increase the potential impact and vulnerability as long as the majority of rice field is irrigated and semi-irrigated. Each social, economic modalities and non rice farming components play important roles on adaptive capacity. However, its mechanism to influence to adaptive capacity and vulnerability acts differently according to criteria. The good farmer group and supporting infrastructure for rice farming could are modality characters forvery low vulnerability. The good non rice farming activities and the main source of household income are pivot criteria of adaptive capacity, if the other social-economic modalities are inferior.

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Table 1: Potential impact (PI) and adaptive capacity (AC), and their criteria and subcriteria

Component	Indicator	Sub indicator
A. Potential impact	a.1. Landuse (x1)	Dry land
		Rice field
		Upland
		Forest
		Unproductive land
		Degraded land
	a.2. Type of rice field (x2)	Irrigated
		Semi-irrigated
		Simple irrigated
		rainfed
	a.3.Percentage of rice farmers to the total population (x3)	
B. Adaptive capacity	b.1.The level of Education (x4)	Elementary school
		Junior high school
		Senior high school
		College education (1 yrs)
		College education (2 yrs)
		Undergraduate
		Graduate
	b.2 The main source of household Income (x5)	rice farmer
		agriculture worker
		government employee
		arm forces and police officers
		local trader
	b.3. Farmer group (x6)	
	b.4. Rice field ownership (x7)	Owner
		Worker
		Renter
	b.5. Supporting infrastuctures for rice farming (x8)	hand tractor
		hand sprayer
		Grain removers
		Agriculture vendor
		Breeder
	b.6. Coffee plantation (x9)	
	b.7. Livestock (x10)	Goat
		Lamb
		Broilers
		Local chicken
		Duck

Table 2 : Landuse of villages of Lebong Sakti District. Percentage indicates the proportion of landuse type to the total area of the village.

Village	Total area	dry land	rice field	Upland	Plantation	Forest	unproductive land	degraded land
	Ha	%	%	%	%	%	%	%
Ujung Tanjung I	298.8	5.69	48.44	2.34	17.42	11.71	5.69	8.70
Muning Agung	213.3	5.16	39.01	1.41	17.86	22.50	5.16	8.91
Ujung Tanjung II	267.62	2.99	51.42	25.41	1.12	11.21	3.36	4.48
Ujung Tanjung III	236.62	16.48	37.45	21.55	6.34	10.57	3.38	4.23
Magelang Baru	248.99	1.20	54.62	10.84	5.22	14.06	7.23	6.83
Lemeupit	395.31	37.94	41.50	7.59	12.33	0.00	0.63	0.00
Tabeak Kauk	316.01	1.90	32.28	15.82	9.49	21.52	7.91	11.08
Tabeak Dipoa	414.06	1.69	30.69	16.42	15.70	20.53	9.90	5.07
Suka Bumi	369.89	40.55	46.08	9.46	3.10	0.00	0.81	0.00

Table 3 : The Type of rice field at the Villages of Lebong Sakti District. Percentage indicates the proportion of the each type to the total area of rice-field.

Village	Total	Irrigated	Semi-irrigated	Simple irrigated	Rainfed
	Ha	%	%	%	%
Ujung Tanjung III	88.87	48.62	28.37	23.12	0.00
Ujung Tanjung II	137.62	53.21	32.87	13.88	0.00
Ujung Tanjung I	144.75	54.20	30.54	12.16	3.11
Muning Agung	83.2	48.08	28.85	22.48	0.60
Magelang Baru	135.99	34.72	42.00	23.38	0.00
Tabeak Dipoa	115.6	60.55	30.28	6.06	2.60
Tabeak Kauk	106.86	63.31	33.43	2.81	1.55
Lemeupit	164.06	60.65	31.76	7.56	0.00
Suka Bumi	170.44	35.99	58.45	5.67	0.00

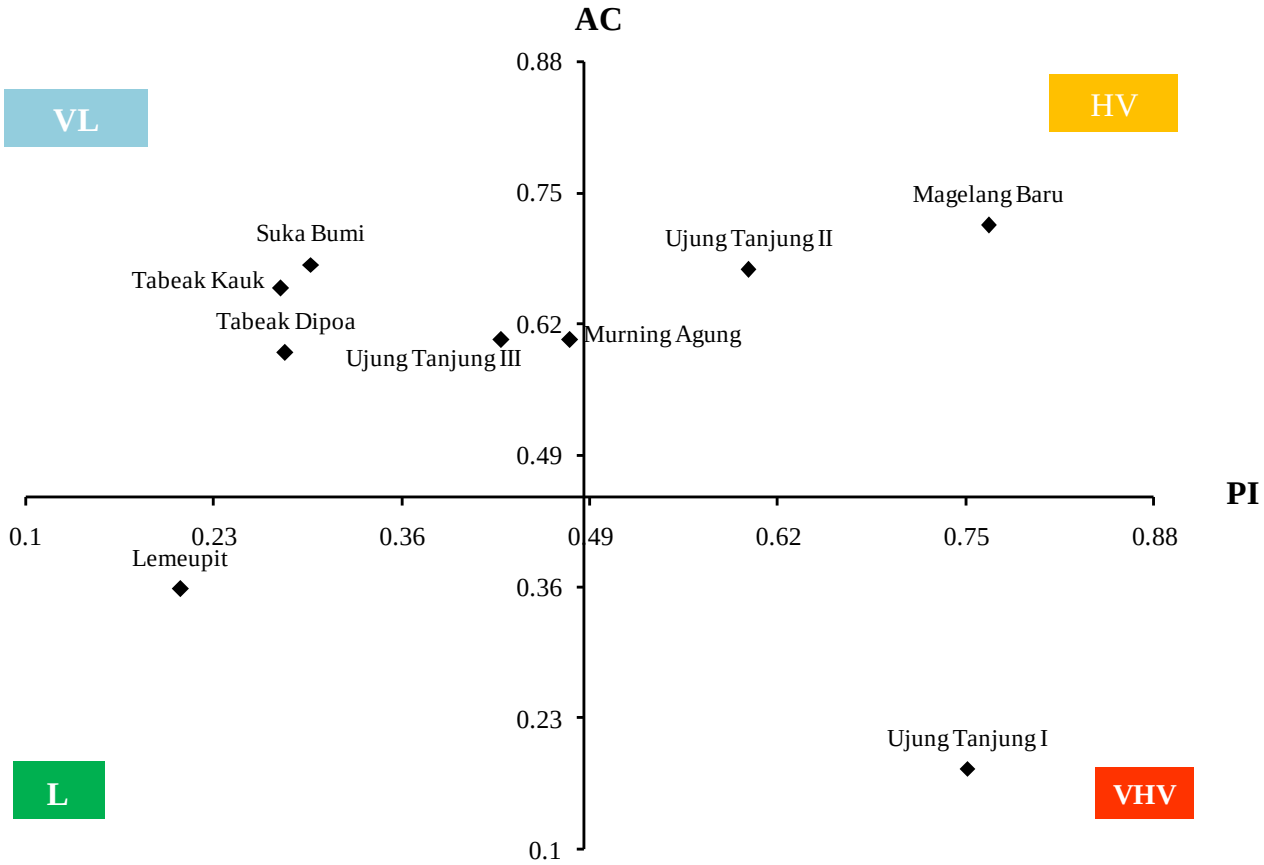

Figure 1: The vulnerability of the villages around Kerinci-Seblat National Park. Lebong Sakti distict, Lebong, Bengkulu. Potential impact (PI) and adaptive capacity (AC). Very high (VHV), High (HV), Low, and very low (VLV) vulnerabilities

Figure 2: The Spider web diagrams of Potential impact. PI (left) and adaptive capacity,AC, (right) of the villages nearby Kerinci-Seblat National Park, Lebong Sakti , Lebong, Bengkulu.