Enhanced Climate Change Resilience of Food Production Systems for selected PICTs

Tonga Vulnerability Analysis Report

Introduction

The 3 sites in Tonga were selected by the technical committee of the Tonga Joint Action Plan for Disaster Risk Management (JNAP). The sites are (i) Kolonga Village in the Northeast of Tongatapu which is prone to exposure to coastal strong winds; (ii) Houma village in the Northwest of 'Eua also prone to exposed winds in the central parts of the island and soil rather droughty; and (iii) Tefisi village in the western side of Vava'u with agricultural land mostly on sloping lands, very prone to soil erosion.

Descriptions of Soils on the Sites

The properties of the main soils on the selected sites were obtained from soil survey reports of the islands that were done by the Soil Bureau of the Department of Scientific and Industrial Research of the New Zealand Government in the 1970s to the 1980s.

Houma:

Houma soil series, named after Houma village in the north-west of 'Eua, occurs on undulating to strongly rolling (<15^{o}) and hilly slopes along the central parts of 'Eua, at elevation between 60m and 300m, within the northern half of the island. Houma series are formed from between 50cm to 2.5m of andesitic tephra overlying either old foraminiferal limestone or older tuffaceous sediments and in a few places, coral limestone. The presence of small weakly weathered lapilli in A horizons, as within most of the soils of 'Eua, suggests that upper horizons of Houma series have formed from recent accretions of tephra.

Houma series has reddish coloured (generally dark reddish brown 5YR3/2) silty clay textured A horizons with moderately to strongly developed structure, over reddish brown and red (mainly hues 2.5YR and 10YR), friable to firm, clay and silty clay textured B horizons with strongly developed blocky structure. Bt horizons have sticky and plastic wet consistence and well developed continuous clay coatings with some distinct manganese patches. Houma soil series are mapped on mainly undulating and easy rolling slopes to hilly slopes (15 to 30^{o}).

Houma soils is considered to have severe limitations for cropping but moderate for fruit trees and minimal limitations for forestry.

Tefisi

Longomapu soil have been mapped along the western side of Vava'u including Tefisi village except the very steep slopes which are mapped as Panagaimotu soils. Longomapu soils are developed from a deep cover of a younger brown tephra overlying older tephra or limestone. The profile shows some 20cm of very dark brown friable silt loam to clay loam A horizon, with moderately developed medium nut and fine granular structure, resting on a dark brown

friable clay loam with strongly developed coarse blocky structure. These soils are suitable for producing a wide range of crops except on sloping lands where potential soil erosion is a threat. Pangaimotu soils on the steeper slopes are similar but more developed soils than Longomapu which can grow a wide range of crops. On the slopes, the limitation is potential soil erosion.

Kolonga:

The predominant soil in Kolonga is the Lapaha series. Profiles are characterized by an A horizon about 30cm thick of a dark reddish brown (5YR2/2) dark brown (7.5YR3/2) friable clay containing few weathered lapilli and few hard black lapilli. The B horizon is a brown (7.5YR4/4) firm heavy clay with a moderately blocky structure with thin clay coatings on ped surfaces. This soil is normally well drained but, because of lower percentage of large pores in B horizons, permeability is likely to be slower than other volcanic ash soils in Tonga, and aeration of the soil could be reduced during wet periods. With higher content of clay it would also be more difficult to work during wet periods so that the Lapaha soils are regarded as slightly less versatile than the othe volcanic ash soils (Vaini and Fahefa soils).

Lapaha soils are considered to have slight limitations of workability and aeration for subsistence food crops, ground cash crops, and urban uses and minimal limitations for tree cash crops and pastoral use. The Lapaha soils, rolling phase which are on the Kolonga exposed site have limitations for pastoral use, slight limitations for ground cash crops, and moderate limitations for subsistence food crops, tree cash crops and urban uses.

Community Vulnerability Analysis

The community vulnerability analysis was conducted with representatives from the 3 communities. It involved use of Participatory Rural Appraisal (PRA) Tools; Household Income Expenditure Surveys (HIES); and transect walks.

In Houma, ‘Eua the PRA workshop was attended by over 30 people on the 10th of April and the HIES on the 11th April.

In Tefisi the PRA was attended by 24 farmers on the 15th April and the HIES on the 16th. This was because the message that went out to the community was - there will be a PRA for farmers. During the HIES, the opinions of women were also sought on issues from the PRA with the men.

In Kolonga, the PRA was attended by 30 people (men, women, youth) on the 18th April and the HIES on the 19th.

Plates 1a Youth Group during PRA

Plates 1b Women Group during PRA

Results

Exposure

Changes in temperature and rainfall are indicative of change in season. **When characteristics and the pattern of temperature, rainfall and other climate elements have changed from the normal situation, the communities are exposed to new climate and the communities can be vulnerable to this climate change.** The seasonal calendar assesses how far the seasons at local level have changed. The participants should be asked to mark on the calendar the beginning and end of winter (cold days) season, hot (hot days) season, rainy season, dry season, etc first the current (within last 5 years) and then the before (as long as 30 years back the community recalls).

The participants did paired ranking of climate induced hazards by considering every pair of hazards in turn and decide by consensus which is the most critical. They enter this into the box. When the table is complete, the number of times each hazard was chosen is added up. These scores then suggest which hazards are the greatest priorities.

If the community identifies that there is a difference in the climate events and the season between now and in the past, then they should be asked whether that change is low (1), medium (2), high (3) or very high (4). The ranking is required for each of the variable or elements assessed. The number of variables or elements can be different from community to community depending upon the perception of the people.

Table 1a. Assessment of climate variables (Elements of Exposure 'E') of Houma, 'Eua

Parameters	**Indicators**	**Perceived changes/remarks**	**Score index/remarks**
Temperature	• Numbers of hot days increased • Number of cold days decreased	High High	3.3 3.3
Precipitation	• Rainfall has become increasingly	V. High	4

	unpredictable		
Plant and animal indicators	• Flowering and fruiting of some of the fruit trees like breadfruit and mango • Animal behaviour like chicken egg laying is changing	Med-High V. High	2.66 4
Climate induced disasters	• Drought • Hurricanes • Pests and diseases	Medium Med - Medium Med- high	2.33 2.66 2.66
	Average Exposure index	**High**	**3.11**

Table 1b Assessment of climate variables (Elements of Exposure 'E') of Tefisi.

Parameters	**Indicators**	**Perceived changes/remarks**	**Score index/remarks**
Temperature	• Numbers of hot days increased • Number of cold days decreased	High High	3.3 3
Precipitation	• Rainfall has become increasingly unpredictable	High	3.3
Plant and animal indicators	• Flowering and fruiting of some of the fruit trees like breadfruit and mango • Animal behaviour like chicken egg laying is changing • Yam season (pests and diseases)	High Medium - High	3.6 2.6 3
Climate induced disasters	• Drought • Hurricane	Medium - High Medium - High	2.6 2.6
	Average Exposure index	**High**	**3.2**

Table 1b Assessment of climate variables (Elements of Exposure 'E') of Kolonga

Parameters	**Indicators**	**Perceived changes/remarks**	**Score index/remarks**
Temperature	• Numbers of hot days increased • Number of cold days decreased	High High	3.16 3.16
Precipitation	• Rainfall has become increasingly unpredictable	High	3.33
Plant and animal indicators	• Flowering and fruiting of some of the fruit trees like breadfruit and mango • Animal behaviour like chicken egg laying is changing • Yam season (pests and diseases)	High Medium - High	3.66 2.66 3
Climate induced disasters	• Drought • Hurricane	Medium - High Medium - High	3.33 2.33
	Average Exposure index	**High**	**3.04**

It is evident from the exercise that the community perceived that there is a change in climate over the last 3 decades. They also saw some changes in behaviour of plants and animals as manifestation of climate changes. It is also interesting that the communities also saw a correlation between climate change and changes in planting dates of yams and the changes in pests and diseases.

Plates 2a, 2b, and 2c also show the exposures of the sites to climate changes. The photos show that all are exposed to potential impacts of climate variability with Houma and Kolonga exposure to strong winds and Tefisi exposure to soil erosion from high intensive rainfall.


Plate 2a. Houma


Plate 2b. Tefisi


Plate 2c. Kolonga

Sensitivity

The groups were initiated to discuss different past climatic hazards and their impacts on the communities. Discussions were led to the effects of climate change and related hazards on the resources. The focus here is on Sensitivity regarding the magnitude of effects of climate change and related hazards on 5 sectors namely

1) Agriculture and Food Security
2) Forest and Biodiversity
3) Water and Energy
4) Settlement and Infrastructure and
5) Human Health

Once impacts are decided then a ranking of low, medium, high and very high like with exposure is done to assess severity of impacts.

Table 2a. Sensitivity Assessment (elements of Sensitivity 'S') for Houma

Parameters	**Hazards**	**Indicators**	**Perceived changes/ remarks**	**Score index/ remarks**
Agriculture and food security	Hurricanes	Loss of productive lands	High	**3**
	Drought	Loss of crop production	Med - High	**2.6**
	Outbreak of diseases	Production decline	Med	**2**

Forest and biodiversity	Drought	Loss of forest cover	Med - High	**2.67**
Infrastructure	hurricanes	Trails and roads damaged	High	**3.33**
Water resources and energy	Hurricanes	Loss of qualty fresh water	Medium	**2.33**
	Drought	Reduction of freshwater	Med - High	**2.67**
Human health	Hurricanes	Emergence of waterborne diseases	Med	**2.33**
Average Sensitivity Score			**Med - High**	**2.64**

Table 2b. Sensitivity Assessment (elements of Sensitivity 'S') for Tefisi

Parameters	**Hazards**	**Indicators**	**Perceived changes/ remarks**	**Score index/ remarks**
Agriculture and food security	Hurricanes	Loss of productive lands	High	**3.6**
	Drought	Loss of crop production	Very High	**4**
	Outbreak of diseases	Production decline	High	**3**
Forest and biodiversity	Hurricane	Loss of forest cover	Med - High	**2.6**
	Drought	Loss of bidiversity	Medium	**2.3**
Infrastructure	Hurricanes	Trails and roads damaged	High	**3.6**
Water resources and energy	Hurricanes	Loss of quality fresh water	High	**4 3**
	Drought	Reduction of freshwater	High	**3**
Human health	Hurricanes	Emergence of waterborne diseases	Med - High	**2.8**
Average Sensitivity Score			**High**	**3.06**

Table 2c. Sensitivity Assessment (elements of Sensitivity 'S') for Kolonga

Parameters	**Hazards**	**Indicators**	**Perceived changes/ remarks**	**Score index/ remarks**
Agriculture and food security	Hurricanes	Loss of productive lands	High	**3**
	Drought	Loss of crop production	Very High	**3.33**
	Outbreak of diseases	Production decline	High	**3**
Forest and biodiversity	Hurricane	Loss of forest cover	Med - High	**2.33**
	Drought	Loss of biodiversity	Medium	**2.33**
Infrastructure	Hurricanes	Trails and roads damaged	High	**3.6**
Water resources and energy	Hurricanes	Loss of quality fresh water	High	**3**
	Drought	Reduction of freshwater	High	**3**
Human health	Hurricanes	Emergence of waterborne diseases	Med - High	**2.8**
Average Sensitivity Score			**High**	**2.81**

All communities perceived that the 5 different sectors (Agriculture and food security, forest and biodiversity, infrastructure, water resources, and human health are impacted by exposure to climate variability and climate induced disaster of cyclones and drought. Many of the farmers also indicated that farming is becoming more difficult now as climate is changing and impacting of environmental parameters important for food production.

Food Consumption

Houma

Fig 3a1. Energy consumption by Houma community

Food Sources										Total
Foods	**Taro**	**Cassava**	**Banana**	**Yam**	**S. Potato**	**Breadfruit**	**Rice**	**Flour**	**Noodles**	
g/peson/day	**74.4**	**17.9**	**44.6**	**65.4**	**127.9**	**339**	**21**	**95.2**	**10.4**	
Kcal/day	**63.8**	**19.5**	**28.7**	**66.1**	**116.8**	**203.4**	**75.4**	**346.5**	**36.5**	**950.7**
	492.3 (51.8%)						**458.4 (48.2%)**			

Fig 3a2. Protein consumption by Houma Community

	Food Sources							Total
Foods	**Chicken**	**Fish**	**Canned Fish**	**Chicken**	**Turkey**	**Beef**	**Mutton**	
g/person/day	**14.9**	**187.4**	**12.8**	**137.9**	**11.9**	**32.7**	**17.9**	
Protein/day	**1.83**	**24.0**	**2.66**	**16.96**	**1.92**	**6.05**	**2.41**	**55.83**
	25.83 (46.2%)		**30.0 (53.8%)**					

Fig 3b1. Energy consumption by Tefisi community

Food Sources										Total
Foods	**Taro**	**Cassava**	**Banana**	**Yam**	**S. Potato**	**Breadfruit**	**Rice**	**Flour**	**Noodles**	
g/peson/day	**325.8**		**60**		**22.6**	**276.6**	**7**	**101**	**8**	
Kcal/day	**282.7**		**45**		**20.8**	**166**	**25.2**	**367.6**	**29.3**	**936.6**
	514.5 (54.9%)						**422.1**			

Fig 3b2. Protein consumption by Tefisi Community

	Food Sources							Total
Foods	**Mutton**	**Pork**	**Fish**	**Bivalve**	**Canned fish**	**Chicken**	**Mutton**	
g/person/ day	**4.5**	**18.1**	**97**	**30.6**	**31.7**	**22.7**	**38.5**	
Protein/ day	**0.6**	**2.4**	**9.99**	**6.12**	**7.2**	**2.8**	**5.2**	
	19.11 (55.6)				**15.2**			**34.31**

Fig 3c1. Energy consumption by Kolonga community

Foods	**Taro**	**Yam**	**Cassava**	**Breadfruit**	**Rice**	**Flour**	**Noodle**	**Total**
g/person/day	**115.6**	**258**	**102**	**81**	**13.6**	**54**	**23.8**	
Kcalorie	**99.4**	**260.6**	**111.2**	**48**	**48.9**	**196.6**	**87.3**	
	519.2 (60.9%)				**332.8**			**852**

Fig 3c2. Protein consumption by Kolonga Community

Foods	**Fish**	**Chicken**	**Mutton**	**Total**
g/person/day	**204**	**272.1**	**74.8**	
g protein/day	**21.01**	**33.45**	**10.1**	
	21.01 (32.5%)	**43.55**		**64.56**

For energy consumption, the consumption of local food is still more but is under threat from increasing relance on imported foods such as rice and flour. The protein consumption is more vulnerable for Houma and Kolonga with more than 50% consumption of imported sources of protein. Tefisi households are consuming more local proteins as sea foods. In general the food security is quite vulnerable considering that the food production systems are also vulnerable to impacts of climate variability and climate induced disasters.

Adaptive Capacity

The adaptive capacity helps the communities to respond to effects of climate change. Assessment of adaptive capacity looks into the assets of the community which are required to respond to effects of climate change. Such assets are both materials assets and immaterial assets. However the assessment of adaptive capacity will focus on assessment of five

livelihood assets of the communities namely 1) human assets 2) natural assets 3) physical assets 4) financial assets and 5) social assets.

A resources map may be developed with natural and physical resources available to the communities listed. The status of the resources in terms of quantities and qualities and availability as they contribute to adaptive capacity is assessed and recorded.

Adaptive capacities then are ranked by communities from low (1), medium (2), high (3) and very high (4). Lower numbers mean adaptive capacity is poor and must be addressed to improve resilience to climate change.

The adaptive capacities of the communities were collated from this exercise plus from data from the HIES in table under the livelihood assets and then matirices were used to generate the spiderwebs below. The communities clearly do not have the capacity to withstand the clumate change trends as well as extreme events.

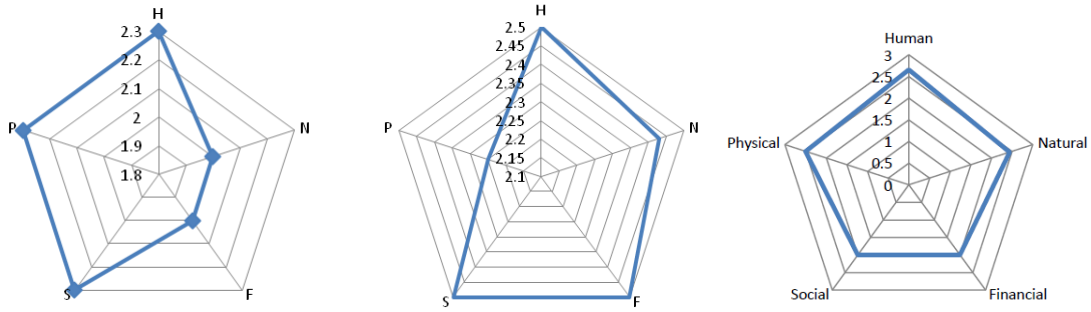

Fig. 4 Adaptive capacity of Houma (left); Tefisi (middle); and Kolonga (right)

For Houma the crtical assets that needed addressing relates to human helath and financial assets; for Tefisis the most critical assets that needs improvement relates to physical assets; and for Kolonga the most crtitical assets that need addrssing are social and financial assets.

Development of Adaptation Strategies

From all these exercises issues were used to establish a problem tree and from the problem tree a logframe was developed for each site. The logframes are given below:

Houma

Intervention Logic	Objectives Verifiable Indicators (OVIs)	Baseline	End of the Project	Means of Verification (MOVS)	Assumption
GOAL: Household of Houma Village in 'Eua are food and income secured	Contribution of local foods to the diet Contribution of food production to household incomes				
PURPOSE: Improved resilience of food production systems to Climate change impacts on food security	Threat level to food production systems, related to CC effects	Food production systems vulnerability rated as high	By end of the project the vulnerability level in Houma village will be rated as medium	Project reports Farming systems evaluations	CC measures are long term and the project may not capture all changes in ecosystem vulnerabilities
OUTPUTS					
1. Improved knowledge and awareness of climate change by stakeholders	Targeted communities trained in climate change threats and adaptation measures reducing vulnerability, in particular to food security	Community knowledge in the adaptation measures to reduce food security is limited	At the end of the project 70% households with at least one member having knowledge of climate threats and adaptation measures	Project reports Project reports	Community structures need to be strengthened Community leaders will promote participation of communities
2. Adaptable food production systems to CC impacts developed for the Houma community	• Increase production and area of crops	Current acreage and yield/area	By end of the project there will be a 40% increase in area of crops and yield per area		Strong support from Govt and donors
	• Increase production and number of small livestock animals	Current number of animals	Animal numbers will increase by 40% by end of project		
	• Conduct research in priority areas that will improve productivity	Currently no research	By end of the project research results will be generated to support adaptation strategies		
3. Improve food availability and accessibility by households	• Household food production	Backyard gardens and variety of foods produced	By end of the project 70% households have backyard gardens and produce varieties of foods		
	• Household incomes	Currently household incomes low	By end of project household incomes will be doubled		

Tefisi

Intervention Logic	Objectives Verifiable Indicators (OVIs)	Baseline	End of the Project	Means of Verification (MOVS)	Assumption
GOAL: Household of Tefisi Village in Vava'u are food and income secured	Contribution of local foods to the diet Contribution of food production to household incomes				
PURPOSE: Improved resilience of the community food production systems to Climate change impacts	Threat level to food production systems, related to CC effects	Food production systems vulnerability rated as high	By end of the project the vulnerability level in Tefisi village will be rated as medium	Project reports Farming systems evaluations	CC measures are long term and the project may not capture all changes in ecosystem vulnerabilities
OUTPUTS					
1 Improved knowledge and awareness of climate change by stakeholders	Targeted communities trained in climate change threats and adaptation measures reducing vulnerability, in particular to food security	Community knowledge in the adaptation measures to reduce impacts of CC on food security is limited	At the end of the project 70% households with at least one member having knowledge of climate threats and adaptation measures	Project reports Project reports	Community structures need to be strengthened Community leaders will promote participation of communities Strong support from Govt and donors
2 Productivity of food production systems on the slopingland of Tefisi improved	• Conduct on-farm trials in priority areas that will improve productivity	Currently no research	By end of the project research results will be generated to support adaptation strategies		
	• Increase production and area of crops	Current acreage and yield/area	By end of the project there will be a 40% increase in area of crops and yield per area		
	• Increase production and number of small livestock animals	Current number of animals	Animal numbers will increase by 40% by end of project		
3 Adaptive capacity of target households improved	• Household food production	Backyard gardens and variety of foods produced	By end of the project 70% households have backyard gardens and produce varieties of foods		
	• Household income	Currently household incomes low	By end of project household incomes will be doubled		

Kolonga:

Intervention Logic	Objectives Verifiable Indicators (OVIs)	Baseline	End of the Project	Means of Verification (MOVS)	Assumption
GOAL: Household of Kolonga Village in Tongatapu are food and income secured	Contribution of local foods to the diet Contribution of food production to household incomes				
PURPOSE: Improved resilience of the community food production systems to Climate change impacts	Threat level to food production systems, related to CC effects	Food production systems vulnerability rated as high	By end of the project the vulnerability level in Kolonga village will be rated as medium	Project reports Farming systems evaluations	CC measures are long term and the project may not capture all changes in ecosystem vulnerabilities
OUTPUTS					
1. Improved knowledge and awareness of climate change by stakeholders	Targeted communities trained in climate change threats and adaptation measures reducing vulnerability, in particular to food security	Community knowledge in the adaptation measures to reduce impacts of CC on food security is limited	At the end of the project 70% households with at least one member having knowledge of climate threats and adaptation measures	Project reports	Community structures need to be strengthened Community leaders will promote participation of communities Strong support from Govt and donors
2. Productivity of food production systems in the coastal area of Kolonga improved	• Develop crop production systems resilient to exposure in the coastal area	Currently prone systems	By end of the project resilient production systems developed	Project reports	
	• Increase production and area of crops	Current acreage and yield/area	By end of the project there will be a 40% increase in area of crops and yield per area		
	• Increase production and number of small livestock animals	Current number of animals	Animal numbers will increase by 40% by end of project		
3. Adaptive capacity of target households improved	• Household food production	Backyard gardens and variety of foods produced	By end of the project 70% households have backyard gardens and produce varieties of foods		
	• Household income	Currently household incomes lo	By end of project household incomes will be double		