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Impact of Climate Change on Agriculture and Food Crops: Options for Climate Smart Agriculture and Local Adaptation in East Nusa Tenggara, Indonesia

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Abstract. *Impact of climate change on agriculture may manifest in the form of deficit in yields from rain-fed agriculture (due to water stress and temperature change) and reductions in crop growth period (e.g. changing pattern of onset of rain days and the changing nature of dry spells). Researchers have shown that every 1°C increase in the minimum temperature, rice yields decrease between 10-25%. Small farmers are more vulnerable to the change therefore they will be affected most by climate extremes. Overall, climate change have put more pressures in local food systems especially production sub-systems. In Sumba Island, small farmers often face production deficit due to erratic climate condition and changing pattern of rainfall. In addition, farmers often face difficulties in growing enough main crops such as maize because of the shocks in production often lead to seed deficits for the next planting seasons. Access to alternative seeds is limited due to lack of ability to pay for seeds in the local market which in many cases not suitable for the local climate. While the local government often has their own budget cycle that is not compatible with the farmer's seed demand and local climate system as they often lately distribute seeds and other means to farmers. The erratic climate of NTT has strongly impacted the local food system especially the seed availability and therefore food security in general. Subsistence farmers often loss their seed due to harvest failure especially when dry spell occurs soon after planting corn or either harvest were rotten as the rain come coincidentally. In this paper we identify some of the innovation in water use efficiency and water management at crop levels such as mulching, water diversification measures and agro-forestry system being exercised by a few successful farmers. We propose some of the interventions such as dripping irrigation for (mainly for cash crops) agriculture, rainwater harvesting, identification (and re-introduction) of some drought resistant crop varieties, building a sustainable local seed systems, participatory breeding, livestock adaptation measures and improvement of existing agroforestry as well as knowledge management.*

Introduction to Climate Change and Agricultural Crops

- Climate change is unequivocally happening (Intergovernmental Panel on Climate Change (IPCC) (2007) as experts have reached consensus as supported by robust evidence of climate change (IPCC 2007, 2012). The climate change manifests in climate extremes is likely to increase losses from in development sectors including agriculture. IPCC predicts in some countries climate change top-up additional risks that exacerbate deficit in yields from rain-fed agriculture (with some scenario of up to 50% during the 2000-2020 period) and reductions in crop growth period (Agoumi, 2003).
- Agriculture sector is very sensitive to climate variability such as rainfall and humidity. Therefore, it is even clearer that agricultural crops are very sensitive if exposed to climate extremes and sea level rise. With the changes in the onset of rain days and the variability of dry spells, IPCC 2007 suggests some areas scenarios farmers can experience a huge fall in crop net incomes, decrease local and national production of many crops.[1]
- The climate dependency of an agricultural crop makes it is more likely to be impacted by the increased warming, sea level rise and changing precipitation patterns (Naylor and Mastrandrea 2010, Förster et. al. 2011). In addition, depending on the risk context, the agriculture sector may have been exposed to multiple hazards and risks may accumulate over the years (Lassa 2012)

[1] See for instance http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch9s9-4-4.html

- Research at the International Rice Research Institute in the Philippines suggests that for every 1°C increase in the minimum temperature, rice yields decrease by 10% (Naylor et. al. 2007, Peng et. al. 2004) - This calculation can be higher because Naylor et. al. (2002) predicts that for every 1°C change in May-August SSTAs (sea surface temperature anomalies), Indonesia rice production varies on average by 1.4 million tons [which is equivalent to 25-33% yield for farmers outside Java including NTT.
- Climate change will impact rice production - especially during the period of agricultural drought where "soil moisture is insufficient to meet crop water requirements, resulting in yield losses. Depending on timing, duration, and severity, this can result in catastrophic, chronic, or inherent drought stress, which would require different coping mechanisms, adaptation strategies and breeding objectives" (Wassmann, et al. 2009: 81)
- About 25-30% annual production of maize in South and Southeast Asia has been frequently affected by floods and waterlogging problems not including drought. Climate change is likely to alter maize production (Cairns et. Al. 2012) in the regions like East Nusa Tenggara in Indonesia.
- Therefore, increased temperature scenario has put more pressure on farmers (especially small farmers) to find more ways to cope with and adapt to different effects of climatic change such as less rainfall, more dry-spell during rainy season, more drought and higher temperature that trigger water loss and stresses. Therefore, climate change may cause major impact on food availability and thus to world food security.
- The macro impact above is due to the accumulation of stresses at plants and/or crops levels as climate change may modify local climate (a-biotic) stressors such as rainfall and temperature pattern (which affect water availability and soil moisture), but also may trigger biological condition that may be favorable to pests. In fact, climate change may modify the effects of pests and diseases (Goudriaan and Zadoks1995). At the local level, unfortunately, people are not well informed of the situation. This includes people and local governments in Sumba Island and East Nusa Tenggara Province (Indonesia).
- Climate change is likely to alter livestock production at different levels: it can modify feeds quantity and quality. Increased temperature and humidity creates heat stress on both feeds and livestock. Changing rainfall patter and droughts alter water availability. Together the humidity, rainfall and temperature change and modify livestock diseases and disease vectors. It may modify biodiversity of the grasslands systems and also alter livelihoods systems especially both grasslands and silvicultural system. A set of indirect impacts is likely to happen. Without significant temperature change, higher concentration of CO_2 in the atmosphere can be positive for feeds (Thornton et al. 2009)

Sumba Agricultural Context

- **Agriculture and Economy Context**. Sumba is the third largest island in NTT, one of the poorest provinces in Indonesia. It comprises 22% of the total land area of the NTT province, i.e. 47.7 km^2. Sumba is now divided into West Sumba and East Sumba districts, Central Sumba and Southwest Sumba districts. Today, all four Sumba districts have been among "the poorest" districts (out of 21 districts/cities in the province). East Sumba remains the largest land area district in the island. In

East Sumba, Agriculture sector (including food crop and livestock sectors) contributed about 35% to the Gross Domestic Product (GDP) during 2008 – 2012. Despite their large contribution to East Sumba economy and GDP, food crops and livestocks are very vulnerable to climate change.

- **Sumba Erratic Climate Context.** Sumba is a semi-arid are where more than half of land area is savanna, which is suitable for dry land agriculture and pastoral development. In general, the climate especially rainfall is erratic. In general, apart from some high rainfall spots in West and Central Sumba, the island has low rainfall intensity. In Some part of East Sumba over the last 5 years the total number of rainy days was less than 45 days[2] of which the total rainfall during that period was less than 700 mm.[3] In the other hand, for instance Tabundung sub-district often experience more rainfall than the rest of the region. However, it also experience climate uncertainty as shown recently that sometimes rain started earlier in December 2008 so farmer can grow crops during Dec-Feb. While in 2010 farmers, farmers delayed their growing till January and it was wet during January-June which made harvesting more difficult. The rain also came early in October 2010 and lasted until April 2011 at the time when harvesting should take place.
- In addition, there is high uncertainty in the climate which make it difficult for farmers and policy makers to make prediction for planting. Overall there is also a decline in rainfall trend in East Sumba [See Annex 1]. Most of the farmers felt uncertain in when and what to grow. For instance the Figures below suggest that in Haharu sub-district experience drought (as indicated by severe (an/or long) dry-spell during November-December-January and February-March-April) as it had very little rainfall during 2007-2008. In 2008, Haharu (and other places) experienced their driest period probably after 1998 El-Nino. During 2009, the rain started in February and ended in March. During 2010, the region enjoyed four months rainfall during starting January-April. In 2011, the rain started earlier in December 2010 and ended in February but suddenly it came back in April 2011 when the farmers should harvest their crops. While in 2012, there had only rain in January. This gives farmers difficulties to decide when to start planting their crops. Delays in growing crop may be ending up harvesting crops that coincided with the rainfall. This suggests that farmers need serious sound water management strategy in order to cope with the water stress.
- **Water and Other A-biotic Stress.** Figure 2 shows how erratic is the local climate in the selected district of East Sumba. High uncertainty in rainfall leads to high uncertainty in production because farmers cannot predict when is the best time to grow crops. In fact, this often leads to lack of anticipatory action due to limited knowledge concerning decision to grow.
- What makes areas like East Sumba and others vulnerable to climate risks is the fact that local institutions responsible for climate data collection have under-performed. The quality of climate data is poor and there is systematic error in climate data entry at district level, especially in East Sumba. There are always missing data from more than a half of the rainfall stations and this has been associated with the internal shift of human resources, under performance of human resources, and ignorance of the importance of climate data for agricultural policy in East Sumba. **Crops stress**

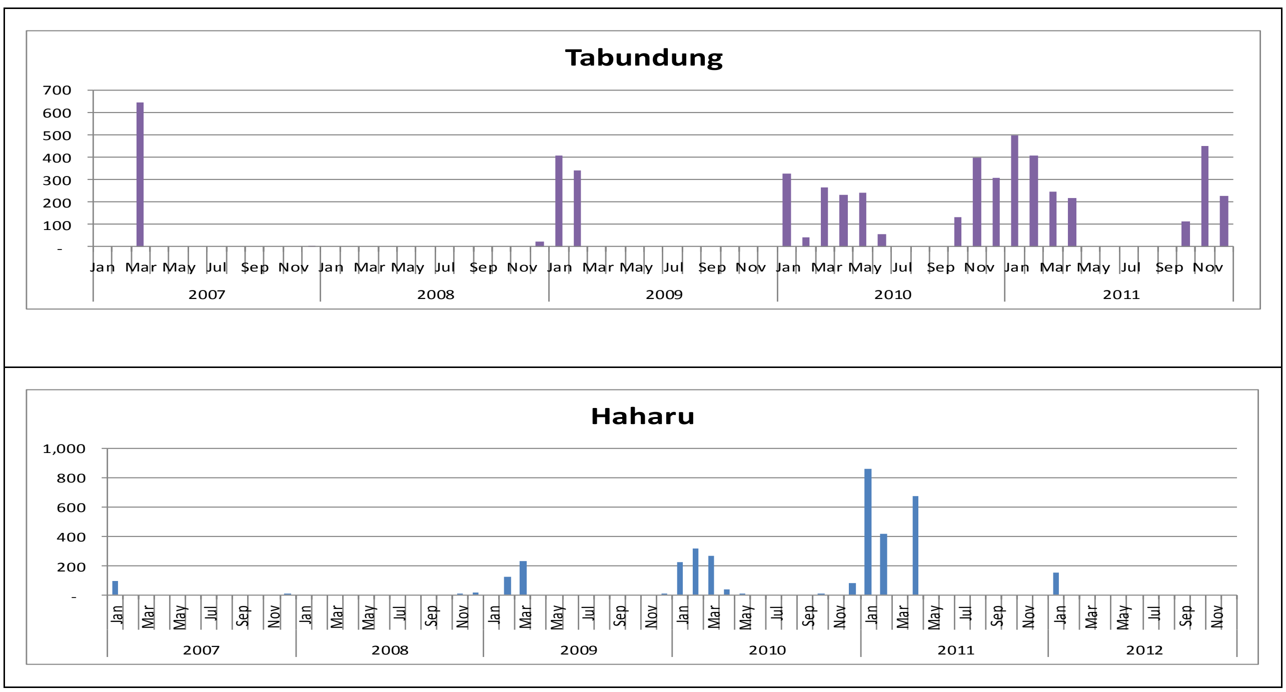
2 Based on average calculation from 13 stations in East Sumba district.

3 Even though the quality of data is poor, some information can still be harvested from the Agriculture and Horticulture Service of East Sumba. Data collected for this study is available since 2000-2010. It was found that the process of data collection is often constrained by poor quality of human resources and lack of attention given by the Service Agency to improve the data collection. Source: personal interview – for the safety of the source, the identity of the interviewee will not be shared.

from lack of water and higher temperature is therefore sometimes seen as given. In Haharu, there is a relative stability during May-October and sometimes until December when there was no rainfall at all. This creates problems namely water stress at plants as water loss due to high evaporation and evapotranspiration. However, if there is **adequate adaptation measures**, this could be read in a more positive tone, because this may mean that as long as farmers can secure water for agriculture from other means (e.g. groundwater or wells), and adopt **water loss measures** they can grow cash crops during May-October each year.

- Given the nature of agrosilvopastoral (crops, pastures/animals, and trees) of Sumba, the erratic climate often result in lower livestock productivity due to reduced availability of feed and fodder as well as longer heat and UV radiation.
- Therefore, this makes **rational planning more difficult** due to lack of accuracy in climate prediction – both scientifically and vernacularly. For the former, local institutions e.g. meteorological services hardly available to farmers to make anticipatory action. For the later, farmers have no idea why their traditional seasonal calendars could not be used to predict the climate. **The missing link** between meteorological services and farmer's decision to grow crops persist. Institutional innovation barely available which often lead to inaction to address the impacts such as water shortages.

Figure 1. Example of Erratic Climate in East Sumba - Selected sub-districts



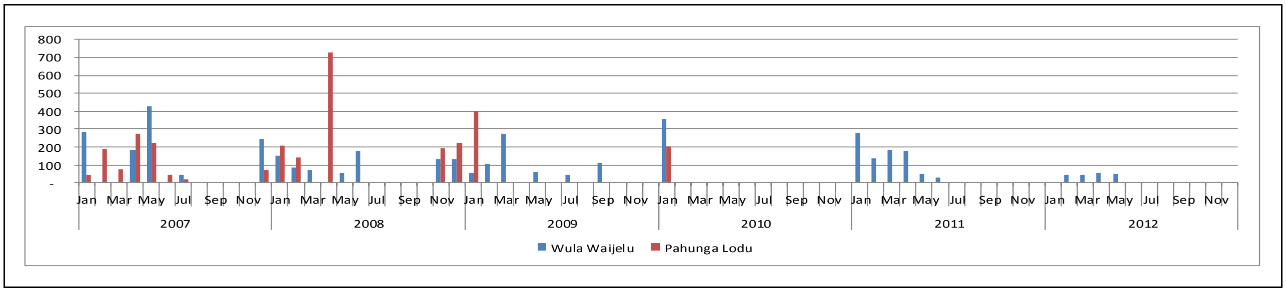
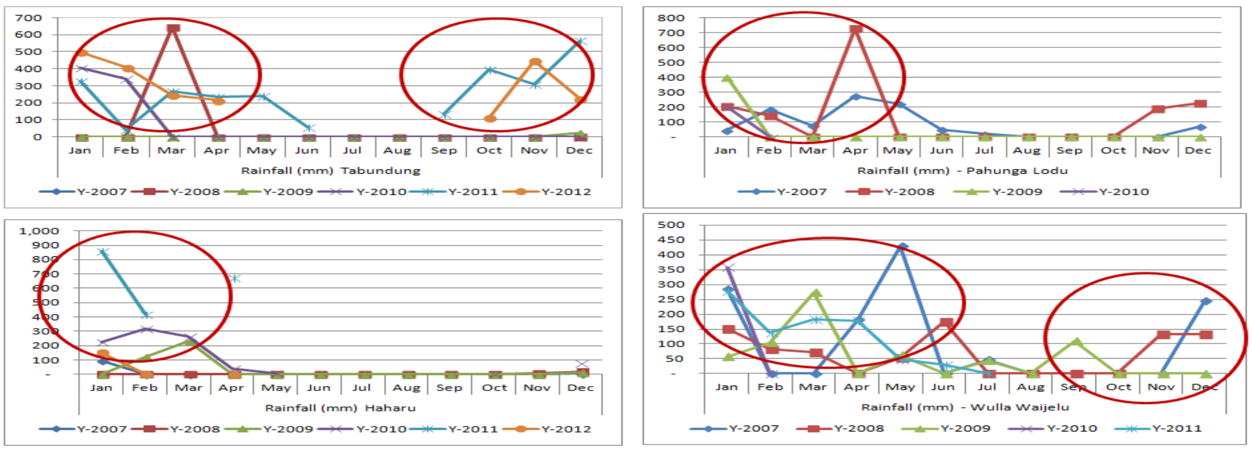


Figure 2. Erratic Climate in East Sumba - Selected sub-districts



Environmental Vulnerability and Grassland Burning

- Water stress that arises from the lack of rainfall has been exacerbated by the disappearance of some marginal forest in Eastern Sumba and the persistence of uncontrolled burning of the grassland savanna. During 2002-2003, Russell-Smith et. al. (2007) found that fires blistered an annual average of 29% of eastern Sumba's grassland savanna. In fact, the net forest cover has been probably less than 6.5% - as it fell from about 50% in 1927 to 10% in 1997 (Burung Indonesia 2009). The degradation of forest and vegetation has been associated with unsustainable consumption of forest products and unsustainable form of land use management (in the form of grassland burning). In addition, since birds ecosystem are very sensitive to change (of climate and forest ecosystem), East Sumba also experience a serious challenge to Sumba's birds.[4]
- This rapid local environmental change has modified livelihood outcomes of the people of Sumba. From 'anthropological' perspective, the burning practice can be best explained as partially an 'efficient practice' in grassland livelihoods systems because burning reduces labor cost (amid the

[4] Sumba houses at least 240 species of birds where 10 are endemic. See Sumba's bird database at http://avibase.bsc-eoc.org/checklist.jsp?region=idlssm&list=clements. See also http://burung-nusantara.org/birding-sites/lesser-sundas/sumba/. Last access on 20 Oct 2013.

absence of land clearing technology) as the farmers expect faster re-growing of grassland that benefits livestock production.

- Recent research also looks at the impact of burning in 'exacerbating soil erosion and resultant downstream/coastal sedimentation'.[5] In addition, the burning not only destroys other livelihoods assets, including crops and forests resources, non-timber forest products and other bio diversity loss and soil nutrient loss. Uncontrolled burning cause vegetation/biomass losses (which could be a source for mulching) as well as the loss of soil moisture content.

Climate Change Impact on Local Food System

- The erratic climate (shorter rainfall days, severe events of dry spell) of Sumba has affected the crop production and yield. East Sumba is often classified into a climate type with a shorter wet season, i.e. only 0-2 wet months. While some (or most?) local variety of crops require longer period of time. The climate pressure on dryland agricultural production in this island has been seen as 'normal' long before the issue of global warming and climate change resonates. It often suffers from crop failures due to drought and erratic climatic fluctuations. This is compounded by the decline of dryland farming land, which in the last several years occurred of about 50% (Dinas Pertanian dan Perkebunan NTT, 2010).
- The incompatibility of climate (0-2 month rainfall) but some seeds and/or crops being planted/grown such as corn and paddy often requires 3-5 months. This requires newer strategy where options for crops can be compatible with the erratic climatic conditions which for many decades have rendered farmers in NTT Province to be adaptive with water scarcity, degraded arable land, unpredictable rainfall, prolonged droughts, and longer dry spells during the rainy season.
- High evaporation and evapotransipation often exacerbate by the fact that farmers in general do not have the knowledge and skills pertaining to water loss measure and improvement of soil moisture content.

Unsustainable Seed System and Seed Storing Technology

- The erratic climate has strongly impacted the local food system especially the seed availability. Subsistent farmers often experience shortage of seeds due to harvest failure especially when there was no rain after planting corn or either the harvest was rotten as the rain come coincidentally.
- In some part of the region such as Makamenggit, (Dusun Matawai Turung), some farmers often give up their first growing season as their field often flooded. This causes the next growing season most farmers will have no seeds to grow. While seed distribution from the government often arrived at wrong time as the budget cycle does not coincide with climate events.
- While most of the farmers do not have firmed strategy in building a sustainable seed system. In fact, all their drought resistant crop seed varieties (in case of rice, corn and peanuts) have been partially superseded by hybrid seed varieties sold at the local markets. For some advanced (or progressive) local farmers, seed options depend on their purpose of growing. Some did not actively sell the

5 Interview with Kopesda 22 Sept 2011.

harvested corn. If there is no surplus in production, they often milled and fed their pigs. So they sell the pigs to get some cash for rice and children's education.

- In an interview in Palakahembi (Pandawai), one of the successful farmers argued that "this year (in 2013), the corn price was good but our harvest was not good. Last year it (the price) was not too good so people must be lazy to grow. But when the price is good, there is none in the market, as people did not produce [off course - decline in supply increase the price given the demand is either constant or increase]." According to the interviewed farmers, they often opt for local seed corn because it offers them better chance to bind and hang the corn in their house. This method often guarantee longer period of being un-rotten (or in good condition) until the next planting season. While hybrid seeds often have fuller corn meat which could cause difficulties in binding the corn into *Kuda* system.

Figure 3. Example of Onion Storing in Palakahembi

3A. Onion tied and hang (store) on top of roof	3A. Local corn tied and hang on top of roof
	
3C. Onion tied and lied down and got rotten	3D. Hybrid corn are difficult to be tied
	

- In the second cropping season, farmers in Palakahembi often grow peanuts and green bean as long as the water pump work. The growing at the second cropping season is to anticipate the shortage of seeding in the next round because when the rainy season comes it may damage seed. This year, Mr. Riwu family does not plant enough onion because the seed were rotten due to exposure to rain. "If it is store to long, it gets rotten. We have stored the seed but somehow it was hit by the West Wind, then it became wet and rotten. I was too busy with the field so I did not anticipate. A week after when checking the seed, it was all rotten. Last year the onion had no leaves so we did not hang the seed. It was too dry so we simply put on the bale-bale. If it is hung, it will be durable." (See Figure 3).

Figure 4. Example of Agroforestry in East Sumba

Agrosilviculture system in Tabundung, East Sumba

Agrosilviculture system in Haharu, East Sumba

Agrisilviculture in Kambera, East Sumba

Silvopastoral system in Tabundung, East Sumba

Agro-Ecosystem in Sumba and NTT

- Agroforestry system can be classified based on what is called as structural basis based on the nature and arrangement of the components such as: Agrisilviculture (combines crops and trees including shrubs and trees), Silvopastoral (pasture/animals and trees), Agrosilvopastoral (crops, pastures/animals, and trees), and others (multipurpose tree lots, apiculture with trees, aquaculture with trees, etc) (Nair, 1991). Agroforestry system, as defined above, have been practiced by farmers in NTT Province since decades. This system is commonly known as Watani but specific local names apply for different parts of NTT Province [Figure 4]. In Timor for instance, farmers combine woody perennials such as areca nut (*Areca catechu*), with crops such as taro, yams, etc. while animals can be raised under the canopy of the trees. This system is known as “mamar” in Timor. Similar system is also found in other islands such as Sumba, Flores, Alor, and Rote with different local names.

- Alley cropping is a type of agroforestry technology system commonly found in NTT Province, especially in Timor and Flores islands (Benu and Mudita, 2013). In this system, food crops are planted between hedgerows of planted shrubs and trees, commonly leguminous species. The hedges are pruned periodically during the crop's growth to provide biomass (which, when returned to the soil, enhances its nutrient status and physical properties) and to prevent shading of the growing crops. The hedgerow plants commonly used in East Nusa Tenggara includes legume trees such as 'Lamtoro' (*Leucaena leucocephala*) 'Turi' (*Sesbania grandiflora*), 'Gamal' (*Gliricidia sepium*) and 'Kaliandra' (*Calliandra calothyrsus*). These are nitrogen fixing trees that can enhance soil nutrient content through roots or biomass. The biomass of these trees can also be used as nutrient rich source of feed for animals, especially cattles, horses, and goats.
- It is interesting to note that there is little publication concerning impact of climate change to agro-forestry. In fact, agroforestry is often seen as the basis for building resilience livelihoods of poor farmers around the developing world and it also seen as a basis for climate change mitigation and at the same time adaptation to climate change (See Nair et. al. 2007, Verchot et. al. 2007). What is now needed is a more systematic approach in adopting agroforestry as the foundation in climate adaptation policy in the areas such as NTT. Stronger promotion of the technology is necessary and reform required at the local level.

Adaptation Options for People and Farmers of Sumba and NTT

- Some farmers have been successful in adapting to the erratic events. Often grow vegetables and onion in May. Some farmers view the days without rain during May-October can be a blessing because this gives them a relative stability in growing cash crops such as onion. According to Riwu (2013), "onion can be harvested in August if it is planted in May or If planted in June, we will harvest in September". One of the reasons is due to the fact that this family has access to water pump from a local 'rainwater harvesting'. Therefore ensuring water access during both dry spells and dry seasons is the key to sustainable food crop production and therefore food security.
- Most food crops in East Sumba are produced in dryland farming system, with maize, upland rice, peanut, cassava, and sweet potato the most predominant crops, in both total harvest area and total production. Climate Smart Agriculture related intervention options are; therefore, need to be focused on these commodities [See LWR Concept of CSA in Annex 2].
- There is an urgent need to develop and to use types of crop varieties that are resistant to abiotic stresses (of climate related such as drought, erratic climate e.g. long dry spell, and flooding), as well as pest and disease outbreaks. This can be done by first evaluating local crop varieties that are able to sustain the extreme conditions of the changing climate, followed by both conventional and molecular/biotechnology breeding methods to generate high yielding and adaptive crop varieties. NTT Province inherit some pool of food crop germ-plasm that can be used as parental sources in developing high yielding as well as biotic and abiotic stresses resistant crop varieties.
- Generating new superior crop varieties at local level in developing world is a huge task as it is time consuming, laborious and expensive. Therefore, the existing promising local varieties can be directly multiplicated and distributed to the farmers with the assistance of trained seed producer officials. Seeds of commercial varieties are also now can be accessed easily directly from the producers, the Agriculture Department or seed shops.

Recommendation

- Considering the existing climate smart agriculture practices in NTT Province as well as the agro-climatic conditions of East Sumba, more specifically the two contrasting target areas, Haharu (dry) and Tabundung (more humid), the following options are recommended:

  1. **Improvement of water management at farmers' level.** Assessment study on Sumba has shown that only farmers who have the water management skills and technology can be resilient to water stresses. This should also be complemented by increasing water use efficiency and develop measures to reduce water loss at plants level.
  2. **Participatory plant breeding where farmers identify crop varieties that are suitable for East Sumba's climate context.** There is an urgent need to develop and to use types of crop varieties that are resistant to abiotic (climate) stresses such as drought, erratic climate, and flooding, as well as pest and disease outbreaks resulting from climate change. There is existing promising local varieties can be directly multiplicated and distributed to the farmers with the assistance of trained seed producer officials. This needs to be followed by a strategic action concerning building local seed system encompassing some crops such as maize, Upland Rice (e.g. Pare Wangi that is a national variety generated from a local variety of Southwest Sumba), Sandle peanuts (a local variety of East Sumba that has been established by Indonesian Minister of Agriculture as a national variety in 2010), local seed Sabu Mungbean that has long been cultivated by farmers in East Sumba, high yielding and short duration (2 months). Seeds of Kacang Lokal Sabu can be easily, obtained from local seed producers in east Sumba.
  3. **Recruiting early adopters in adaptation technology.** The emphasis in No 2 for using suitable crop does not equal with the rejection nor equals with the idea to skip experiments with newly develop varieties that are potential in being adaptive to Sumba's erratic climate and should also be subject to farmers' preference. This means that a project that involves risk taking behavior from farmers who are willing to be **early adopters should be a necessary condition for the future success of adaptation**.
  4. **Increasing options for seed storing technology that is fit for the purpose.** For subsistent farmers, this project suggests the farmers to opt for their local variety that is compatible with their existing storing technology. For farmers who combine commercial corn and intensive livestock (pigs), they can grow corn that can be harvested at shorter period of time. In addition, farmers can be also introduced to new options for storing where they can control the water content of the harvested crop to avoid rotten.
  5. **Adjustment of cropping patterns with the changing climate/weather**. Determination of appropriate cropping pattern, especially sowing/planting time will help farmers to make decisions on when to start planting and what are the most appropriate cropping patterns. To be successful, there is a must to develop a good coordination among the related parties involving farmers, NGOs, and Government Institutions to provide quick and accurate climate and weather information in order to make the right decision on planting time.
  6. **Improvement of Multiple Cropping Systems and Agroforestry Systems**. Multiple cropping systems and agroforestry systems are adaptive coping strategies that have long been exercised by farmers in their dryland farming system to tackle the climate change impact. However, it must be realized that these existing systems in NTT Province need to be improved for a more

sustained and efficient land use management. Cropping systems in Haharu and Tabundung Districts so far rarely incorporate legume species in the same farm land. The farmers need to be enlightened that legume crops such as peanut, mungbean, cow peas, and soybean are nitrogen fixing crops that can benefit other crops when incorporated in a multiple cropping system. It is, therefore, recommended that where two crops can planted in a single growing season, the crop rotation combination of maize+mungbean, maize+peanut, rice+mungbean, and rice+soybean are good options to be implemented in their farming system. As with multiple cropping systems, the existing agroforestry systems in East Sumba need also some improvements. Alley cropping is an ideal model of agroforestry systems that has been proved to be successful in dryland agriculture system in Timor and Flores Islands but is lack of attention in Sumba Island. This model can be simply implemented in this island by selecting good combination of hedgerow plants and food crops. Ideal hedgerow plants would be “lamtoro” (*Leucaena leucocephala*) and “turi” (*Sesbania grandiflora*). In addition to their role as nitrogen fixing trees, these two plants also produce biomass that can be used as green manure as well as nutrition rich feed for animals. Other legumes tress such as ‘gamal” (*Gliricidia sepium*) has been incorporated in agroforestry system in Sumba Island but it should be realized by the farmers that roots of this crop has been proved to produce allelopathic substances that are disadvantageous to the neighbouring plants, including food crops. This crop is then more appropriate to be incorporated in silvopastoral system than in the agrisilviculture system that involves food crops and tuber root crops in the farming system.

7. **Further research is necessary.** For instance, Sumba is well known for its Sumba peanuts which have been function as a very important icon for Sumba agro industry for the last two - three decades. However, under the changing climate scenario, little is known for the sustainability in Sumba peanuts' production. No loss assessment being made and therefore, no loss mitigation scenario being provided nor prescribed to the farmers. **In addition, a more strategic adaptation options in Sumba** informed by sound scientific research is necessary.

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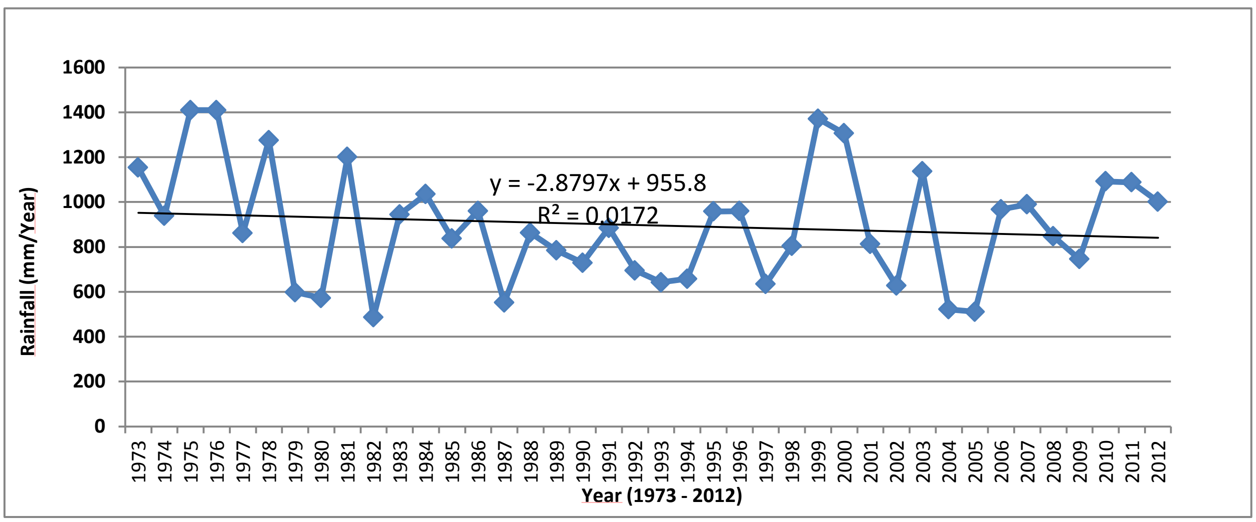
Annex 1. Average annual rainfall in Waingapu, East Sumba



Source: Mau Hau Meteorology Station, East Sumba

Annex 2. LWR Concept in Climate Smart Agriculture

Lutheran World Relief (LWR) is a U.S. based non-profit development organization engaged in seeking lasting solutions to poverty through a model of accompaniment, supporting and developing the capacity of local partners to target those most at need in remote and rural communities.

In responding to these challenges, and as driven by LWR's values and mission to "end poverty, injustice and human suffering," as well as the first two Directional Goals of LWR's Strategic Plan (DG1: Develop Strong Local Economies; DG2: Build Resilient Communities); LWR promotes and adheres to the following principles:

1. Food systems must ensure the availability of food for men, women, boys and girls; ensure equal access to food for men, women, boys and girls; and support ways to ensure better utilization and nutrition, especially for the world's poor. Market and structural forces must play a positive role in protecting and enhancing the livelihoods of small producers. Public and private actors must work together to build robust markets that benefit and serve small producers while striving for policies and market reforms that do not unduly penalize or work against their interests.

2. LWR's agriculture programs must develop in ways that increase both the incomes and the food security of small producers, both as critical suppliers of the world's food and as the majority of the world's poor.

3. LWR's agriculture programs must both increase production and better manage and sustain the planet's biodiversity and land and water resources. Research on and use of seeds, nutrient and genetic and biological diversity must be combined with input and participation from all stakeholders.

4. LWR's agriculture programs must engage a blend of conventional farming, science, economic, land and market reform and environmentally sustainable practices, and no single methodology can be applied or promoted for all possible farming situations.

5. Relegating small producers to subsistence farming, while allowing other parts of the value chain to reap disproportionate economic benefits of agriculture markets, is inherently unjust. Small producers' participation in and benefit from agricultural value chains (AVC) is vital to their income generation and, ultimately, to their increased food security.

6. Access to financial services and credit (savings and loans) is crucial to helping smallholder producers use their assets to work their way out of poverty; however, financial institutions are often reluctant to lend due to small farmers' lack of collateral, savings and credit histories. Women smallholder farmers face even greater disadvantages than their male counterparts as they typically have even less access to financial and social capital, market information and productive resources such as land. LWR should take steps to increase gender equitable access to and control of resources.

7. Small producers, in particular women, need to have the skills, access to information, and financing to participate as empowered agents in decisions pertaining to agriculture. LWR should seek strategies to reduce the time-constraints placed on women by the demands of unpaid labor that restrict their available time for paid activities.

To achieve these directional goals, LWR staff has identified five core program areas. The core program areas are both areas in which LWR has already built expertise, as well as areas in which we need to grow to achieve both our objective goal and our directional goals. One of those core program areas is Climate Smart Agriculture

LWR Climate Smart Agriculture – Core Program 5

Outcome Statement: Men and women smallholder farmers are better able to protect their agricultural assets in the face of changing climates and environmental degradation.

FAO defines Climate Smart Agriculture (CSA approach) as "agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (GHGs) and enhances achievement of national food security and development goals." LWR's CSA approach works specifically to help small producers adapt to and mitigate the effects of changing climates. In addition to protecting their rural incomes, LWR's CSA approach seeks to enhance farmers' own household food security by addressing the various components of a sustainable production system — ranging from soil conservation and nutrient management, sustainable water access and use, environmentally sensitive pest management, resilient crop varieties and crop diversification. This is particularly relevant to women who are often responsible for using and preserving land for food and fuel production, thereby making them more vulnerable to climate change impacts such as desertification, erosion and soil degradation.

LWR's approaches to CSA are closely linked to what the FAO refers to as Conservation Agriculture and Sustainable Land Management models, which are the cornerstones to the future of a sustainable global food system. Key elements of LWR's approach to Climate Smart Agriculture include, but are not limited to more environmentally-friendly cropping practices, improved irrigation technologies, access to improved seed varieties such as drought-tolerant ones,, land and soil management and agro-forestry models. As part of the CSA approach, LWR recognizes that many different techniques

will be needed to produce more food at affordable prices, ensure livelihoods for small farmers and reduce the environmental costs of agriculture.18 As stated in the Principles for Programming, while supporting organic agricultural, LWR will not exclusively promote such measures, rather it will encourage agricultural practices that support healthy ecosystems and limit the use of agro-chemicals, ensuring their appropriate use when they are required.

LWR Indonesian Context

Lutheran World Relief as part of its Memorandum of Understanding with The Coordinating Ministry for the People's Welfare of the Republic of Indonesia in mandated to work in Nusa Tenggara Timur.

Lutheran World Relief Indonesia has also identified as part of its annual operational planning that the environment/climate change adaptation and disaster risk reduction are key focus area for programming in Indonesia.