

Identify issues, purpose, system, context, and variables for the food security vulnerability assessment with climate change in Bali/Indonesia

Dr. Takeshi Takama¹, Ms. Pudji Setyani², and Dr. Edvin Aldrian²

1. JICA/Stockholm Environment Institute
2. Meteorological, Climatological and Geophysical Agency | BMKG

Introduction

The devastating impact of climate change is already evident in Indonesia. The combination of high population density and high level of biodiversity, together with its more than 15,000 islands and a coastline that has a staggering total of tens of thousands kilometers, make Indonesia one of the most vulnerable countries to the impact of climate change. Bali is, as a small island of Indonesia, likely to be affected by climate change, impacting various aspects such as rising sea level, drought, flood, as well as food security.

Since September 2010, there has been technical cooperation in the project of Capacity Development for Climate Change Strategies in Indonesia between the Government of Indonesia and Japan International Cooperation Agency (JICA). One of the subprojects concerns a vulnerability assessment of climate change and is expected to produce the studies and maps of vulnerability to climate change in Bali.

The purpose of this paper is to show how the project team identified the focus area of vulnerability assessment in Bali, based on multiple assessments including literature reviews, statistical assessment, stakeholder/policy assessment, and interviews with farmers. The focus areas have to be applicable not only in Bali Island, but also the rest of Indonesia in order to make this study scalable in the future. Through a six-step process, the project team identified issues concerned in climate change, the purpose and system of vulnerability assessment, potential risk/harm in context, and potential variables for a further assessment.

According to Harvey, there are ten steps to complete a vulnerability assessment to create vulnerability indicators (Harvey et al., 2009). This paper applies the first six steps namely from identifying range of issues to the potential variables (Figure 1). Reviews on the existing reports identified ranges of issues. The purpose and system of vulnerability assessment and potential harms were identified by stakeholder meetings and policy assessment in Bali. The findings from these qualitative assessments were backed up and revised by statistical

assessment. The findings were reviewed by interviews with farmers and the interview results helped to recognize potential variables to assess vulnerability for the food security issue in climate change.

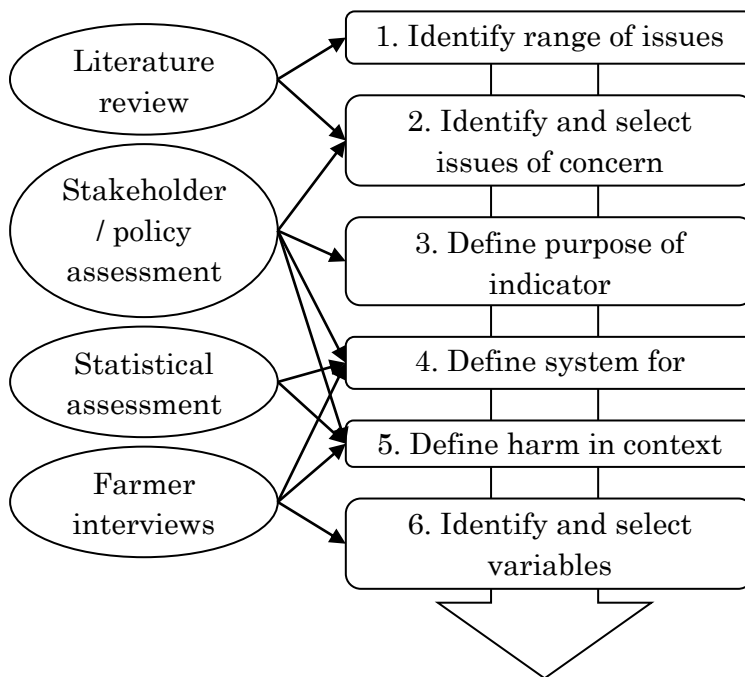


Figure 1 Process of identifying issues, purpose, system, context, and variables for a vulnerability assessment

Backgrounds on Climate Change Adaptation and Vulnerability in Indonesia

Vulnerability concepts

The IPCC (2007p.883) gives the most quoted definition of vulnerability: “Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.” Extensive climatic and socio-economic vulnerability may be worsen poor farmers composing the majority of rural populations in developing countries including Bali/Indonesia.

The vulnerability of climate change has been defined differently (Adger, 2006; Birkmann, 2007; Fussel, 2010; See e.g. Kelly & Adger, 2000; O'Brien, Eriksen, Nygaard, & Schjolden, 2007), but it is distributed between outcome vulnerability and contextual vulnerability (O'Brien et al., 2007) (Figure 2). Outcome vulnerability defines vulnerability as the compound result of impact assessments and adaptive capacity. Contextual vulnerability assumes that vulnerability is determined by the potential characteristics of issues, context, purpose, and system. In either definition, vulnerability changes when the context of issues, context, purpose, and system change. Therefore, it is important to identify these before a vulnerability assessment is conducted.

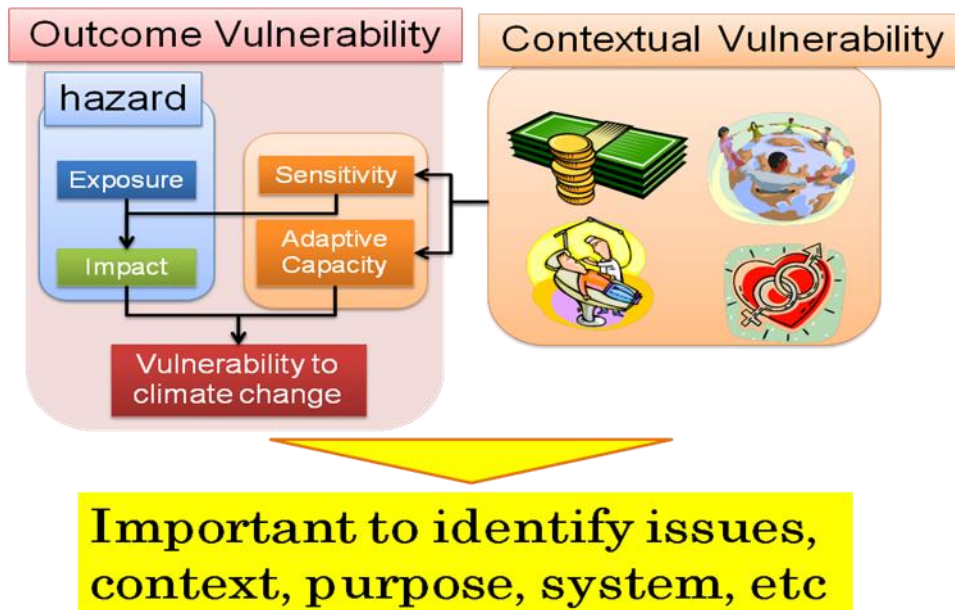


Figure 2 Vulnerability concepts and importance of finding issues, context, purpose, system, etc.

Climate change in Indonesia and Bali

Indonesia is the largest and widest archipelago country in the world and is known as a tropical maritime continent country. Indonesia is among the countries that will be significantly affected by accelerated global climatic change (Kawanishi, Takama, Ogawa, & Takahara, 2011-02).

Bali Island in Indonesia is located south of the equator, is approximately 153km wide and spans approximately 112km north to south. The total area of the island is 5,636.66 square Kms, which is 0.29 percent of the total area of the country. The province is divided into eight regencies

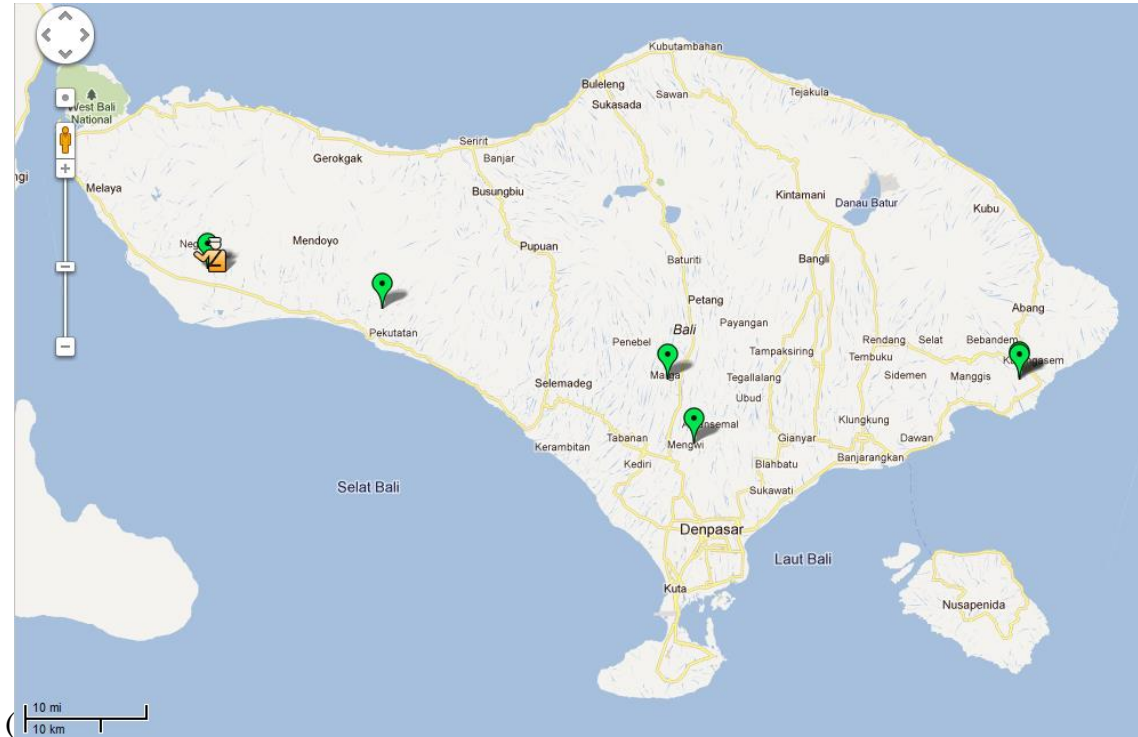


Figure 3).

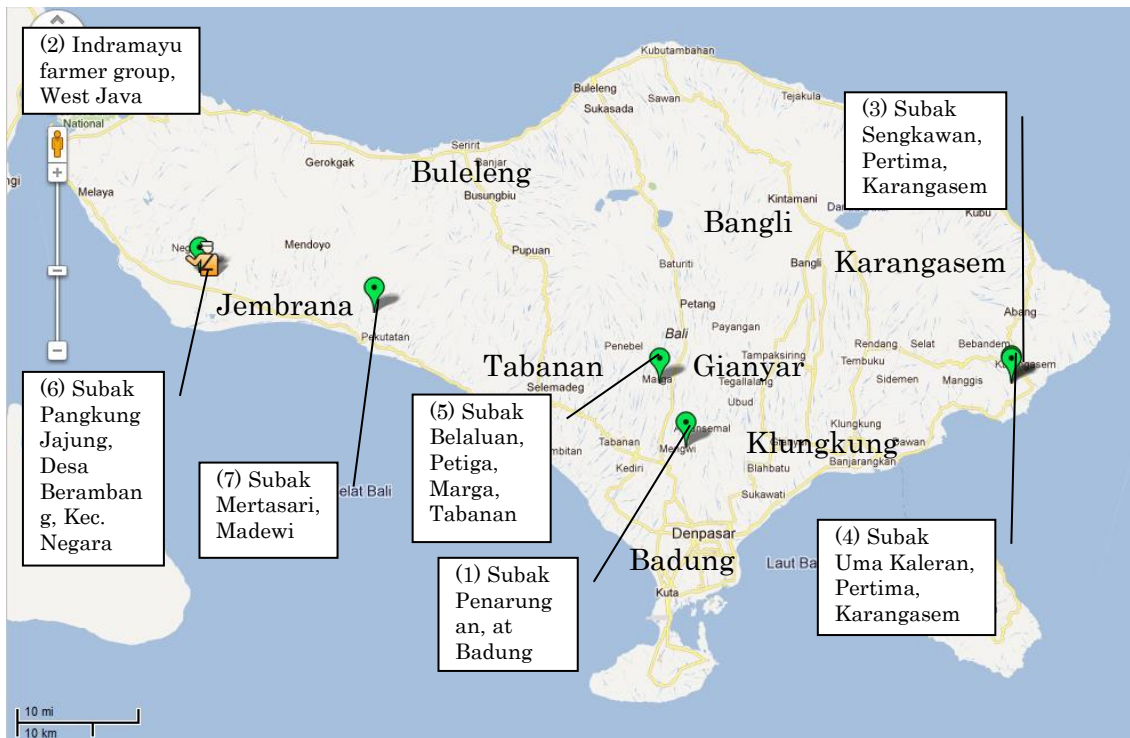


Figure 3 Topography of Bali Island

There is some evidence showing rainfall patterns have changed with data between 1951 and 2000 (Meteorology, Climatology and Geophysics Agency (BMKG), 2010). The onset of rainy season and dry season have been delayed or advanced, depending on locations. In Java, some areas become wetter and others exhibit an opposite pattern as shown in Figure 4. The map is dominated by white to yellow colors. The white color means no significant trend of dry spell. The yellow color means significant positive trend with dry spell increasing to 5 days for 10 years. Figure 5 shows the trend of maximum wet spell (maximum number of consecutive days with rain). The trend value ranged from -2 (red) to 1 (blue) day/10 years. The wet spell trend varies with location. Some locations become wetter and others become drier or unchanged. Also, the study demonstrated some areas have changed the pattern of heavy rain (rainfall more than 50 mm/day).

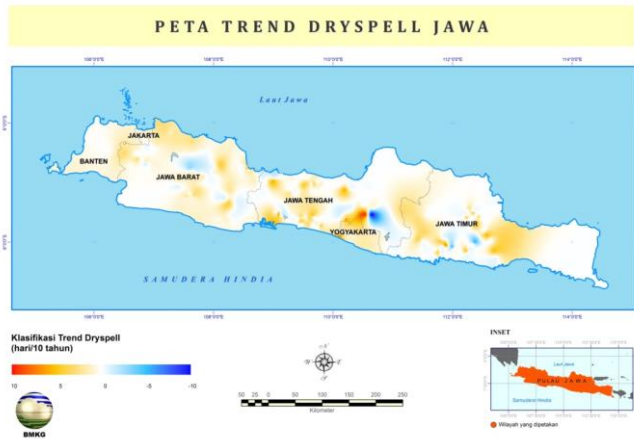


Figure 4 Trend of consecutive dry days in Java (Meteorology, Climatology and Geophysics Agency (BMKG), 2010)

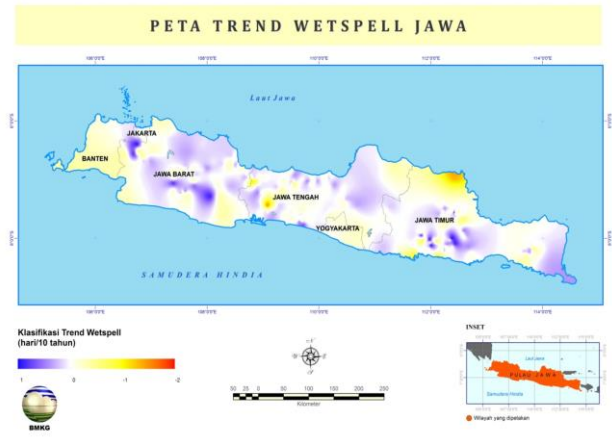


Figure 5 Trend of consecutive wet days in Java (Meteorology, Climatology and Geophysics Agency (BMKG), 2010)

Bali Island has a high possibility of disturbance with the season (Makmur, 2011). As shown in Figure 6, precipitation in each month has a high level of disturbance based on 30-year data. For example, if rainfall decreases significantly, a wet season becomes very dry and if rainfall increases significantly, a dry season becomes very wet. That is, wet and dry seasons may flip, so this will cause significant problems in water-related sectors including agriculture. Although it is a preliminary result, Figure 7 signaled that average temperature of Bali has increased roughly by 1 degree Celsius compared with 10-20 years ago.

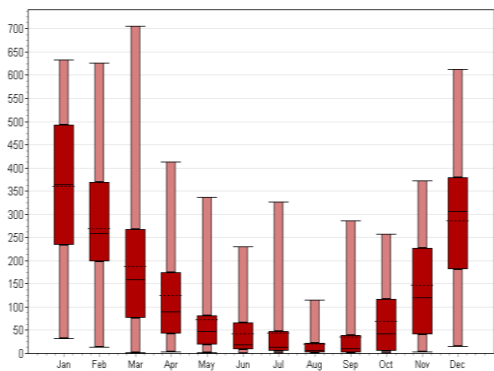


Figure 6 High possibility of disturbance within the season (Makmur, 2011)

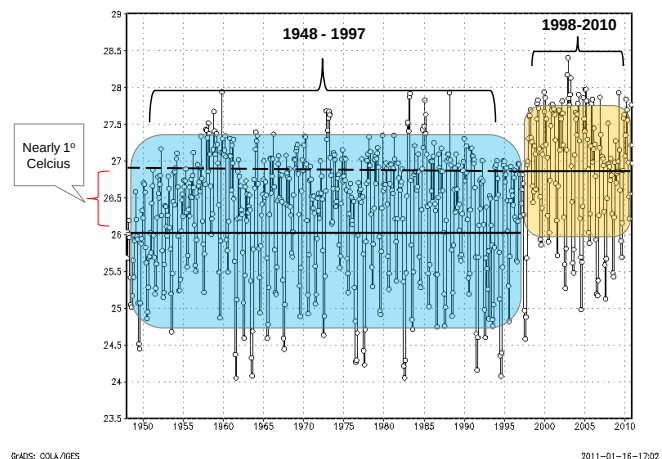


Figure 7 Signal of climate change in Bali (Makmur, 2011)

Also, a study suggested that Bali's climate may get hotter in the future in the CIP platform, which downscaled projections for most of Asia (CIP, 2011). A model shows that temperature in Bali may rise by 2 degrees. Top panels of Figure 8 and Figure 9 show 10th to 90th percentile multi-model range of monthly mean daily maximum temperatures for 20th century (grey) and future period (red). Bottom panels show 10th to 90th percentile multi-model range of monthly mean daily maximum temperature anomalies between the future simulation period and the 20th century simulation period.

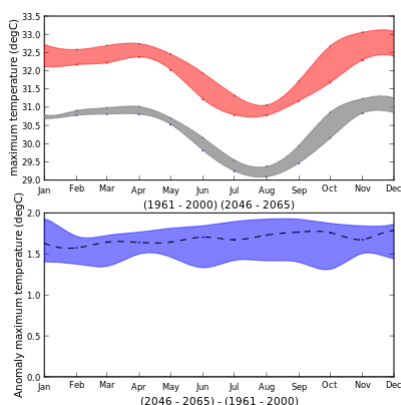


Figure 8 Downscaled Monthly Daily Max Temp. Projections (CIP, 2011)

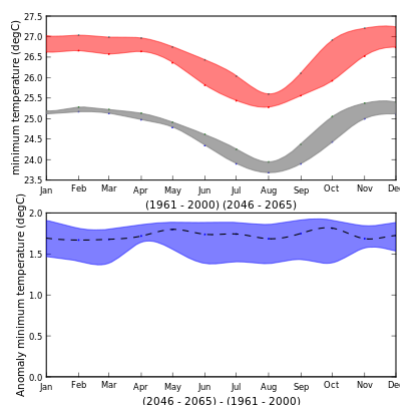


Figure 9 Downscaled Monthly Daily Min Temp. Projections (CIP, 2011)

Methods

Six-step identification process

After reviewing relevant projects, the project team decided to apply a vulnerability assessment process developed during a study in EU (2009). The process is used in more developed countries in larger areas than this project. However, the EU study was aimed to be used by policy makers and was designed to make a vulnerability index. These two aims are the same as those of our project, which is also aiming to scale up to all of Indonesia after the current Bali assessment. Therefore, the process was a suitable one to apply. Nonetheless, the project team revised the process if necessary to fit the context of Indonesia as well as the capacity development project within government offices. The six steps implicitly have a number of iteration and refinement issues in the process, and different degrees of detail were required for different types of assessments. The following sub-sections provide a description of each step in the process.

Step 1: Identify range of issues

This first stage was about setting the general context and nature of the problem in Bali, but also applicable in Indonesia. This was mainly done by literature reviews of policy documents.

Step 2: Identify and select issue of concern

This step made the project team focus on specific issues. Initially, more than one issue was identified as relevant and important to target users through literature review, but the selection process narrowed down the issue of concern by stakeholder meetings and policy assessment.

Step 3: Define purpose of vulnerability assessment

A key process in this step was to tie in the policy objectives, actions, and targets of users, as different vulnerability assessments should be needed for different purposes. Defining a purpose shaped the structure of the project and helped determine the rest of the identification steps.

This was carried out with stakeholder meetings and policy assessment as well as other meetings with local authorities

Step 4: Based on purpose, define workable system

The project team defined a system as a policy framework we work within to determine the issues and purpose identified in previous steps. Moreover, scientific framework was used to refine the system by making explicit the assumptions used in a future vulnerability assessment, for example, the three pillars of IPCC vulnerability definition and WFP's food sustainability. This process was conducted together with Step 3, but the paper keeps the two steps separate to be consistent with the EU process.

Step 5: Define harm in context

A vulnerability assessment requires a definition of what harm means for the system of interest and subject exposure units in the system (Bisaro, Wolf, & Hinkel, 2010). Potential harms were mentioned in the previous steps in literature, meeting and policy assessment, but statistical assessments were used to confirm and revise these harms.

Step 6: Identify and select variables

As well as nominated variables indicated in the previous steps, this paper demonstrates the selection process of variables through farmers' interviews. This approach starts with finding relevant factors affected by the identified harms, rather than studying general contexts of exposure units (Hinkel, 2011).

Data

Literature review is based on 12 policy documents related to climate change adaptation and vulnerability:

1. Directorate of Coasts and Ocean, Indonesia. (2009). Means of adaptation and mitigation of climate change and disaster at coastal areas and small islands (Directorate of Coasts and Ocean, Indonesia, 2009)
2. Indonesia. (1999). The first national communication on climate change convention (Indonesia, 1999)
3. Ministry of Public Work (PU). (2007). National action plan addressing climate change (Ministry of Public work (PU), 2007)
4. Ministry of Development (Bappenas). (2009b). Overview of Indonesia's mid-term development plan 2004 – 2009 (Ministry of Development (Bappenas), 2009)
5. Ministry of Development (Bappenas). (2010a). Indonesia climate change sectoral road map - ICCSR (Ministry of Development (Bappenas), 2010a)
6. Indonesia. (2010b). Mid-term national development plan 2010-4 (RPJMN). (Ministry of Development (Bappenas), 2010b)
7. Ministry of Environment. (2001). Identification of less greenhouse gas emission technologies in Indonesia. Jakarta: Ministry of Environment. (Ministry of Environment (KLH), 2001)
8. KLH, I. (2004). Stock take report (July-September 2004) national capacity self-assessment No. PROJECT 00033093) (KLH, 2004)

9. KLH, I. (2009). Summary for policy makers: Indonesia's second national communication under the united nation framework convention on climate change (UNFCCC) (KLH, 2009)
10. KLH, I. (2010). Mid-term national environmental plan 2010-4 (NARASI). (KLH, 2010)
11. Triastuti, U. H. (2008). Mainstreaming climate change into national development planning. Kick-Off Meeting of Asia Pacific Gateway to Climate Change and Development, Bangkok Thailand. (Triastuti, 2008)
12. UNDP. (2006). United Nations development assistance framework. Indonesia. 2006-2010 (UNDP, 2006)

Statistical assessment was carried out with data from BPS namely Census of Agriculture and BPS Official News, which regularly publishes information about working population, paddy production, poverty, etc., as well as data from BMKG. We used the data between year 2000 and 2011 although some data were missing in some variables. Other types of information used in the paper are mentioned in the section below.

Stakeholder meetings

The first local stakeholder meeting was carried out in March 2011 and discussed food and water security issues with regard to climate change vulnerability in Bali. The representatives of 12 local agencies participated in the meeting including development and planning agency (BAPPEDA), Agriculture agency (BPTP), and BMKG as well as local non-governmental organizations and university professors. The results of stakeholder meeting were presented to seven national agencies including Ministry of Environment (BLH) and Ministry of Agriculture (KEMTAN) to receive feedback from a national perspective. There was a total of 39 participants involved in the process. The second stakeholder meeting was also carried out in July 2011 to confirm and revise the findings from policy assessment in Bali. In the second meeting, we invited only local agencies as the project focus more on the local policy assessment. Fifteen representatives participated in the meeting and the many were the same representatives as the last meeting.

The stakeholder process was designed based on multiple documents including CARE's Climate Vulnerability and Capacity Analysis Handbook and SEI's stakeholder guideline (CARE International, 2009; Stockholm Environment Institute, 2007). It was important to identify planned adaptation policies to make this vulnerability assessment useful and support science-based policy-making. One of the key processes in the meeting was to create "Climate Change Sensitivity Matrix for Food Security." The objectives of the process were to synthesize existing knowledge on climate vulnerability, to provide preliminary vulnerability estimation, and to identify existing and planned strategies/policies to deal with vulnerability. The project team asked participants to list the livelihoods of issues selected and then work backward to list the productive activities of these livelihoods and the ecosystem services that support those elements, i.e., exposure units (Parry, Carter, & Hulme, 1996). Then, the participants listed the present climatic threats (or opportunities) and trends that are significant for the list of livelihoods (or exposure units) to make them the columns of the matrix. The participants filled in the matrix by ranking each cell to show how thresholds of vulnerabilities differ between exposure units and decided the three most sensitive exposure units:

- 3 = significant impact on the exposure unit
- 2 = medium impact on the exposure unit
- 1 = low impact on the exposure unit
- 0 = no impact on the exposure unit

Policy assessments

Based on the findings from the stakeholder meetings, we assessed regional policy related to food security and climate change by creating two matrixes (Harvey et al., 2009). However, the matrix is organized with livelihood instead of hazard as it was more relevant with this case and consistent with the matrix created during the first stakeholder meeting. Therefore, the columns were labeled “Livelihood,” “Region,” “Hazards,” “Activities” (targets), and “Resources” (ecosystem service). Then, existing policies are assessed with the list of potential issues involving three criteria: 1) the level of risk (magnitude), 2) the imperative for a local authority role, and 3) the potential for aggregation with other issues.

IPCC AR4 (Parry, 2007p.785) set the level of defined risk by scale (the area or number of people affected) and intensity (the degree of damage caused). The potential local authority role was based on how well the issue fulfils the justifications identified above. Potential for aggregation with other issues was useful in determining indicators of different hazards that could be used to help measure the effect of climate change, for example on welfare, ecosystem services, and various types of capital. This could be through aggregating issues within one region (multi-sector, multi-hazard) or for one issue across the site. The original methodology from Harvey, et al. (2009) uses the matrix to assess the policy quantitatively. We still use the quantitative aspect of the policy assessment, but we mainly use the matrix to organize the list of policies to help qualitative assessments.

Interviews with farmer groups

In October 2011, we conducted interviews with subak members including each subak head or someone who has similar authority such as a former subak head. Subak is a community-based organization coordinating water use amongst farmers obtaining water from the same stream and the farmers in the same subak also coordinate and synchronize their farming practice (Geertz, 1980; Lansing, 1987). We visited seven subaks including one farmer group in Indramayu, West Java, to reflect the situation outside of Bali (Figure 3). The purposes of those interviews are to seek and understand potential variables for vulnerability assessment of food security in climate change. Particularly we focused the types of land use, land change, and the factors that define the types mainly in Bali. For example, if a paddy land is converted to a cacao plantation, overall rice production in Bali will be reduced by an amount of rice the converted cacao land would have produced. Interviews were carried out either at their subak offices or the house of a subak head. The seven subaks were selected based on the recommendation from subak experts or government officers including the agricultural ministry and BMKG.

Results

Step 1. Identify range of issues

Literature review identified and roughly selected the range of important issues related to vulnerability assessments in Bali and Indonesia. In the 12 policy reports, five sectors were referenced repeatedly such as agriculture, water resources, coastal zone, forestry, and human health, which are considered as the most common areas of vulnerability and adaptation assessments. Our assessment in the five sectors throughout policy reports identified sets of adaptation measures and vulnerability assessment needs. The numbers of sets identified are:

- Agriculture sector has 23 sets,
- Water resources sector has 20 sets,
- Coastal zone sector has 15 sets,
- Forestry sector had 12 sets, and
- Human health sector 11 sets.

The agriculture sector needs more adaptation supports to cope with climate change impact. Identified potential adaptation supports are, for example, “the necessity in a drought early warning system” in National Action Plan 2007 (Ministry of Public work (PU), 2007) and “requirement in the impact study of climate change to the cultured fisheries” in Indonesia Climate Change Sectoral Roadmap (ICCSR) (Ministry of Development (Bappenas), 2010a). Moreover, President Yudhoyono stated, “... the government could focus and prioritize its resources to address the key issues of food insecurity ...” in Kemtan's food security report (WFP & Ministry of Agriculture (Kemtan), 2009).

Food security is stated as one of eleven national priorities aimed at addressing the challenges faced by the nation in the upcoming period (Ministry of Development (Bappenas), 2010b pp. I-49-57): “Priority 5: Food Security - This priority pertains to efforts to increase food security and to continue the revitalization of the agricultural sector for realizing self-reliance in food, increasing the competitiveness of agricultural products, increasing the income level of farmers, and conserving the environment and natural resources. Increasing the growth rate of the agricultural sector in the GDP to 3.7% and increasing the Farmers Terms of Trade to 115-120 by 2014.”

As well as a development priority, food security has a status to be the most vulnerable sector to climate change, since agriculture is sensitive toward the climate condition in the related areas in Indonesia (Indonesia, 1999 p. 2-13). Major decreases in rainfall in dry seasons will impact on food crops' production. The current cropping pattern might not be feasible in the future. At present, the cropping pattern used in most of the rice growing areas of Indonesia is a rice-rice two-crop system. The second planting depends heavily on irrigation water. Under extreme drought years, the availability of irrigation water is becoming very limited and this normally will cause huge rice production loss. Under a changing climate, drought may be more frequent and the dry season may last for longer periods. Indonesian farmers may face more crop failures if they use the rice-rice two-crop system.

Similarly, a rise in the temperature and increased length of seasons may also cause crop pests and diseases. For example, Brown Plant Hopper population boosts when rainfall in the

transitional season increases (Huang, Cheng, & Wu, 2010; Wicaksono & Nakagoshi, 2009). The changes in cropping patterns may also alter crop pests and disease problems in the regions. New pests and diseases may intrude due to changing climate.

ICCSR summarized five climate change vulnerability issues in the agriculture sector as follows (Ministry of Development (Bappenas), 2010a p. 27):

- Agriculture sector is the main producer of food, supplier of agro-industry, and bioenergy;
- Sea level rise would decrease agriculture land in the coastal zone;
- Increase of atmospheric temperature would decrease crop productivity, damage agriculture land resources, and infrastructure;
- Limited land resources because of degrading land quality declining production and potential;
- Change in rainfall pattern, causing a shift in planting period, season and planting pattern, land degradation, and decrease in water availability.

Step 2. Select issues of concern

The local stakeholder meeting provided opportunities to confirm the issues studied in the literature. All participants noted, in particular, considerable concern about and increasing research needs on food security in climate change. The vulnerability assessment from the sub-project will be aiming at improving our basic understanding of vulnerabilities as well as key elements related to the climate system, impacts, and response measures in the food security of Bali province. In the meeting, the project team developed “Climate Change Sensitivity Matrix for Food Security” (Figure 10). The participants agreed on the two elements: 1) focus on farming land, fisheries, water quality and quantity to find the first sector of a formal vulnerability assessment, and 2) From the perception of policy makers, drought, flood, and torrential rain are more dominant hazards in Bali for the three potential sectors. The following meeting with representatives from national ministries confirms the focus areas. Through scientific activities, the participants recognised the valuable roles of vulnerability assessment to improve the policy-making process integrating the adaptation to climate change in Indonesia. It was agreed that the joint involvement of national policy makers should be encouraged in areas of common interest.

	Drought	Heavy rain	Floods
Farming land	0	1	2
Fishery	0	1	2
Water	0	1	2

Figure 10 Climate Change Sensitivity Matrix for Food Security Please change label above to “Farming land.”

To determine the first case of a vulnerability assessment, policies related to food security and climate change were further assessed with two matrixes. The first matrix summarizes the focus areas identified during the first stakeholder meeting (Figure 10). The assessment started by identifying key issues in climate change vulnerability with food and water security. Besides information gathered during stakeholder meetings, policy reports from Bali development agencies were used for the assessment, namely Mid-Term Development Plan, Bali Green Province, and Bali Action Plan Facing Climate Change (Development Agency (BAPPADA) Bali, 2007; Development Agency (BAPPADA) Bali, 2009; Development Agency (BAPPADA) Bali, 2010). The information from stakeholder meetings gave initial information about exposure and potential adaptive capacity in Bali. The policy reports were used to confirm the findings in Table 1. The first and third columns represent vulnerable livelihoods and the impact or type of hazard.

Livelihoods potentially affected by climate change are spread fairly across the island except salt farmers, traders, and foresters. The numbers in the hazard column are the potential impacts mentioned by the two groups of the stakeholder participants, i.e., “0 = no impact” and “3 = significant impact”. Drought and floods affected seven out of nine livelihood groups; therefore this confirms the significance of the hazard in the island. Fisheries are affected by ocean-related hazards namely a rise in sea level and change in sea surface temperature.

The second matrix summarizes the existing policy matters in Bali. It is important to assess the quality and context of policies related to each livelihood, but the matrix shows that paddy agriculture has many potential risks, important roles local authorities need to play, and aggregated potential to other sectors. For example, paddy farming is strongly linked with the tourism sector and issues with land conversion. Also, the implementation of organic farming will support a better local ecosystem. There are a number of policies discussed and implemented in the ocean fishery sector, but aggregation with other issues and sectors seems limited.

Table 1 Matrix of climate change vulnerability with food and water security

1	Paddy farmers	Tabanan, Gianyar, Buleleng, Badung, Karangasem, Jembrana, Klungkung, Bangli, Denpasar	Drought (3, 3), Floods (3, 3), Dry spell (1, x), Wet spell (2, 2), Strong wind (x, 1)	Paddy fields, Livestock,	Water resources (quality & quantity), land resources, irrigation system
2	Fisherman (Sea)	Kawasan Pesisir Selatan Bali & Kawasan Pesisir Utara Bali	SLR(3), SST(3), Wet spell (1, 1), Strong wind (x, 3), High tide (3)	Fish, Aquaculture	Sea, Mangrove, Coastal land use
3	Fisherman (Freshwater)	Jembrana, Gianyar, Buleleng, Karangasem, Badung, Tabanan, Klungkung, Denpasar, Bangli	SLR(3), Heavy rain (x, 1), Wet spell (1, 1), Strong wind (x, 3),	Fish, Aquaculture	Water resources (quality & quantity), land resources, irrigation system, Lake, River,
4	Stockman (cattleman)	Karangasem, Buleleng, Bangli, Tabanan, Badung, Gianyar, Klungkung, Jembrana, Denpasar	Drought (2), Wet spell (2), Flood(1)	Livestock, livestock production	Water resources (quality & quantity), land resources,
5	Salt farmer	Kusamba (Klungkung), Tejakula (Buleleng)	Dry spell (1), Wet Spell (3, 1), Flood(3), SLR (2), SST (1), Strong wind (x, 3), High tide (3) Heavy rain (1)	Salt Production	land resources, Sea
6	Businessman (trader)	Denpasar, Badung, Gianyar (Handicraft), Tabanan	Drought (2), Dry spell (1), Wet spell (2), Flood(3), Landslide (1), SLR(1)	Transportation, Sales	Street network (access)
7	Crop farmers	Buleleng, Karangasem, Tabanan, Jembrana, Klungkung, Bangli, Badung, Denpasar, Gianyar	Drought (3), Wet spell (3, 3), Floods(1), Landslide (1, 3), Strong wind (x, 1), Flash flood (x, 3), Heavy rain (3)	Plantation, Livestock, Vegetable& Fruits	Water resources (quality & quantity), land resources,
8	Foresters	Buleleng, Jembrana, Karangasem, Tabanan, Bangli, Badung, Klungkung	Drought (3), Wet spell (3), Floods(1), Landslide (1, 1), Strong wind (x, 1), Forest fire (1)	Forestry	Water resources (quality & quantity)
9	Tourism company	Badung, Denpasar, Gianyar Buleleng, Bangli, Karangasem, Klungkung, Tabanan, Jembrana	Floods (2), Heavy rain (3),	Tour guide, Restaurant, Other food and beverage, Hostelling, Conferences,	Sea, Land use, irrigation system, River, Coastal areas,

Table 2 First screening matrix of climate change vulnerability with food and water security

1	Paddy farmers	- Land use decrease for paddy field. - Climate change may affect to water availability. - Farmer population including changing job to the tourism sector - Soil fertility decreases with inorganic fertilizer which leading to the reduction of productivity. - Volatility of International price - Pressure from domestic distributors (not too influential)	- Establish policies such as tax breaks, subsidized fertilizers, credit facilities, moreover, is in green belt area or a tourist area. - Development of post-harvest handling to provide added value of agricultural production - Quality and quantity improvement of water structure and infrastructure (Bali action plan, p.42) - Integrated watershed management (Bali action plan, p.25) - Drafting of local legislation on watershed management (Bali action plan, p.25)	- Develop strong agriculture in broad meaning towards independence, prosperous and fairness - Synergize the development of agriculture with the tourism sector - Aligning the concept of the program with related institutions at National to village levels - Improving farmers' access to capital in technology, marketing and other supporting facilities - Agricultural research on degraded areas (Bali action plan, p.38) - Development of organic farming (Bali green province, p.10) - Development of integrated farming system (Bali green province p.10) - Controlling land conversion (Bali green province, p.11) - Strengthening of farmer's
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					institutional through the establishment of 'gapoktan'/farmer's group (Bali action plan, p.28) (Bali action plan, p.38)
2	Fisher man (Sea)	1. Sea current change and SST may reduce/increase production 2. Water pollution and waste water management 3. Reduction of fisher population 4. Coastal construction destroy coral reef which reduce production. 5. SLR and high tide affects aquaculture 6. Volatility of domestic price	1. Develop main, leading and pioneer commodities as well as increasing fishery productivity and production 2. Improving the management of fish resources and aquatic ecosystem, coastal and inland including mangrove forest and coral reef (Bali green province, p.11) 3. Program of awareness and law enforcement in the marine resources utilization 4. Program of empowerment group of fisherman, and cultivation fish farmers 5. Flood control and coastal security 6. Educational and law enforcement on coastal-border (Bali action plan, p.40) 7. Installation of coastal border marked with stakes/poles (Bali action plan, p.41)	1. Conservation and protection of natural resources 2. Control of pollution and destruction of environment	
3	Fisher man (Fresh water)	1. Water temperature change production, e.g. changing reproduction 2. Water pollution and waste water management 3. Flood disasters 4. Drought disasters 5. Land use change 6. Diseases 7. Wind/up welling	1. Cultivation fishery development program (Production/productivity of cultivation fishery increased) 2. 'Aku Gemar Ikan' /I like fish Program (Instruction of Bali Governor-Fishery agency) 3. [Same as seawater fishery]	1. Conservation of lakes and springs (Bali green province, p.11) 2. Conservation/rehabilitation of watershed (Bali green province, p.11) 3. Spread information about the market of fishery products of Bali Province both regional and international	
4	Stock man (cattle man)	1. Diseases 2. Most livelihoods are decreasing except chickens and pigs 3. Reducing the population together with famer population 4. Industrialization will reduce the needs for Buffalo, which reduce the incomes of stockman 5. Volatility of domestic price 6. Availability of HMT/hijauan makanan ternak (livestock feed)	1. Prevention and control program of livestock diseases 2. Improvement program of livestock production & market	1. Processing and utilization of agricultural waste as cattle feed, energy and household industries (Bali action plan, p.28) 2. Development of processing technology of cattle waste as biogas, organic fertilizer and bio-urine (Bali action plan, p.28)	
5	Salt farmer	1. Too much rain will reduce the productivity dependent on the sun 2. Water pollution and waste water managements 3. Land conversion 4. Local salt has low on iodine level	1. Management and rehabilitation of coastal and marine ecosystem 2. Program of awareness and law enforcement in the marine resources utilization 3. Flood control and coastal security	1. Integrated management of coastal and marine (Bali green province, p.11) 2. Sea and coastal clean action (Bali action plan, p.30) 3. Education and law enforcement of coastal-border (Bali action plan, p.40)	

6	Busin essma n (trade r)	1.	Traffic jam affected by weather	1.	Develop infrastructure, transportation, information and adequate communication, especially for the area of North, West and East of Bali.	1.	Development of environmentally friendly technology (Bali green province, p.11)
		2.	Sea transportation affected by climate condition	2.	Strengthening the development of cooperative and other populist economic institution	2.	Structuring and controlling pollution by industry (Bali green province, p.12)
				3.	Develop marketing partnership between small and medium industries	3.	Development of corporate social responsibility (Bali green province, p.12)
				4.	Development of environmentally friendly certification (ISO 14000) (Bali green province, p.12) and market (green market) (Bali green province, p.12)		
7	Crop farme rs	1.	Climate change may affect to water availability	1.	Cropping pattern development (Bali action plan, p.27)	1.	Technical development of water and land conservation (Bali action plan, p.27)
		2.	Farmer population may be changing	2.	Processing and utilization of agricultural waste as compost and fertilizer (Bali action plan,p.27)	2.	Subsidized fertilizers for agricultural sector (Bali Governor Regulation No. 3, 2010)
		3.	Soil fertility decreases with inorganic fertilizer which leading to the reduction of productivity.			3.	Efficiency of water use with 'macak-macak' system (Agriculture agency)
		4.	Determination of high taxes			4.	Policy on Subak- (Agriculture and culture agencies)
		5.	Insects/pest and diseases				
8	Forest ers	1.	Flood	1.	Protection and conservation forest resources	1.	To rehabilitate a critical area in its various aspects, development the welfare forest, city forest and green open area, reforestation (Bali green province, p.11)
		2.	Droughts	2.	Rehabilitation forest and land (Bali action plan, p.23)		
		3.	Illegal logging	3.	Development and control forest product industry		
		4.	Change in land use for the other cropping farming.	4.	Forest fire risk zone mapping (Bali action plan, p.23)		
		5.	Encroachment	5.	Emergency response system (Bali action plan, p.23)		
		6.	Forest fire	6.	Establishment village/community forest (Forestry agency)		
				7.	Local regulation/local sanction for local forest (Forestry agencies)		
9	Touris m compa ny	1.	Political issues	1.	Develop "populist tourism" that can provide a double effect (multiplier effect) for most of the local Balinese community.	1.	Research on global warming impacts on industry (tourism and craft industry) (Bali action plan, p.43)
		2.	Natural disaster	2.	Improvement infrastructure supporting tourism.	2.	Development of corporate social responsibility (Bali green province, p.12)
		3.	Security issues	3.	Providing opportunities to local communities through cooperatives to manage hotel business or purchase stock.		
		4.	World economy	4.	Research and development on tourism accommodation construction to adapt with global warming (Bali action plan,p.43)		
		5.	Domestic economy	5.	Eco-tourism (Tourism agency program)		
		6.	Generally bad weather	6.	Culture-tourism (Tourism agency)		
		7.	Traffic condition				
		8.	Waste problem				

With more detailed qualitative assessment with policy reports and interaction with local authorities, the importance of paddy was highlighted. For example, Mid-term Development Plan stated the general importance of agriculture in food security:

“Enhancing the role of agriculture sector in Bali economy, especially in food security and farmers' welfare increased by optimizing Bali's natural and human resources management, institutional strengthening, improving farmers' access to capital in technology, marketing and other supporting facilities”

With further discussion with local authorities, the project team decided to work from paddy food security while we keep options to assess other agriculture and water sectors later in the viewpoint of food security.

Steps 3 & 4. Define purpose of indicator and a workable system

Stakeholder meetings were also used to identify purpose and system as well as potential risk, and contexts. The project team also had smaller meetings with local stakeholders to define the purpose and system work. By the time we had the second stakeholder meeting it became clear that the vulnerability assessment in this project is to support local authorities because of their willingness to participate in the assessment and the general nature of an ODA project.

The project agreed to work for the vulnerability assessment related in food security especially in paddy as the first case. Therefore, the purpose of a vulnerability assessment became to support the operation of policy makers/local authorities namely, BMKG, BAPPEDA, and the Agricultural Agency in Bali. The project team and policy-making agencies explored a list of policies as a system the team works for. Then, we decided to use Presidential Decree No. 5 “Protection of National Rice Production in Facing Extreme Climate Condition” as our system (Government of Indonesia, 2011). Decree No. 5 is the risk analysis of extreme climate impact on production and distribution of rice and disseminating the information to farmers. Decree No. 5 was issued in 2011 and each province was requested to report its assessment periodically to the national government. The team and policy agencies chose the decree because of relevancy to the purpose, urgency for the response, and strong needs from the agencies. Particularly, the needs from the agencies were important to make the assessment useful for the reality. The project team held a meeting with the Governor of Bali and Bali Agriculture Agency in September 2011, as well as with the Provincial Agriculture Agency of Bali. The governor expressed his support and expectation that the project would be beneficial to society in Bali. He also suggested disseminating the project activity and result to both the provincial and regency governments.

Furthermore, during meetings, the Bali authority mentioned that they cared about the coordination of community food security in three aspects namely availability, distribution, and consumption in all regencies. Communities with malnutrition status are one of the greatest concerns in food security by the Bali authority. The non-production food security might become significant in the future due to greater consumption from rapidly increasing population and economic growth. These growths are expected in other parts of Indonesia although causes and scale are different. With the consideration of climate change, the impacts are likely to be multiplied. A system we work for is Presidential Decree No.5, which considers paddy production only. But as Bali authorities care generally about food security issues in Bali, we therefore consider the issue of food consumption and distribution while keeping our focus on the production of paddy.

Step 5. Define harm in context

We used quantitative assessments to define potential harms in the context of food security especially with paddy production, in addition to the qualitative assessment by stakeholder meeting and policy assessments. Several potential harms were already mentioned above and in this section this paper demonstrates the identification process of the largest potential climate and non-climate harms, namely drought and land use.

A spatial analysis shows rain pattern changes of 46% and 54% in Bali areas in wet and dry seasons between the 1970s and 2000s (Prasetya & Novianti, 2011). As a result of this, our assessment showed that soil climate suitability for paddy production might be reduced by 20% between the 1990s and 2000s (Figure 11). The research outcomes reconfirmed the possibility of climate change in Bali as well as the strong possibility of paddy insecurity with climate change. The reduction of suitability is mainly due to the decline of precipitation. North and north east of Bali has been getting drier based on BMKG's analysis. Therefore, drought is potentially the number one concern within the weather-related disasters for paddy production.

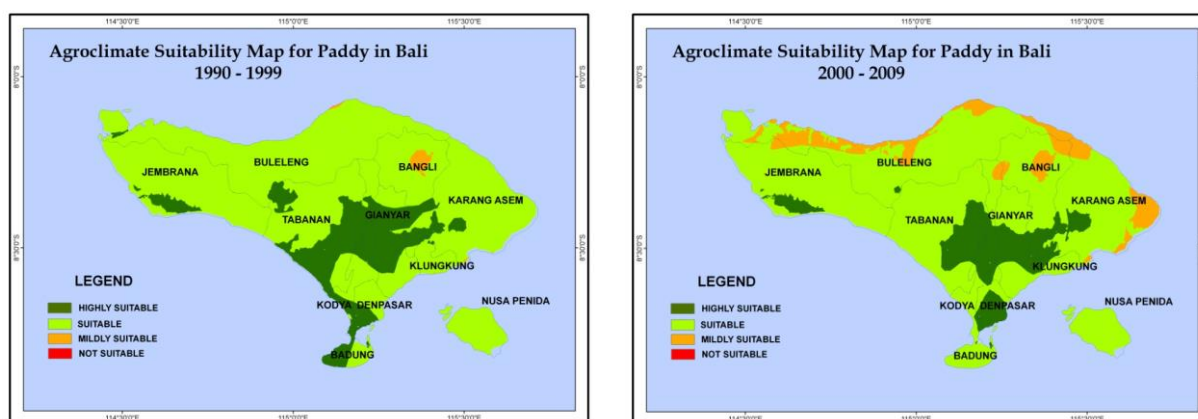


Figure 11 Reduction of crop suitability (Prasetya & Novianti, 2011)

Statistical assessments show another potential harm related with land use. Generally, the land use for agriculture shrinks from 2000 to 2008 although it is fluctuated around 2006 (Table 3). This means that land conversion from agricultural to non-agricultural occurred in 2000-2008. Land use change needs some preparation, so the fluctuation is likely to be due to measurement or reporting errors, but further investigation is needed to confirm this assumption. Particularly as Denpasar and Badung are tourism areas, land conversion from agricultural use to non-agricultural is because of economic reasons. The sale of agricultural land to entrepreneurs from outside Bali has increased (Development Agency (BAPPADA) Bali, 2007).

Table 3 Area of land by type of use in Bali 2000-2008

2000	85,776	267,794	210,097
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2001	84,860	268,258	210,551
2002	83,562	268,948	211,155
2003	82,644	269,473	211,549
2004	82,089	269,411	212,134
2005	81,207	273,332	209,127
2006	80,997	273,386	209,283
2007	81,235	271,704	210,727
2008	81,482	274,755	207,429

Most agriculture land is used for non-paddy agriculture including maize, soybeans, mungbeans, timber, estate crops, and grassland. Agricultural land use for paddy is shrinking except in Bangli Regency and land use for non-paddy agriculture is increasing slightly in most regencies except Bangli, Denpasar and Tabanan Regencies (Table 3) and this leads to the reduction of harvested areas, which is the multiplication of land area for paddy and the number of production cycles per paddy (Table 4), e.g., if a paddy area produces paddy twice a year, the harvested area is double the paddy area.

In general the production of paddy is decreased from year 2000 to 2005 and then increased slightly in 2006-2008. Decline in paddy's production is in line with the shrinking of harvested areas for paddy. In contrast, the production rate has been increased; therefore, it negates the reduction of total yield level. From year 2000 to 2008, the harvested area has been reduced 7.1%, productivity rate increased 9.5%, and production size increased 1.6%. The paddy production may not be able to rise or may even shrink in the future if paddy areas are further reduced or production rate and production cycle are reduced by climate change. Therefore, inappropriate land use may harm the production of paddy.

Table 4 Total harvested area, production rate and production of paddy in Bali, 2000-2008

2000	155,049.00	53.33	826,838.00
2001	147,942.00	53.35	789,232.00
2002	148,025.00	54.70	809,688.00
2003	145,294.00	54.60	793,260.00
2004	142,663.00	55.00	788,361.00
2005	141,577.00	55.00	785,481.00

2006	150,557.00	56.00	840,891.00
2007	145,030.00	58.00	839,775.00
2008	143,999.00	58.37	840,465.00

This paper does not present other potential harm in other agricultural products and other types of food security such as consumption. However, in summary, the most produced crop in Bali is cassava followed by maize and sweet potato, which are the same as those of the national average (WFP & Ministry of Agriculture (Kemtan), 2009). Crops that have increased in production include cassava, sweet potato, and peanuts, while production of crops such as maize, mungbeans and soybeans has decreased. The production of some fruits namely banana, orange, salacia/salak, and mango tend to increase.

In terms of food consumption, the greatest expenditure for food in both rural and urban is for cereals and prepared food and beverage. Generally, monthly average expenditure per capita for food is increasing during the period 2006-2008. The population of Bali has been increasing rapidly with a total population of 2,998,770 and 3,522,375 in 2000 and 2010, respectively, which means the population increased by 17.5% in a decade.

Step 6. Identify and select variables

Potential variables to conduct vulnerability assessments for paddy food security under climate change had been mentioned in the stakeholder meetings and estimated through policy and statistical assessments. This section shows the selection of variables especially in relation with land use change through interviews with paddy farmers (Figure 3). The interviews were carried out to investigate how paddy production is affected by climate-related disasters considering other related issues namely changing to crop agriculture and land conversion. Also, the interview looks at the farmers' behavior for the weather-related disasters and rationale to change farming practice.

First, the interview found four classifications of land use/farming practice. A “rice intensive” subak is the subak that has sufficient water and its annual cropping cycle is paddy – crop – paddy or paddy – bera (empty) – paddy. About 10 years ago, farmers in Subak Penarungan practiced paddy – paddy – paddy cycle sometimes if a situation allowed (e.g., enough water) and necessary (e.g., need extra income), but they do not practice the three paddy cycle anymore. Currently, Subak Penarungan and Subak Sengkawan are under this category.

A “rice and crop balanced” subak is located relatively in dry areas or near a downstream of a main channel. The cropping cycle we have observed under this category is paddy – crop – bera (empty) in Subak Pangkung Jajung and the Indramayu farmer group and paddy – crop/crop – paddy, which rotates the cycle between two separated land areas in Subak Uma Kaleran. Water availability at paddy – crop/crop – paddy subak is insufficient to satisfy all areas of subak at the same time so that a subak area is divided into two areas. Subak Uma Kaleran started this swapping practice after the region built a dam in upper stream that diverted the water flow into the subak.

The “plantation” subak plants cash crops such as coconuts, cacao, and other fruits and vegetables, but not rice. Those subaks pay particular attention to the prices of cash crops as well

as the water level. Some subak members in Subak Belaluan and all members of Subak Mertasari changed to other crops including cacao and cloves.

The project team found that the factors which affect the decision-making on long-term cropping cycle and land use are water level, the relative price of rice and alternative crops, climate especially rain, insect problem, and governmental policies (e.g., extension agents, tax, subsidies), and subak roles (e.g., allowance to change crop cycle), work amount, and opportunities for the second or alternative jobs, and lack of successors.

In general, people consider the sufficiency of water as one of the key factors that define farmers' behavior. Several interviewees changed their land function from paddy agriculture to other agriculture because of water insufficiency. In a few subaks, a water problem has resulted since the water was used not just for farming but also for settlement. In Subak Belaluan and Subak Pangkung Jajung, interviewees said that the shortage of water was judged just from their harvest failure experience. In addition, members of Subak Belaluan mentioned that people might anticipate the water problem to carry out rice farming if the lack of water continues for 3 months.

Relating to water sufficiency in a subak, climate – especially rain – affects the farmers' decision on land use and crop patterns although the path of influence could be different amongst subaks. Subak Pangkung Jajung is partially rain-fed, so small precipitation affects negatively the paddy production directly where water in the subak irrigation is insufficient. Farmers in all subaks and farmer groups mentioned that too much rain would increase pests such as brown hopper, so too much rain also affects the harvest negatively. For the latter case, as a pest control, farmers do not practice paddy – paddy – paddy cycle except some farmers in Indramayu, where there is no strong coordination amongst farmers. Moreover, farmers seem not to reduce the number of paddy cycles because of rain or pests except 3 to 2, for example, farmers are not willing to change their crop cycle from paddy – crop – paddy to paddy – crop – crop as a pest control.

The relative prices of rice and alternative crops are other key factors mentioned by multiple subaks. The value of cocoa and clove could reach 5-10 times higher and the vegetables around two times higher than paddy in Subak Mertasari and Subak Belaluan. In this instance, farmers got well off by changing from paddy to plantation farming even though a government gives subsidy only to paddy. Having said that, a rice price is more stable and that stability might also contribute to the decision-making of farmers. For example, the members of Subak Penarungan said that market price of rice is generally stable; governments will buy rice at a higher price if the market price dropped significantly; and the government compensates farmers when a crop failure happens. Subak Penarungan has not experienced any harvest failure for more than 20 years and their production has been increasing. In addition, the price is stabilized at a high price; therefore, they prefer to stay with paddy agriculture.

Moreover, a price for land for housing has a similar effect as the price of alternative crops in Subak Pangkung Jajung. Twenty percent of the subak has already converted to housing because farmers need cash to send their children to school. Normally, a farmer in the subak gets six tons of paddy per hector, which is worth Rp.24,000,000. The farmer can sell one hector of their paddy

land at between Rp 500,000,000 and Rp1,000,000,000. They normally make paddy only once a year, so roughly, they will get 20 to 40 years worth of their income if they sell their land. As they mentioned, the reason they sale the land is not only the high price of their land, but also lack of enough water for paddy, alternative jobs, and successors.

The lack of alternative jobs and work required for paddy effected the changes in land use. Farmers in Subak Pangkung Jajung need cash, but they cannot access alternative jobs as their location is far from Denpasar where most job opportunities are, so they sell land. Farmers interviewed in Subak Belaluan have a second job and it is easier to plant cocoa instead of paddy as cocoa requires less work. The situation is similar to the land conversion in Subak Mertasari. As well as the high price of cocoa, light labor to grow cocoa appealed to farmers in the subak as its paddy field is located on a steep hill, which makes paddy agriculture severe hard labor.

We also asked about government policies, for example an extension program. It seems that the policies support paddy agriculture, but do not support other crop agricultures. Extension officers provide counseling about the prevention of pest and diseases as well as techniques to grow paddy. Farmers thought that those programs were beneficial in all subaks. However, extension officers tend to recommend only planting paddy in spite of whether a subak's condition, such as the lack of water, is unsuitable for their land. Their government provides subsidies and fertilizer to rice farmers. Moreover, current policies recommend staying with paddy, but not restricting farmers moving from paddy agriculture to other agriculture if a subak situation is not suitable for paddy. Farmers in Subak Penarungan mentioned that if the land tax for agricultural land increased dramatically, the tax policy may discourage farmers from continuing their farming.

Last, subak rules may prevent the land use change in some subaks. Selling subak lands to outsiders is restricted in Subak Sengkawan and Subak Uma Kaleran. Other subaks visited do not restrict changes, for example, from paddy to cocoa plantation or paddy to housing. Moreover, subak members have to follow the group decision on paddy or crop as long as they practice paddy agriculture.

The land use might change from farming to another purpose such as housing and tourism. A "land converting" subak is limited to a small fraction of all subaks we visited except Subak Pangkung Jajung. Statistical data from BPS support this trend. For example, the members of a village or community/group have to own all land of their subak and are not permitted to sell land to outsiders in Subak Sengkawan and Subak Uma Kaleran. Although most young people are working on other sectors in other cities, they and their parents do not sell the land because they want to return to their village as farmers after retiring in Subak Penarungan. On the other hand, the head of Subak Pangkung Jajung told us that 20% of rice fields in his subak were sold for housing. The land sold was not restricted to local people but was also sold to people from outside, who would pay a higher price. An estimated selling price is worth their income for several decades should the farmers continue to farm.

There are three main conclusions from the results of interviews and they are summarized in Figure 12. First, "Rice intensive" and "rice and crop balanced" subaks seem more common, but statistical data from BPS shows that the "plantation" subak is becoming popular and the "land

converting” subak is still very small compared with other types. Second, the relative price of rice, alternative crops, and land water levels, and alternative/second job opportunity seem to influence most the types of subaks in the past and today. Climate, insect problem, policies (extension of Agriculture, tax, subsidies), and subak roles showed signs of influence in the farmers’ decisions too. The factors of the latter group may become important if values of these factors changed dramatically, for example, high land tax for agriculture. Moreover, as mentioned above, some factors in the latter group are related to the former group. For example, climate is related to the level of water availability in a subak. As observed in previous studies (Quinn, Ziervogel, Taylor, Takama, & Thomalla, 2011; e.g. Takama, Ziervogel, Taylor, & Thomalla, 2010), farmers perceive the risk of continuing “rice intensive” subaks with water availability in irrigation, but not in rain. Third, the decision-making factors seem to influence the long-term decision on a subak type and the decision is made with multiple factors, but not only one dominant factor. For example, even if farmers have enough water to plant rice seedlings three times a year, they do not do that because these will outbreak the pest numbers in the rice subak. Also, if farmers in Subak Pangkung Jajung have opportunities to gain some cash to send their children to school, they might not need to sell their land. Therefore, it is necessary to consider these variables to understand the land use change in a subak as a part of paddy food security under climate change in Bali.

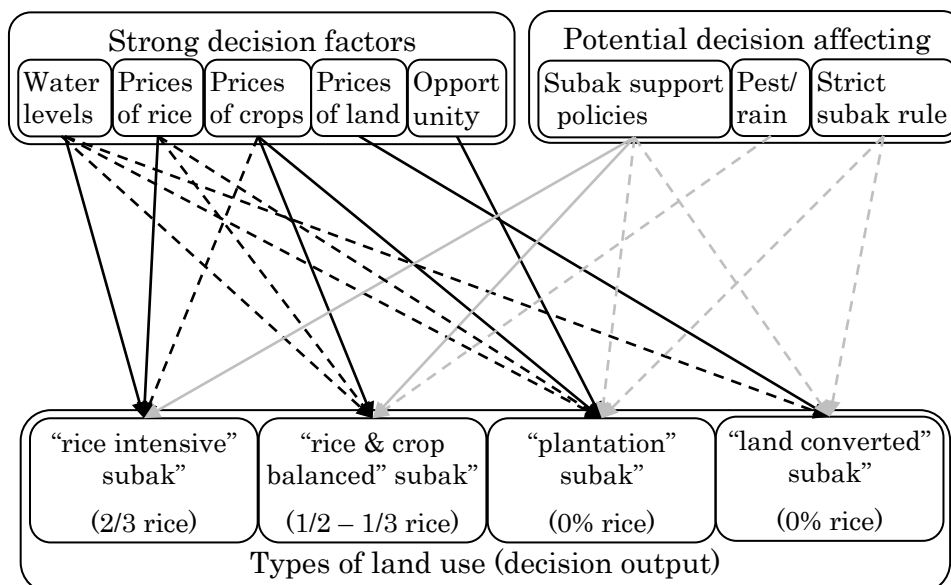


Figure 12 Conceptual choice model for land use change. Black solid and dashed lines indicate positive and opposite relationships between decision-making factors and types of land use as outcomes. Similarly, gray solid and dashed lines indicate potential positive and opposite relationships.

Identified issues, purpose, system, context, and variables

Through the series of assessments, we identified issues, purpose, system, context, and variables for the vulnerability assessment of climate change in Bali, which are applicable to other parts of Indonesia. The outcome is summarized in Figure 13. Reviews on previous climate change vulnerability related projects confirmed that Indonesia is one of the most vulnerable countries. The assessment showed that agriculture is one of the most vulnerable areas and food security is an important issue in Indonesia. Within the food security issue, the first stakeholder meeting

focused on paddy, fishery, and water sectors. Following assessments with policies and statistical data revealed that paddy agriculture was the most appropriate sector in Bali and it would be most effective to work with paddy first as it would have more aggregation potential with other sectors including crop agriculture and water sectors. The decision to start the assessment with paddy agriculture was confirmed in the second stakeholder meeting and agreed upon with the governor of Bali province. At the same time, our policy assessment and discussion with stakeholders confirmed use of presidential decree No. 5 as our framework system. Statistical assessment proved drought, land use change, and potential flooding as potential harms in this context. Interviews with farmers establish potential variables especially within the issue of land use change. For example, the variables that might influence decisions of farmers include water level, rain, prices of rice and alternative crops, and land price, policies, and subak rules.

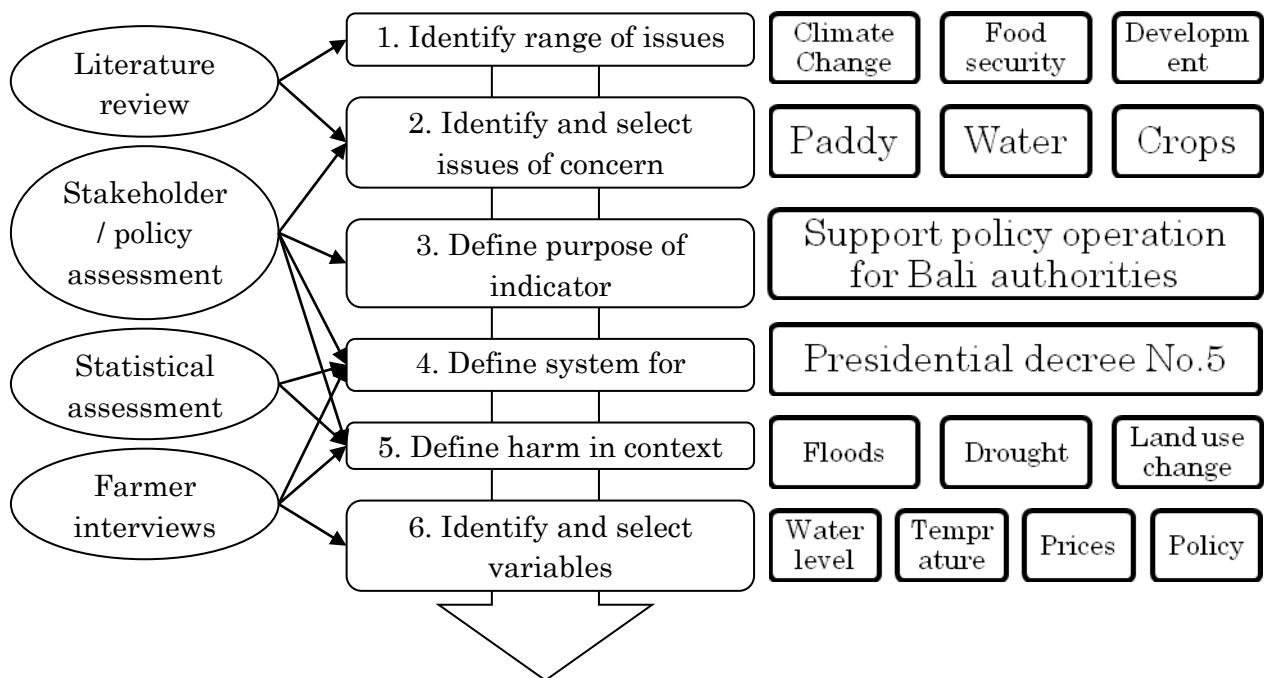


Figure 13 Identified issues, purpose, system, context, and variables for the vulnerability assessment of climate change in Bali/Indonesia

Discussion

Sequential vs. multiple approaches

The identification process is the process of narrowing pertinent areas. As a result, we had to give up several issues. For example, we mentioned fishery and water sectors as potential areas of interest in Step 2. However, these sectors are, at this moment, not considered as the project team decided to focus on the paddy sector. Similarly, food security generally considers three pillars namely production, distribution, and consumption (WFP & Ministry of Agriculture

(Kemtan), 2009). However, we focused more on the productivity issue of food security. In any research or development project, it is important to prioritize and focus a smaller number of issues as our activities are limited by time, finance, and human resources.

On the other hand, some scholars discuss the importance of the multiple sector approach, which considers the several sectors simultaneously; otherwise, resources for adaptation can be misused or lead to maladaptation (Quinn et al., 2011; Ziervogel, Taylor, Thomalla, Takama, & Quinn, 2006). For example, if the public work agency and the agricultural agency do not coordinate the development of their irrigation system, one agency may build an irrigation system, where another agency might consider it not necessary to adapt to potential droughts in the future. The project team recognized these overlapping and maladaptation issues; therefore, the team assessed the issue in terms of “aggregation aspect” in Step 2 and summarized in Table 2. The team found that working in the paddy sector would also help other sectors namely crops and water sectors, so we decided to focus on the paddy first before carrying assessments on other sectors. In other words, the project will come back to crop and water sectors after assessing paddy and we can revise if there are any conflicts and overlaps with paddy assessment at that time.

Moreover, although a multi-sector assessment is good to understand comprehensive vulnerability and adaptation measures, it will be necessary to separate adaptation measures amongst agencies to implement the measures in Indonesia and many other countries as a government needs to allocate a budget amongst agencies. When an assessment found that drought is severe for multiple sectors and found an irrigation system as the best adaptation measure for these sectors, the next step will be to coordinate which agency will be working on the implementation. The logic of the implementation is beyond the objective of this paper, so this paper does not discuss it further, but the process will be complex and complicated. To be a practical ODA project, it was more appropriate and manageable to carry out an assessment on a sector at a time and work with specific agencies. In this project, several agencies were involved, but there is a clear segregation of tasks between the agencies. BMKG is responsible for overall assessment. Bali authority is responsible to report the Presidential Decree No.5 to the national government. BAPPEDA works as a coordination agency between stakeholders including other governmental agencies. In this potentially complex situation, the project decided it was best to focus paddy first to carry out a practical vulnerability assessment.

Practical implication for food security in Bali/Indonesia

The objective of this paper is to show how to focus on important issues, purpose, system, and context and variables to carry out a vulnerability assessment. Then, the next logical step will be to carry out a vulnerability assessment. Therefore, it is better to wait for the final results to make concrete remarks on the food security and climate change vulnerability in Bali / Indonesia. However, the identification process in this paper can be considered as a rapid vulnerability assessment without the details of spatial components and the project team already finds key issues. It is clear that food security is one the most vulnerable areas under climate change in Bali and Indonesia. This paper pointed out there is strong possibilities to reduce paddy production in Bali. Both the domestic government including the Bali authority and an

international aid community can support the vulnerability of paddy production in Indonesia/Bali.

As well as ordinal adaptation measures including irrigation and seed selection, Bali has an unique farming practice, which can be used as adaptation measures. Indonesia's government, as well as the Bali authority, is promoting organic farming. There are some evidences from farmers' interviews saying the productivity has increased when farmers adopted the organic farming, so that this measure may have a potential to improve general adaptive capacity instead of moving toward water-intensive farming under climate change (Kelkar, Narula, Sharma, & Chandna, 2008; Khor, 2009). They said that the quality of rice also improved and the rice could be sold at a higher price; therefore, it may help to increase the income of farmers. Organic farming is actually not new to Balinese farmers (Lansing, 2007), it has been practiced for many hundreds of years, but has not been used once in the last a few decades in some subaks. Therefore, it will be easier and cheaper to implement for local farmers compared with other adaptation measures.

Some farmers mentioned that prolonged rain is associated with pest damages and some parts of Bali and Indonesia are expected to get wetter. Bali's subak system not only manages water allocation, but also synchronizes farming patterns, which will create a fallow period to kill pests in paddy fields (Lansing, 1987; Lansing, 2007). This coordination will be more beneficial when the climate gets wetter in some parts of Bali and so for the rest of Indonesia. When the project team interviewed farmers in Indramayu, Java, they did not have the same synchronic farming practice. It will be interesting to explore the possibility of transferring synchronic farming practices from the subak system to other parts of Indonesia.

BMKG and the agriculture agency have been working with climate field school to educate farmers on how to cope with climate change (ICCTF-BMKG, 2011; Winarto, Stigter, Anantasari, & Hidayah, 2008). The climate field school will be a good place to teach farmers innovative technology and transfer good practices from other regions, as it is coordinated centrally, and focus more on "training of local champions" unlike general extension worker programs.

If the supports for adaptation measures from national and local governments are not enough, international supports will be needed. It is often asked how an official development assistance or ODA can contribute something other than financial support to enhance the adaptation (UNDP, 2010). For example, Japan is also likely to experience damages from climate change (MEJ, 2008). The precipitation level in Japan has decreased in recent years and the rice yield is expected to decrease toward the end of the century, whose consequence sounds similar to that of Indonesia including Bali. Japanese experiences also contribute both hard and "non-market" adaptation technologies in an agricultural sector. Japan has not only advance irrigation drainage technologies, but also one of the largest, if not actually the largest, farmers' cooperatives at a national scale that helps to increase the adaptive capacity of farmers through spreading new technology, working as a community bank, etc (MAFF, 2009 p.96). These hard and soft technologies are not available in Indonesia; therefore, the advance drainage and national-scale agricultural cooperatives can be, for example, potential supports from the international aid community.

Having said that, good experiences in a donor country do not guarantee the success of the same approaches and technologies in Indonesia where physical and human resources, impacts from the climate changes, and government structure are likely to be different or limited. When a project prioritizes adaptation measures, it is important to consider applicability, cost, and effectiveness. For example, extending time to drainage-pounded water and moving a cropping season are effective as adaptation plans, but these may not be effective if customs on water supply are not used to do so. It will be hard to enforce adaptation plans needing huge labor work in developed countries because of declining population and aging societies; however, the situation is likely to be different in Indonesia where there is excessive labor. As long as these limitations in the transferability issues are recognised, adaptation support from developed countries will be useful in Indonesia.

Conclusion

Most Indonesian regions have an annual rainfall of more than 2000 mm with the national annual average of about 2600 mm. Rainfall and relatively high humidity play important roles in inhibiting climate change hazards. Not only climatic factors, but also non-climatic factors influence the vulnerability of Indonesia coming from unique geographical features and the developing state of its economy. Today, there is less room to discuss “if the government should do a vulnerability assessment for climate change risks,” although there is no standardized approach. Vulnerability is dependent on contexts, issues, purpose and system of vulnerability units. Therefore, this paper demonstrated how an international cooperation project identified issues, purpose, system, context, and variables to carry out vulnerability assessment in Bali/Indonesia through six steps with four methodologies.

Through the steps, the vulnerability issues were focused into food security particularly on paddy as the first case. The purpose and system to work for were identified as supporting local authorities to report the Presidential Decree No.5 on paddy food security. Several potential hazards were also identified, which will be further investigated in a proper vulnerability assessment in the future. Drought is possibly the biggest concern among all weather-related disasters. Land use change is likely to affect the production of paddy in the context of Bali. Several variables affect the land use change including water level and prices of rice and land.

These findings can already suggest to Indonesian government and local authority where and how adaptive measures should be implemented to handle paddy food security with climate change. However, it is important to carry out a proper vulnerability assessment for the issues, context, purpose, and system identified in this paper. Then, paddy farmers in Bali will be supported with proper adaptation measures, which will be backed up by a well-focused vulnerability assessment.

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