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Date	July 15, 2017
Subject	Confirmation presentation at IASC2017

To whom it may concern,

This is to confirm that

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presented a paper, entitled

'Studies on climate changes and natural resources management: Findings and lesson learned from West Sumatera, Indonesia'

at the IASC2017 conference, Utrecht, July 10-14, 2017.

We thank the author very much for this valuable contribution to the IASC2017 Conference

In case of additional questions, please contact us via iasc2017@iasc2017.org

Kind regards,

Prof. dr. Tine De Moor,
Professor Institutions for Collective Action in Historical Perspective, Utrecht University
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STUDIES ON CLIMATE CHANGES AND NATURAL RESOURCES MANAGEMENT: FINDINGS AND LESSON LEARNED FROM WEST SUMATERA, INDONESIA[1]

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ABSTRACT

This paper exposes some empirical facts of the regional changes of climatic variability in West Sumatera, Indonesia and presents such identification of its impacts on natural resources and agricultural activities in the region. This study chose the case site in the surrounding Singkarak Lake as the rain-shadow region in West Sumatra. This PEER-USAID-sponsored study found that there are significant changes of seasonal pattern of rainfall in this region during the last 30-40 years. The area in the eastern part of Singkarak relatively has become drier than in the western part Singkarak. Results from the vulnerability analysis shows that the villages in the eastern side of the Lake became much more vulnerable compared with the villages in the western side. Approximately more than 500 ha of upland paddy (rain-fed paddy) in the eastern region Singkarak is already over 30 years are not reprocessed, and many people are now working on dry-land crops and rubber plantation, or even work in non-agriculture jobs or migrate to the cities. Paddy farmers in this region are facing difficulties to set up their planting schedule. Significant impacts are also occurred in the onion farm in the western side of the Lake, where the fluctuation of production during the rainy season is becoming relatively high or more risky. From those identification studies, it can be concluded that the effects of global climate change has affected the regularity of the local climate in this area of study and then influence the natural resources condition and agricultural activities. Such empirical researches are still being conducted in order to develop such adaptive agricultural management models, integrated catchment management model as well as the study on the behavioral changes of farmers in this affected region of climate change.

KEYWORDS: climate changes, agricultural activities, socio-economic impacts

Introduction

The facts of the increased of the earth temperature is not an issue or just a public opinion anymore. Various results from scientific researches using global climate data have been published internationally in various forms of publication; journal, books, working papers, and etc. On the IPCC (2007a, 2007b) report, it was stated that the changes of land uses and deforestation in the tropical region has lift up around 1.7 billion ton of carbon to the atmospheres. Moreover, it was globally

[1] Paper presented in the XVI Biennial IASC Conference, 10-14 July 2017, Utrecht, the Netherland.

reported that if there is not much changes of the exploitation activities of natural resources from the earth, the earth surface temperature may increased for 6.4°C in the year of 2100, that of course will worsely affects the balance of energy in the atmosphere and the hydrological cycle in the earth surface.

Findings from relevant researches, either at global, regional or local level, have been reported in numerous publications in order to develop people awareness about the reality of climate changes. Salih (2009) has published his editorial book consists of researches findings about the relationship between the climate changes and sustainable development in many parts of the world, that were coming out from various experts from various discipline. In this book, Salih has given his notes that the impact of climate changes has not only influences the food availability or even food security but also creates conflicts in many aspects, social, political, cultural, market and environmental conflicts.

In Indonesia, the publication of research findings related to the concrete model of adaptation and mitigation of adaptive agricultural system at regional level are relatively low, either in national or international publications. The research team from Andalas University got the research grant from PEER USAID (from June 2012 to Mei 2015) to conduct a research about the dynamic of climate change and natural resources management in the region where for almost three decades has been investigated by numerous researchers from various backgrounds, that is in the surrounding areas of Singkarak Lake. Significant issues or problems of natural resources in this region have been widely published, especially about the conflict of water resources management in Singkarak Lake and the forest degradation in the catchment of Singkarak and the river basin of Agam-Kuantan in general. The catchment degradation that reduced sharply the land cover of the region have influenced the hydrological cycle within the region. One of the main concern of this research is about the agricultural and livelihood changes in the surrounding Singkarak Lake, because the region in the surrounding Singkarak Lake is located in the rain-shadow area (*daerah bayang-bayang hujan*) which usually dried and have uncertainty of rainfall.

Based on the above mentioned background and research problems, a series of reseaches have been conducted to identify the empirical facts of climate change in the study site and to describe the impact of climate change to the agricultural activities and the livelihoods of the local communities in the study site. Based on those researches, this study has identified further investigation could be implemented in this region.

Review of Relevant Literatures

In accordance to the objectives of the study, previous research publications from the case site and other relevant references are then reviewed here in order to develop specific framework and methodology. Helmi (2003) have explored the issues of water management conflict in Singkarak, spesifically Lembang basin in the upstream and Ombilin basin in the downstream of Singkarak lake. One important point from Helmi is the issues of integration among various stakeholders within the Singkarak lake basin, , not only farmers or water users, but also adminitrative sectors from two district government, and private and government-owned companies. He, furthermore, recommended the importance of integrating all stakeholders into one institutional framework that may able to accomodate the construction of integrated water resources management (IWRM) pattern from the upstream upto the downstream of Singkarak Lake.

Febriamansyah (2004) have also presented the result of his study on water resources management in the Ombilin-Singkarak sub-basin in the international round-table discussion in Padang. This study have identified various water resources management problems within the sub-basin, including, flood, land slide, water pollution, water conflict, catchment/forest degradation and also issues that coming out from other users like inland fishery, mining and electric plants. As like Helmi, Febriamansyah has also recommended a holistic approach to integrated various stakeholders of water resources management that may able to help one new body of water resources management called Balai Pengelolaan Sumberdaya Air (BPSDA) Kuantan-Indragiri assigned under the Water Resources Management Agency of West Sumatera Province.

In the context of impact of climate changes to agricultural system, several international publications have identified various indications. Brown and Funk (2008) has identified that the real direct impact of climate changes for the last decade is the changes of agricultural pattern and food system. This is also been mentioned by Schmidhuber and Tubiello (2007), whose specifically stated that all quantitative assessment shows four aspects of agricultural changes due to the climate changes, are: food availability, food stability, food uses and access. In their quantitative prediction model, they predicted that between 5 to 170 million people will be lack of food (hunger) in 2080.

In the context of the development of methodology that study the relationship between the climate change and agriculture, Parry (1990) has given the first step of empirical quantitative method to predict the impact of climate changes to agricultural conditions in several countries in Asia, Africa and America. The impacts did not only on plant growth, but also the impact to the condition of the agricultural land, plant diseases and pest, and also food productivity. Here, Parry has simply used the mathematical functions to develop prediction model that link the determination of climate change to the agronomy and other technical aspects of agriculture. Research and modelling that was developed by Parry is actually a reflection from the study of IPCC that was published earlier, where IPCC mentioned the general prediction of the worse impact of climate changes if there is not much changes of human behavioral pattern in natural resources exploitation.

FAO's Inte-Departmental Working Group (IDWG) on Climate Change (2008), which was leaded by Wulf Killmann has published one guidance material or framework that could be used by researcher to analyze the impact of climate change to agriculture and identify the alternative for adaptation and mitigation. This documentf presents wide and complete description about various possibility of impacts due to the global warming and climate change to food system and food security. Moreover, this book explores various potential strategy of adaptation and mitigation that could be done to maintain the food security conditions.

Dinar et.al. (2009) tried to answer this challenge by developing simulation model that could be used by decision makers in African countries that generally depended on agriculture sectors. With their agriculture economic background, Dinar has involved the research team from various discipline to analyze the interrelationship between climate variability and crop analysis. Therefore, this study has elaborated various aspects; hydrology, climatology, and agricultural system, using cross-sectional and historical data. In addition, based on their quantitative simulation model from the above mentioned data, they have successfully developed synthetic model for each country to be used to design their sustainable agricultural development strategies that more adaptive to the climate changes.

Intenational organization like OECD (Organization for Economic Cooperation and Development) have also supported the discovery of analytical model for adaptive agriculture in regard to the climate changes. Wreford et.al. (2010) have received the research grant from OECD to explore the impact of climate changes specially to agriculture. The approached used by Wreford et.al., to develop adaptation and mitigation pattern is more economic and public policy approach.

Overview of the study site

Lake Singkarak is located in the center of Sumatera island, Indonesia, that is administratively located in the West Sumatera Province (Figure 1). Geografically, the Lake is the eastern side of the mountainuous line (*bukit barisan*) of the island, so the region of the surrounding Lake are located in the rain-shadow area that will get lesser rainfall compare to the western side of the island.

The total area of Lake is around 107 Km^2, that got water from two main natural inflow of Sumpur river in the North and Sumani river in the South. While, the natural outlet of the surplus water goes to Ombilin river in the east side of the Lake which then flow to the Strait of Malacca.

Figure 1. Lake Singkarak in Sumatera island, Indonesia

There are 13 (thirteen) Nagaris or Villages in this surrounding Singkarak Lake namely Sumpur (SMP), Padang Lawas Malalo (PLM), Guguk Malalo (GGM), Paninggahan (PNG), Muara Pingai (MPG), and Saning Baka (SNB) in the Western side of the Lake, and Batu Taba (BTB), Tigo Koto (TGK), Tikalak (TKL), Kacang (KCG), Simawang (SMG), Singkarak (SGK) and Sumani (SMN) in the eastern side of the Lake.

The identification of climate changes in the study site

This study analyzed the rainfall variability in the case site by using the rainfall observation data from the closest station in subdistrict of Rambatan. Before the current data is analyzed, this study also identified the results of rainfall analysis from the previous studies. Slamet and Berliana (2008) used a wellknown Schmid-Fergusson method to identify the shift of the rainfal pattern in Solok (close to Rambatan). The rainfall rate everymonth for each period is identified as dry, humid or wet month. Then, in order to state the status for each month for long period of records, they just calculated the mode of the occurrence of wet, dry of humid month at each period. As a result, Figure 2 shows us that the dry season has shifted from May in the period of 1951-1975 to June in the period of 1976-2000. While, when they added the record upto 2003, the dry season became uncertain, where the wet months from April to October and from January to February.

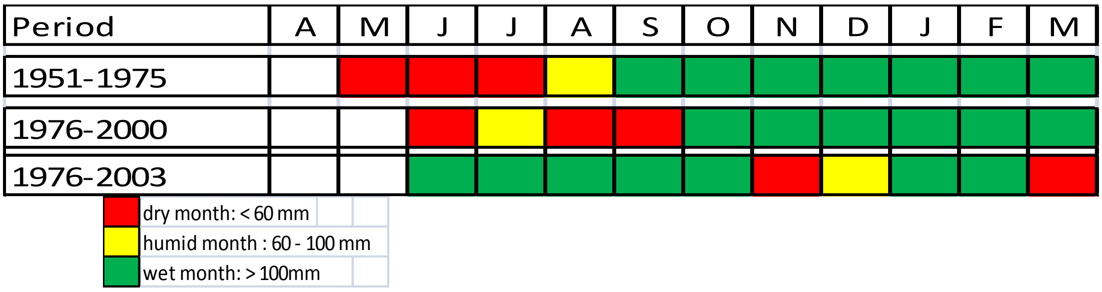


Figure 2. the shift of rainfall pattern from the previous study

This study then tried to identify the local climate change using the observed rainfall data from Rambatan rainfall station. Figure 3. shows the yearly pattern of wet, dry and humid months based on Schmid-Fergusson method. It could be seen here that the rainfall pattern since the last 10 years are very uncertain compare to the previous period (or before 1990s) where the dry season for about three or four months will usually started in June. Then, from November to May (about 7 to 8 montsh) were considered as wet months where the rainfall rate were usually high or above 100 mm. From our discussion with key informants, the earliest pattern of rainfall were identified by them, that mentioned the availability of water in their natural reservoir (*embung* or *talago*) to support their rainfed-paddy field for two short season during the wet months. Since more than the last 10 years, farmers facing the uncertainty of wet months in the case site. Their talago (called *talago janik* could not able to keep water for long to support even one season of paddy in their rainfed areas.

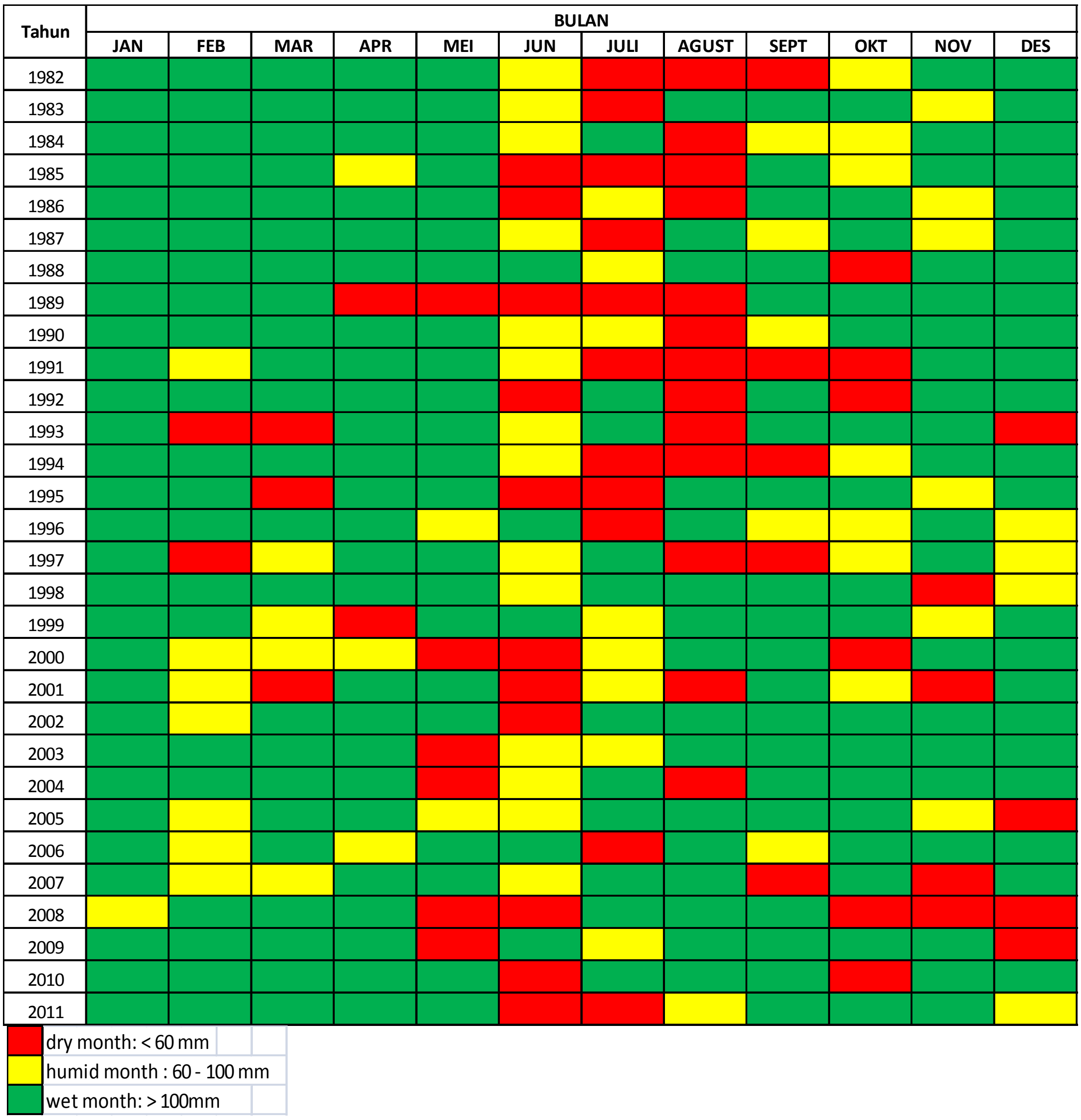


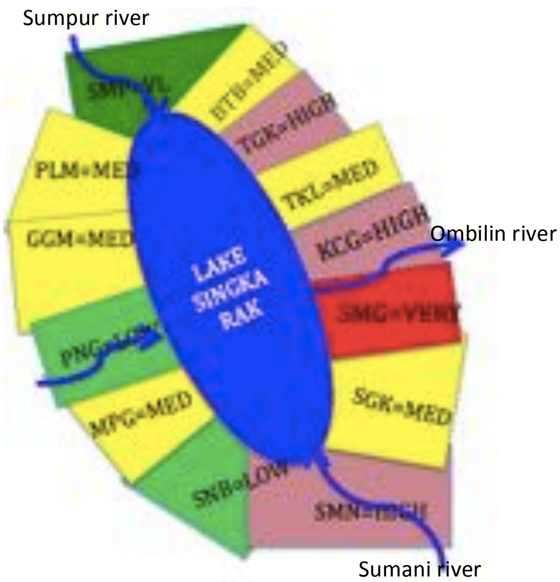
Figure 3. The changing pattern of monthly rainfall variabilities in the case site

The facts of global warming have influenced the local climate variability in the surrounding Singkarak Lake as the rain-shadow area, especially the changes of their seasonal pattern and decreased the annual rainfall in such areas. The changes of the seasonal pattern of rainfall could be the indication of local climate changes in this study site.

The vulnerability analysis of the region

This study have used the IPCC concept to measure the vulnerability of the region to the climate changes, through the Exposure Index (EI), Sensitivity Index (SI) and Adaptive Capacity Index (ACI) by applying Focused Group Discussion, Field observation and Secondary data analysis for all 13 Nagaris (Villages) in the surrounding Singkarak Lake. In order to measure the vulnerability in the case site, this study applied in-depth interview with relevant key informants, secondary data analysis and conducting focused group discussion (FGD) at each Nagaris with such as agriculture extention officers, nagari leaders and other key persons.

The results of the study showed that the eastern side of the Lake is more vulnerable compare to the western side. Based the vulnerability index at each Nagari, Nagari Simawang in the eastern of the Lake is facing the most vulnerable Nagari in this region.



Position	Nagari	Vuln. Index	Category
Eastern Villages (nagaris)	BTB	0.42	Med
	TGK	0.72	High
	TKL	0.53	Med
	KCG	0.81	High
	SMG	1.00	Very High
	SGK	0.58	Med
	SMN	0.72	High
Western Villages (nagar	SMP	0.00	Very Low
	PLM	0.60	Med
	GGM	0.52	Med
	PNG	0.39	Low
	MPG	0.55	Med
	SNB	0.24	Med

Figure 4. The Vulnerability index of the study site

The western Nagaris that have a streamflow from the upstream catchment are still in good condition with low to medium level of vulnerability index. The detail numerical analysis of this vulnerability index is presented in Annex 1.

The agriculture and livelihood changes in the most vulnerable Village

The study has chosen Nagari Simawang (SMG) as the main location to identify the impact of climate changes to agriculture and livelihood of the community. The Nagari is located in the eastern part of Singkarak Lake in West Sumatera that is administratively under the District of Tanah Datar (see Figure 5.). In order to identify the changes of agricultural and livelihood activities in the case site, this study applied the households survey to the community who have the paddy-fields in the rainfed area (*sawah tadah hujan*) that was locally called *hamparan sawah ketaping*. Since there area around 75 HH have paddy-field in this *hamparan*, this study have chosen 30% of them as the respondent. While, in order to enrich the information about the changes of agricultural system in the case site, this study has conducted a focused group discussion (FGD) with relevant key informants, such as agriculture extention officers, nagari and jorong leaders and other key persons in the Nagari Simawang. The FGD was also done with the purpose of identifying the alternative strategies of adaptation and mitigation.

As mentioned earlier, the changes of seasonal pattern of rainfall has created the uncertainty water availability for the rainfed-paddy area in the case site. Although there are more than 100 ha of rainfed-paddy area in Nagari Simawang, this study focused on the area called *hamparan sawah ketaping* of around 50 ha which approximately owned by around 75 farm households who live in *Jorong Darek* and *Jorong Koto Gadang.* Beside from the direct rainfall, the their paddy-field could get the water flow from *talago janik* with the distance of 500 meters from the *hamparan* and one spring within the hamparan.

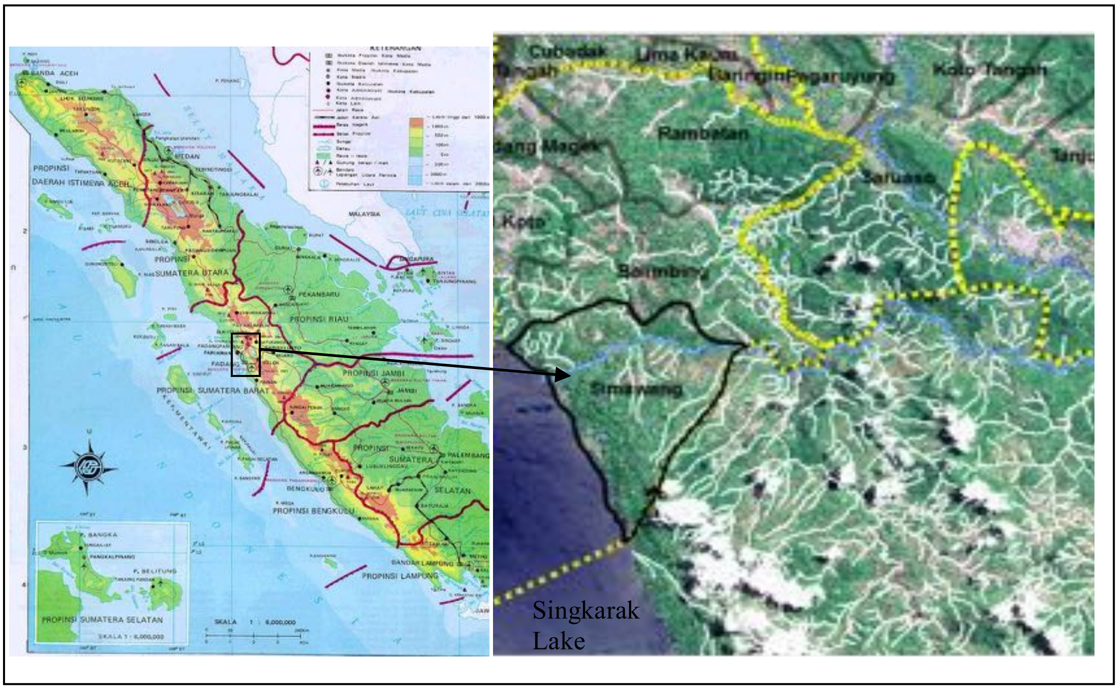


Figure 5. The site of Nagari Simawang in the western side of Singkarak Lake

From the sample survey of those farm households (HH), the average area of paddy-field per HH are around 0.4 ha (see Table 1.). Before the dry period, almost all of respondents able to cultivate their sawah for twice a year, mainly during the wet season from October/November to April/May. One of the key informant during the FGD even mentioned that when he moved to Jorong Koto Gadang by marriage in 1998, he still able to cultivate paddy for two season using the spring water within the hamparan, but one year after that when the spring water became unstable, he could not able to plow it anymore.

Table 1. The rainfed farming condition before the dried period

Before dried period	
average rainfed paddy field	cultivate 0.4 ha rainfed paddy, for almost twice a year
average production	1.400 kg Gabah per season
sold paddy	20% HH sold their paddy for about 25% of yield
dry-land farm *(ladang)*	40% HH cultivate their dry land for cassava, corn and sometimes chili

It was also identified by the sample survey that from the average production of their rainfed paddy-field of around 1.400 kg per season, 20% of HH used to sell their paddy for about 25% of their yield. Beside having income and staple food from their rainfed paddy-field, 40% of HH have also the dryland (*ladang or parak*) which was cultivated for cassava, corn and sometimes chili.

Since the last ten years, when the rainfall were uncertain and the water volume in *talago janik* were much lower than usual, farmers started left their paddy-field uncultivated one by one. One key informant even mentioned that the decreased and uncertainty of rainfall had influenced the confidence of farmers to cultivate their paddy-field. They have failed for many times. When they tried to plow their field after few days of raining, and then started with nursering their seed (*benih)*, the rainfall did not come for a bit long and their field became hard and hard to be planted.

Figure 6. Current rainfed paddy-field (*sawah tadah hujan di hamparan sawah ketaping*)

Table 2 below shows the summary of sample survey about the current condition of their farming activities. Only around 5 HH still able to cultivate their rainfed-field for at least one a year. They mainly use the spring water within the paddy-field area, that usually still able to water for around 2 ha of paddy-field. It is identified that, at this time most of them (42%) working as farm labour who work on other paddy-fields in Nagari Simawang or neighbor's Nagari. Because they do not have their own paddy for their own consumption, 80% of HH used to buy their staple food from market and even 40% of them are registered as poor family to get the rice subsidy from the government.

Those who have skill as building worker (25%), work as ready regular labour for housing or furniture. The other respondent mentioned their current occupation as small trader (*warung, kedai* or coffee house) and other services. Migration became one escape strategy for young people. Almost 75% of HH mentioned that some of their member have migrated to the city like Pekan Baru, Padang or even Jakarta. Information from the FGD even mentioned that the migration from Nagari Simawang mainly started from 1980s and becoming higher in 1990s.

Table 2. The current condition of farm HH on the dried period

On the dried period (current condition)	
% HH cultivate their rainfed paddy field	only 5% (around 5 HH) still able to cultivate their rainfed field, for at least one a year
% HH own cattle	25% HH (started from 1990s)
average cattle per HH	3 cattle (sapi/kerbau) and
	3 goats (kambing)
rice acquisition	20% HH cultivate another paddy fields
	80% HH buy from market
	40% HH got rice subsidy *(raskin)*
other sources of income	42% HH working as farm labour
	25% HH working as building labour
	13% HH working as trader (coffee shop or warung)
	21% HH work in other services
migration	almost 75% of HH mentioned that some of their members migrate to the nearest city, and 10% of them have migrated since 1980s

It seens that 25% of Household raising cattle in the open grazing in their rainfed area. Averagely, each HH have three cattle either cow or carabau. However, this individual cattle management have to conflict with agriculture activities in the rainfed area, because it gives less opportunity for farmer to plant the cash crop in this area.

If we look at the secondary data, the impact of climate change could also be related to the changes of land use cover in Nagari Simawang and its surrounding area. Figure 7. below shows the changes of land use from three different years.

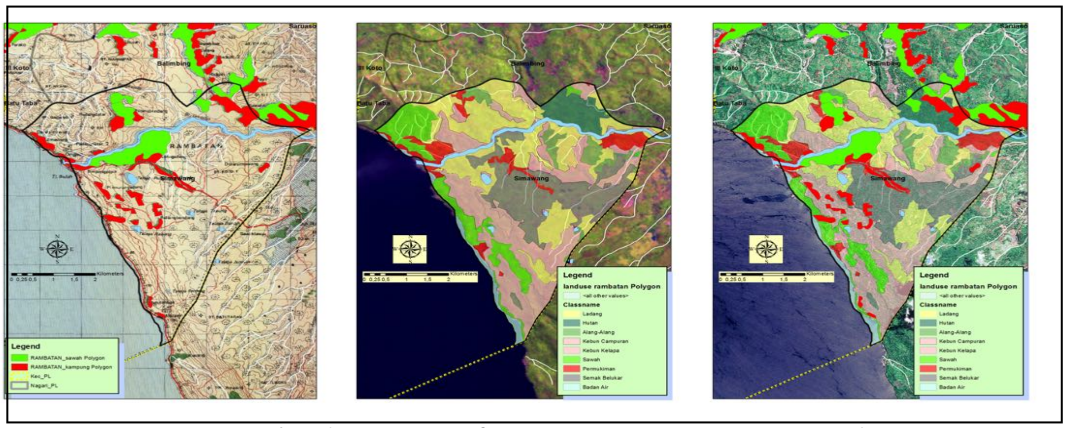


Figure 7. land use map of Simawang in 1976, 2000 and 2008

In detail, the tabulation of each land use in Nagari Simawang is presented in Table 3. This table shows that the paddy-field area decreased sharply from 245 ha in

2000 to 185 ha in 2008. Beside it has been changed to settlement, this paddy-field area has mainly became *semak-belukar* or grass area.

Table 3. Landuse changes in Nagari Simawang

No	Jenis Lahan	1976		2000		2008	
		Ha	%	Ha	%	Ha	%
1	paddy-field	131,60	5,33%	245,83	9,96%	185,51	7,52%
2	settlement	156,50	6,34%	159,99	6,48%	209,67	8,50%
3	road	13,40	0,54%	14,56	0,59%	15,66	0,63%
4	dry land (ladang)	503,43	20,40%	628,23	25,46%	1078,2	43,69%
5	water body (talago)	66,21	2,68%	52,98	2,15%	50,48	2,05%
6	pine forest	207,09	8,39%	125,58	5,09%	70,19	2,84%
7	Semak Belukar	530,17	21,48%	437,62	17,73%	26,52	1,07%
8	Alang-Alang (grass area)	303,92	12,32%	98,98	4,01%	102,23	4,14%
9	Kebun Campuran (mix farms)	497,20	20,15%	645,75	26,17%	671,06	27,19%
10	Kebun Kelapa (coconut farm)	58,29	2,36%	58,29	2,36%	58,29	2,36%
		2.467,81	100%	2.467,81	100%	2.467,81	100%

The risk analysis of onion farming

Red onion (*Allium Ascolanicum*) is a leading horticulture crops in the western side of Singkarak, especially ini Nagari Saning Baka (SNB). However, since around 30 years there is a significant decrease of onion farm area in this Nagari. Local farmers mentioned that the climatic factors, especially the uncertainty of rainfall season has influenced the confidence of farmers to cultivate this horticulture crops. Most of farmers have reduced the intensity of their farm land for onion and change that with rice either in the rainfed area or in the irrigated area.

In this regard, one study have been done to assess the production risk of onion in this region by production function analysis of two season of crop (rainy and dry season).

$$\text{Production Risk (Y)} = ß_0 + ß_1 X1 + ß_2 D_1 + ß_3 D_2 + ß_4 X_4 + ß_5 X_5 + ß_6 D_3 + U$$

Where:

Risk (Y) = Vi, represents variance of onion yield facing each respondent
X1 = quantity of single fertilizer (Kg)
D1 = Dummy for the use of organic fertilizer (yes = 1; no = 0)
D2 = Dummy for the use of special fertilizer (yes = 1; no = 0)
X4 = quantity of Pesticide (litre)
X5 = Frequency of spraying
D3 = Dummy for Variety (Vietnam=1, Bima Brebes =0)
ßo = constant
ß1, … , ß6 = coefficient of variable
U = Error

Farmers applied different quantity of inputs between the two seasons. They used more seeds in dry season than in wet season because the crop spacing in dry season is a bit bigger than in rainy season. Farmers used more insecticide in dry season, while in wet season they used more fungicide. They applied more fertilizer in rainy season compared to the dry season.

We found that farmers faced relatively high risk in both seasons. In the rainy season the level of risk faced by the farmers was 2.97 while it was 3.19 in the dry season. The size of cultivated land was the same in both seasons indicating that farmers did not consider the risk in the second season.

However, the regression analysis reveals that none of variables affecting production risks in the dry season (Table 4.), while in rainy season production risks were influenced by the use of single fertilizer, leaf (foliar) fertilizer and the use of pesticide.

Table 4. Statistical result for factors affecting production risks

No	Variable	Dry Season			Wet Season		
		Coefficient	**t. Statistic**	**Sig.**	**Coefficient**	**t. Statistic**	**Sig.**
1.	Constant	488,267	2,875	0,008	-348,115	-2,541	0,017
2.	Single fertilizer	0,729	615	0,512	0,729	2,621*	0,014
3.	Organic fertilizer	-147,215	-0,215	0,234	-148,346	-1,592	0,123
4.	Leaf fertilizer	75,152	0,715	0,480	250,587	3,076*	0,005
5.	Pesticide	2,422	-0,324	0,748	17,081	5,536*	0,000
6.	Freq. Spraying	-2,911	0,642	0,535	1,555	0,721	0,477
7.	Variety	-146,108	-1,773	0,087	-112,910	-1,084	0,288
F stat			**1,088**	**Sig: 0,394**		**10,439**	**Sig 0,000**
F Table			**2,445**			**2,445**	
R^2			**0,189**			**0,691**	

Dependent variable: Risk *) Significant

At the 90% confidence interval level in the dry season F value of 1,088 <F table 2.445. It means that Ho was accepted; therefore we concluded that none of the variables suspected to affect production risk significantly. The models could not estimate the risk variables. Moreover, the R^2 value in the dry season is also very low. Where, only 18.9% of risk variables can be explained by the independent variables, while the remaining 81.1% could only be explained by other variables outside the model. Other variables outside the model that became a source of risk in dry season could be the climate, smog[2], pests and plant diseases. Climate and smog are a source of risk that cannot be solved by the farmers during the dry season. Pests and plant diseases in the dry season are also difficult to address even though the control has been carried out.

In contrast to the rainy season, the calculated F value of 10.439 was greater than F table of 2.445. The decision was rejected Ho and accepted H1.This indicates that there was at least one independent variables that influence production risk significantly. The model can estimate the risk variables in the rainy season.

The coefficient of determination (R2) in the rainy season was high counting for 0.691, meaning that 69.1% dependent variable (Y) can be explained by the independent variables, while the remaining 30.9% is explained by other variables outside the model.

In the partial test, variable single fertilizers (X1), leaf fertilizer (D2) and pesticides (X4) affect production risk significantly at the 90% confidence level. These

[2] During the period of crop season, there is a smog hazard in the region as the impact of forest fire in Sumatera, which could influence the growth of onion.

three variables were risk-inducing factors, in which increasing the use of these factors may increase the risk.

Hence, it can be concluded that the climate variability are main factor for the risk of agricultural production, especially this Onion farming, because this kind of crop are much depend on the certainty of rainfall pattern. The variation of production (the fluctuation) in the case site is much higher in the rainfall season, because either in the rainy season, the pattern of rainfall is not certain. The production of onion will be fail, if the rainfall intensity is too high during the harvest time.

Conclusion and Lesson learns from the study

The series of this study at least has given such interesting lessons in the relation of climate and natural resources management, especially agriculture in the study site, are:

1. the facts of global warming have influence the local climate change in the surrounding Singkarak Lake as the rain-shadow area.
2. The changes of the seasonal pattern of rainfall could be the indication of local climate change in the case site that have influence the agricultural activity and local livelihoods.
3. The rainfall variability in the case site shows the uncertainty of rainfall season that affect the uncertainty of water availability for the rainfed paddy in Simawang and also Onion farm in the western Nagaris.
4. Various adaptive strategies have been implemented by the affected farm households, such as, raising cattle, working as farm labour, small trading and migrate to the nearest cities/town.

Such further investigation could be implemented in this region are; the assessement of catchment management in the upland area and the behavioural analysis of farmer adaptation to the climate changes.

Acknowledgement
I would like to express my thankful to PEER-USAID which have given us a research grant for this study. My thankful is also presented to the research team, PhD and Master students who involved in this research activities namely, Refdinal, Laily, Yusmarni, Anugrah and Siska.

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Annex 1. The Result of climate vulnerability analysis

No	Indicators	Eastern Villages (nagaris)							Western Villages (nagaris)					
		BTB	TGK	TKL	KCG	SMG	SGK	SMN	SMP	PLM	GGM	PNG	MPG	SNB
Exposure														
1	Rainfall	0.22	0.22	0.33	0.33	0.33	0.22	0.22	0.11	0.11	0.11	0.11	0.11	0.11
2	Paddy Area	0.07	0.21	0.07	0.07	0.07	0.21	0.21	0.07	0.14	0.14	0.14	0.14	0.14
3	Critical land	0.08	0.08	0.12	0.12	0.12	0.04	0.04	0.04	0.04	0.06	0.08	0.04	0.08
4.	Farmers	0.12	0.12	0.04	0.04	0.08	0.08	0.08	0.04	0.12	0.12	0.12	0.12	0.12
	Total (E)	**0.49**	**0.63**	**0.56**	**0.56**	**0.60**	**0.55**	**0.55**	**0.26**	**0.41**	**0.43**	**0.45**	**0.41**	**0.45**
Sensitivity														
1.	Forest Area	0.07	0.07	0.21	0.21	0.21	0.14	0.21	0.07	0.21	0.21	0.07	0.21	0.07
2.	Non-irrigated	0.22	0.11	0.11	0.11	0.33	0.11	0.11	0.11	0.22	0.22	0.11	0.22	0.11
3.	Population density	0.08	0.08	0.04	0.04	0.12	0.08	0.08	0.04	0.04	0.04	0.04	0.04	0.04
4.	Dryland area	0.08	0.08	0.08	0.08	0.12	0.08	0.12	0.04	0.04	0.04	0.04	0.04	0.04
5.	Farm-based income	0.14	0.14	0.14	0.14	0.12	0.14	0.14	0.21	0.21	0.21	0.21	0.21	0.21
	Total (S)	**0.59**	**0.48**	**0.58**	**0.58**	**0.90**	**0.55**	**0.66**	**0.47**	**0.72**	**0.72**	**0.47**	**0.72**	**0.47**
Adaptive capacity														
1.	Irrigated land	0.33	0.11	0.33	0.11	0.33	0.11	0.11	0.11	0.11	0.22	0.11	0.22	0.11
2.	Climate project	0.12	0.12	0.12	0.12	0.08	0.12	0.12	0.08	0.08	0.08	0.04	0.12	0.12
3.	Conservation behaviour	0.08	0.08	0.08	0.08	0.12	0.08	0.12	0.08	0.08	0.08	0.04	0.08	0.12
4.	Owned land area	0.22	0.22	0.22	0.22	0.33	0.22	0.22	0.33	0.33	0.33	0.22	0.33	0.22
5.	Non-farm income	0.22	0.22	0.22	0.22	0.22	0.33	0.33	0.22	0.22	0.22	0.33	0.11	0.33
	Total (A)	**0.97**	**0.75**	**0.97**	**0.75**	**1.08**	**0.86**	**0.90**	**0.82**	**0.82**	**0.93**	**0.74**	**0.86**	**0.90**
Vulnerability Index		**0.30**	**0.40**	**0.33**	**0.43**	**0.50**	**0.35**	**0.40**	**0.15**	**0.36**	**0.33**	**0.29**	**0.34**	**0.24**
Normalized VI		**0.42**	**0.72**	**0.53**	**0.81**	**1.00**	**0.58**	**0.72**	**0.00**	**0.60**	**0.52**	**0.39**	**0.55**	**0.24**
Category of VI		Med	High	Med	High	Very High	Med	High	Very Low	Med	Med	Low	Med	Low

Note: Sumpur (SMP), Padang Lawas Malalo (PLM), Guguk Malalo (GGM), Paninggahan (PNG), Muara Pingai (MPG), and Saning Baka (SNB) in the Western side of the Lake, and Batu Taba (BTB), Tigo Koto (TGK), Tikalak (TKL), Kacang (KCG), Simawang (SMG), Singkarak (SGK) and Sumani (SMN) in the eastern side of the Lake.