Ministério da Agricultura e Pescas

Gabinete do Ministro

Predicted changes to rainfall and temperature in Timor-Leste due to climate change and it's impact on agriculture

The global climate change phenomenon is an important consideration for agricultural and food security planning in Timor-Leste (East Timor). Agricultural impacts may be among the most important effects a changing climate will have on Timor-Leste. Thorough research and an in-depth analysis of the available data is important for Timor Leste's development process.

The main effects of climate change are changes in temperature and rainfall. Temperature and rainfall are also two of the main factors related to plant growth and crop yields.

Precipitation and temperature predictions for Timor Leste can be visualised in map format using the DIVA-GIS program as a platform for inputting data and outputting visual representations. Predictions for the years 2020, 2050 and 2080 (CSIRO, CCCMA, HADLEY) and 2 x CO_2 (CCM3) atmospheric concentrations have been considered in this brief. The data was downloaded from the internet (public domain and free) and loaded into the program at SoL; outputs have been manipulated to show Timor Leste specific images which are useful for predicting long term climatic changes that may affect agricultural production and food security.

This information together with observed data collected in Timor Leste over the last 5 decades will allow us to verify the accuracy of the baseline climate maps, make future yield predictions at the sub-district level and identify which areas will be most effected by changes in temperature and precipitation.

Summary findings:

Temperature— 4 of 4 models predict temperatures to increase by 1.25-1.75 degrees C by 2050. Monthly variation should not change significantly

Precipitation—3 of 4 models predict an increase in rainfall by 2050. The highest annual increase is approximately 7-13%, the highest monthly increases are in January, February and May.

WORLDCLIM—A global climate layer representing the baseline 'current' climate. We use this as a foundation for climate prediction models to build on to produce various climate outcomes under various climate scenarios.

Global circulation models (GCMs) are mathematical models used for simulating the atmosphere and oceans of the earth. The GCMs we used were created by CSIRO, CCCMA, HADLEY and CCM institutions. All the GCMs used the WORLDCLIM climate layer as a common baseline and calculated potential future climatic changes on top of it.

DIVA-GIS is a free computer program for mapping and geographic data analysis (a geographic information system (GIS). DIVA is used to visualise the output of the various GCMs in a common format. All the maps in the following pages were produced using the DIVA-GIS program.

CSIRO -The Commonwealth Scientific and Industrial Research Organisation is an Australia based institution at the forefront of climate research and modelling in the Asia-Pacific region. The CSIRO GCM incorporates El Nino interactions and provides more accurate predictions for the south Pacific regions.

HADLEY– The Hadley Centre for Climate Prediction and Research is the UK's main body for climatic research. It aims to better understand the atmospheric processes that lead to climate change, with a view to simulating the last 100 years of climate change and predicting the next 100. Particular attention is paid to inter-annual and decadal variability.

CCCMA– The Canadian Centre for Climate Modelling and Analysis.

CCM3– From the US National Centre for Atmospheric research. Projections are based on a 2 x CO_2 scenario.

Seeds of Life (SoL) activities form a program within the Timor Leste Ministry of Agriculture and Fisheries (MAF). Funding for the program is provided collaboratively by MAF and the Australian Government through the Australian Agency for International Development (AusAID) and the Australian Centre for International Agricultural Research (ACIAR). The Centre for Legumes in Mediterranean Agriculture (CLIMA) within The University of Western Australia (UWA) is commissioned to coordinate the Australian funded activities.

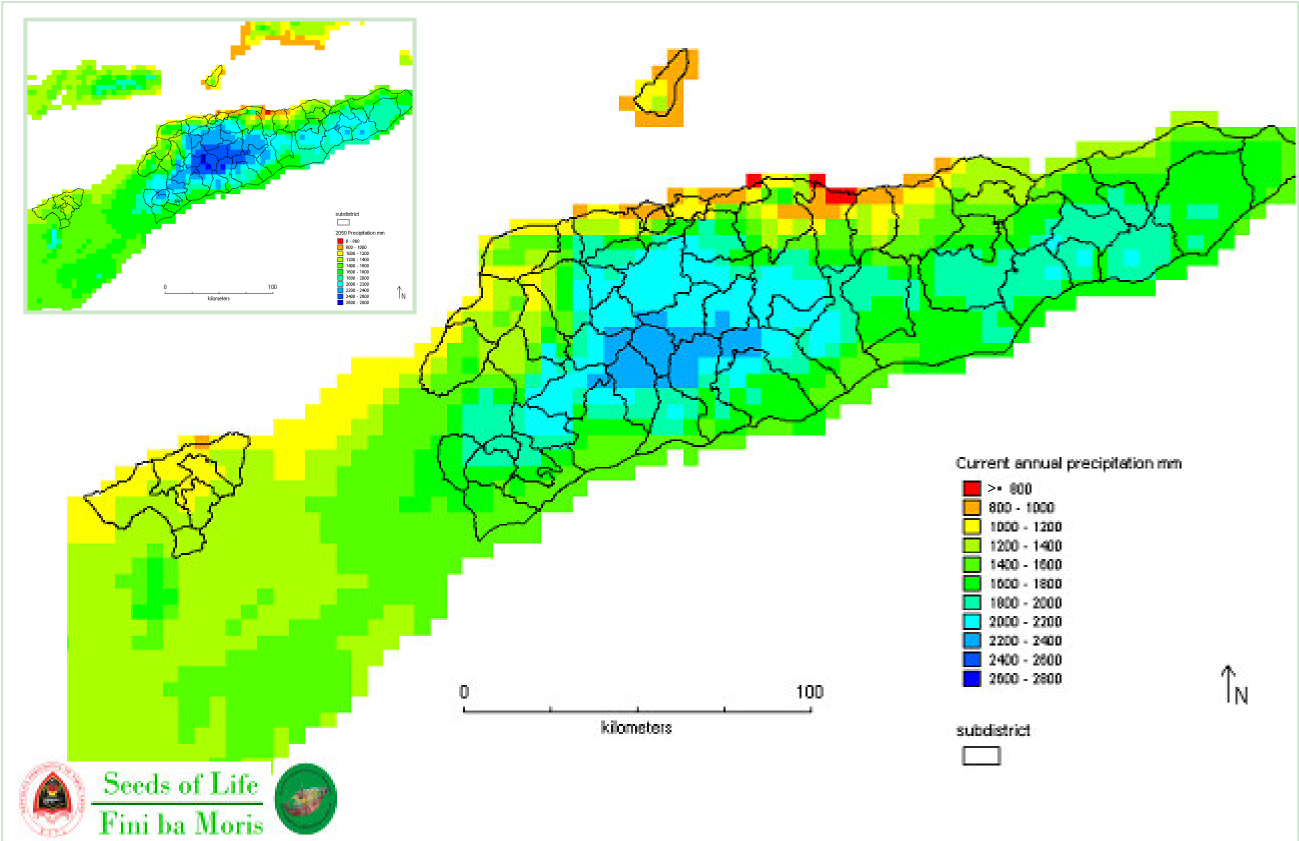

Figure 1.

Baseline annual precipitation in TL (average 1950 - 2000) and a future projection for 2050 (inset) from WorldClim, CSIRO data sources. This model allows us to see a baseline precipitation map and compare it with future projection maps to visualise changes.

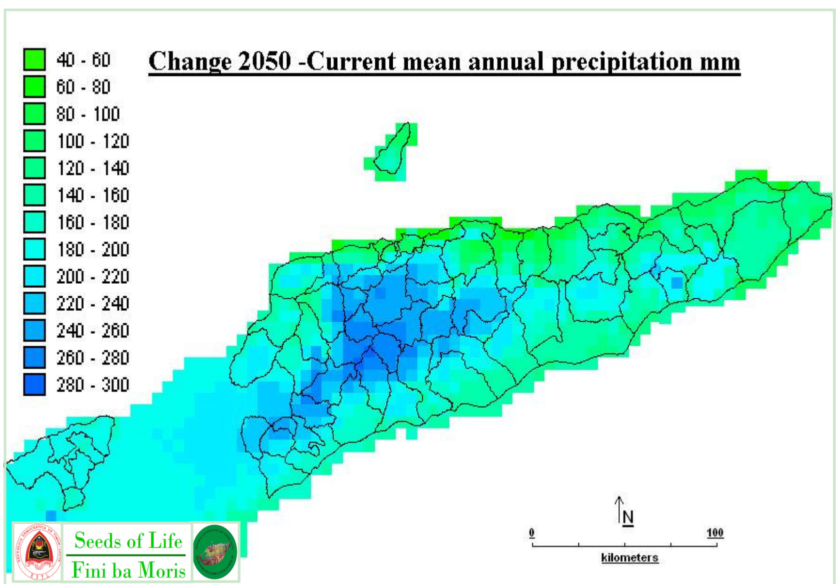

Figure 2.

Predicted change in annual precipitation for 2050 (WorldClim, CSIRO). Notice the darkest blue pixels indicating +280mm of rain per year at some of the higher elevations in Timor-Leste's central mountain range (i.e.Hato Builico and northern Same).

Figures 1 and 2 show the total annual rainfall for the years 2000 and 2050. We can see the increase in rainfall, particularly in the central highland areas, along the spine of the country and with a tendency towards the south coast.

The north coast is currently drier than the south coast and appears to remain drier in comparison to the south coast to 2050. However precipitation on the north coast as with the entire country, increases through time.

The maximum current level of rainfall is in Ainaro, with an annual mean of 2380mm. The projected 2050 value for Ainaro is 2658 mm (an increase of approximately 11.6%).

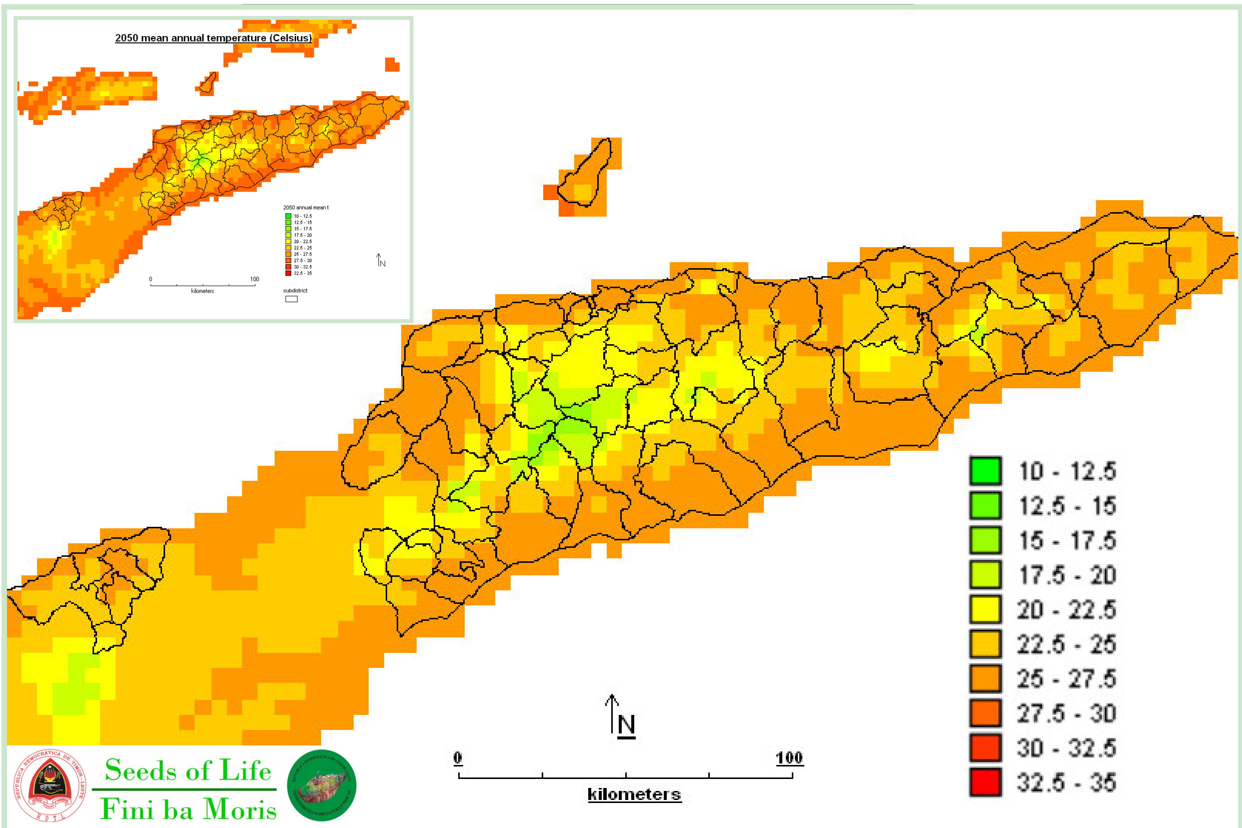

Figure 3.
The baseline mean annual temperature for TL (average 1950 - 2000) and future projection for 2050 (inset) from WorldClim, CSIRO data sources. This model allows us to see a baseline temperature map and compare it with future projection maps in order to visualise changes over time.

Figures 3 and 4 show the mean annual temperature across Timor Leste. The darkening orange colouring of the inset map in figure 3 indicates that the temperature predictions for 2050 are hotter than those observed for the beginning of the century.

Figure 4 demonstrates that in contrast to precipitation, the warming effect is uniform across the country with all areas experiencing an approximate 1.5 degree Celsius increase in average annual temperature.

Figure 5 on the next page displays the monthly average maximum temperature differences between the years.

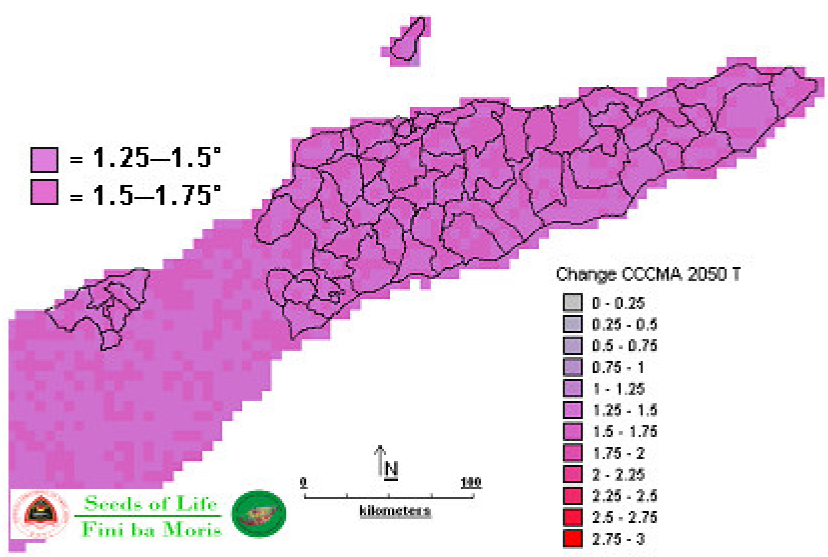

Figure 4.

Predicted change in mean annual temperature between baseline temperatures (2000) and 2050 (WorldClim, CSIRO). All of Timor-Leste will experience an increase of temperature of between 1.25 and 1.75°C. There appears to be no trend for temperature change spatially or with elevation.

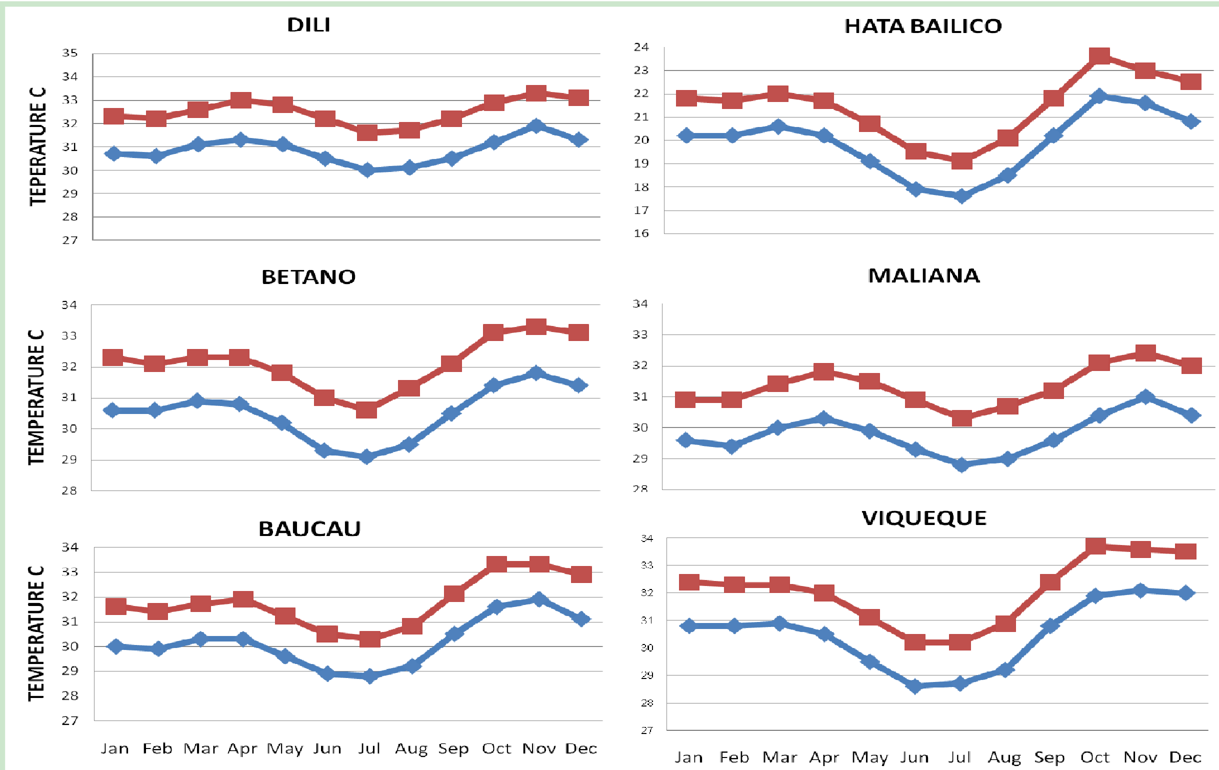

Figure 5.

These graphs show us the changes in mean maximum monthly temperature between interpolated base levels and predicted levels (WorldClim, CSIRO). The red lines are the predicted temperatures, while the blue lines are WorldClim baseline temperatures.

The graphs above show us that all sites throughout the year will experience a fairly uniform increase in temperature of about 1.5 °C that follows the same month-to-month pattern as current monthly temperature trends (coolest in July, warmest in October). There is little variation to this pattern spatially across Timor-Leste, or temporally between the months of the years being compared. All mean annual temperature change maps in figure 11 (comparing predicted temperatures from four models) show a largely uniform spatial temperature increase of between 1.25 and 1.75°C, corresponding with the uniform gaps in the 2 plotted lines in Figure 5 above.

Increased temperatures can negatively affect yields through decreasing the period of growth, disruption of pollination mechanisms and increasing evapotranspiration leading to desiccation. Observed data (Figure 6) shows us the likelihood of daily max temperatures reaching 35°C for consecutive days within a month. Hotter average temperatures correlate with more consecutive days above 35°. An increase of 1.5°C above observed levels across Timor will increase the likelihood of more areas of the country experiencing hot spells during these critical stages. This may have implications on where crops such as maize can be successfully cultivated.

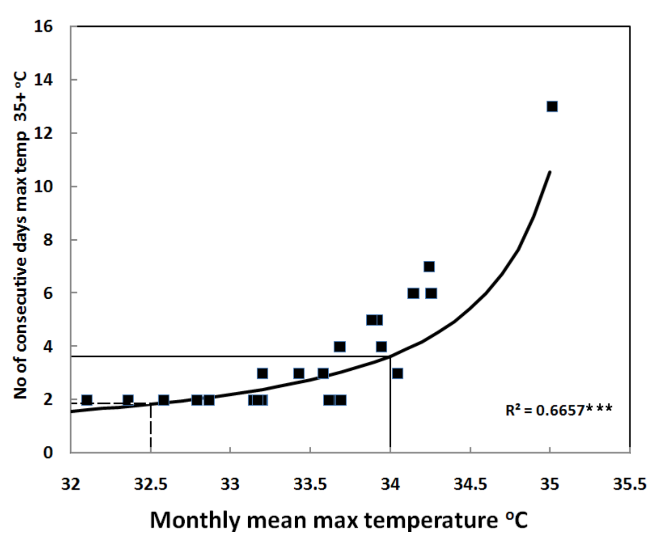

Figure 6.

Under current mean max conditions, 1 or 2 consecutive days are expected to exceed 35°C. Projected conditions to 2050 predict that 4 or 5 consecutive days may exceed 35°C (see graph). April and May are some of the hottest months, and also critical pollination months for rice.

The data in Figure 6 was observed at 3 of the driest areas of Timor, Manatuto, Betano and Dili.

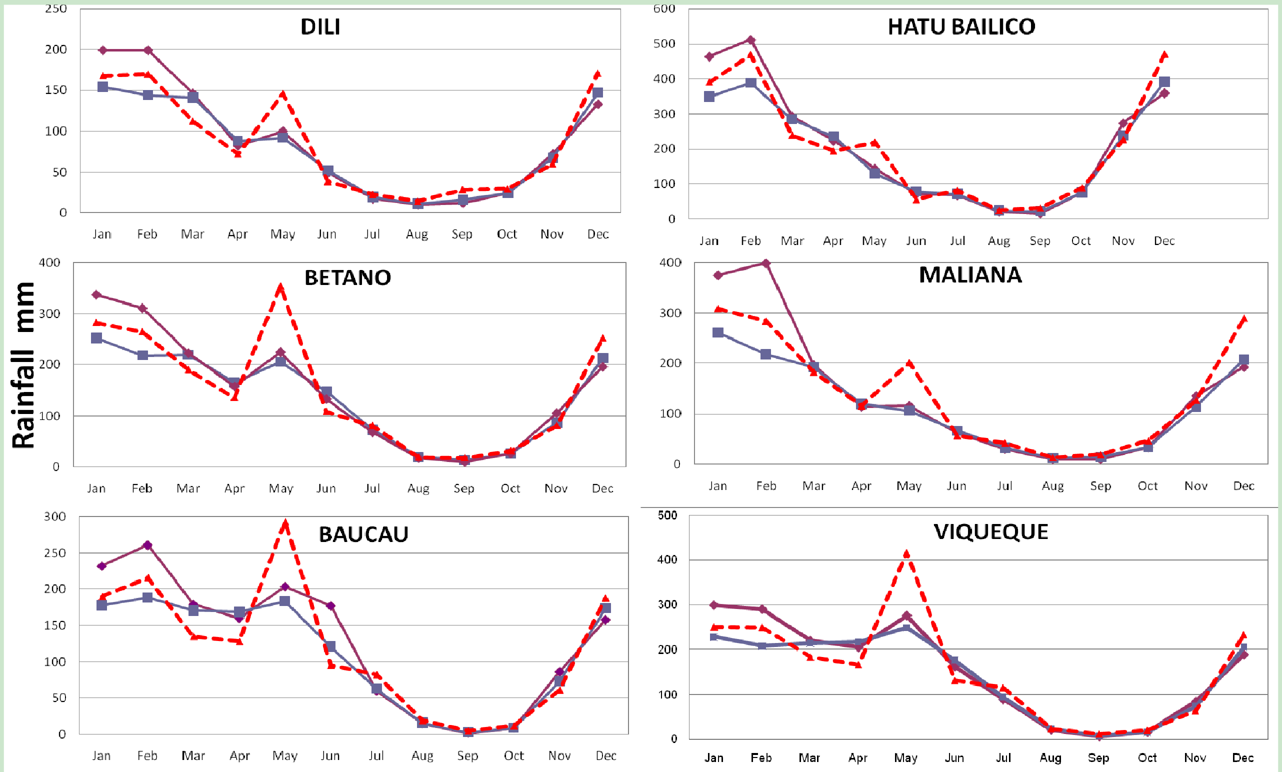

Figure 7.

The precipitation graphs above show obvious changes to the wet-season's monthly rainfall cycles and a high degree of spatial and temporal variability for both the CSIRO 2050 (purple line) and CCM3 2xCO2 (red dashed line) models, when compared to the current rainfall (blue line)

Figure 7 CSIRO—All sites share a common trend of a visible increase in January and February rainfall by 2050, but the same or slightly less rainfall in March and April. Those that currently show a second peak in rainfall in May appear to receive a slight increase by 2050, leading to a slightly stronger bi-modal wet-season pattern. This is most obvious in Baucau, which sees an approximate 35% increase in Jan and Feb, and a 10% increase in May and June.

Figure 7 CCM3 (2xCO2) - predictions differ from the CSIRO (2050) predictions in that they predict a much greater increase in May's rainfall, leading to a far stronger (or in some cases, a new) bi-modal wet-season pattern. This is most obvious in Maliana which currently has a fairly mono-modal wet-season, and in Betano and Viqueque where the current bi-modal norm appears to become more pronounced by 2050, with May's rainfall far exceeding both December's and January's respectively. Dili and Hatu Bailico both also show a more bi-modal pattern in 2050 than the current relatively mono-modal conditions.

However some months and some places, such as during February and March in Betano, may become drier as bi-modal patterns increases in strength. In this case the number of consecutive days with <1mm of rain can increase with important ramifications for yields due to drought affects on the grain filling stages of crops (see Figure 8).

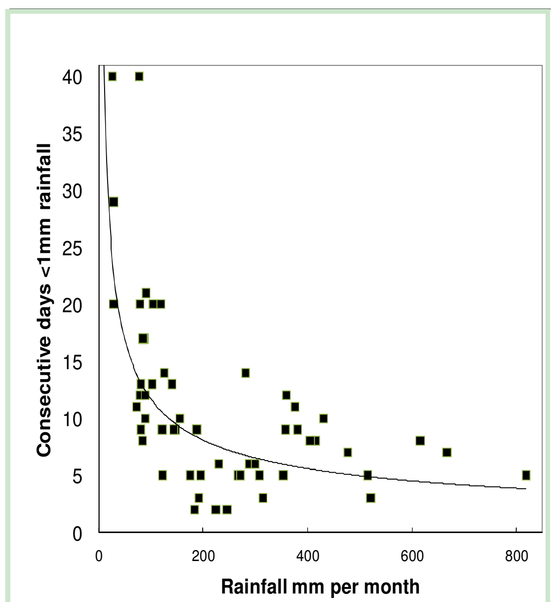

Figure 8.

This scatter graph of data points from locations across Timor (Betano, Manatuto Aileu and Maubisse) shows the relationship between monthly wet-season rainfall and the number of days when <1mm of rain is collected in that period.
Less rain means more consecutive dry days. This is most noticeable under 200mm/month.

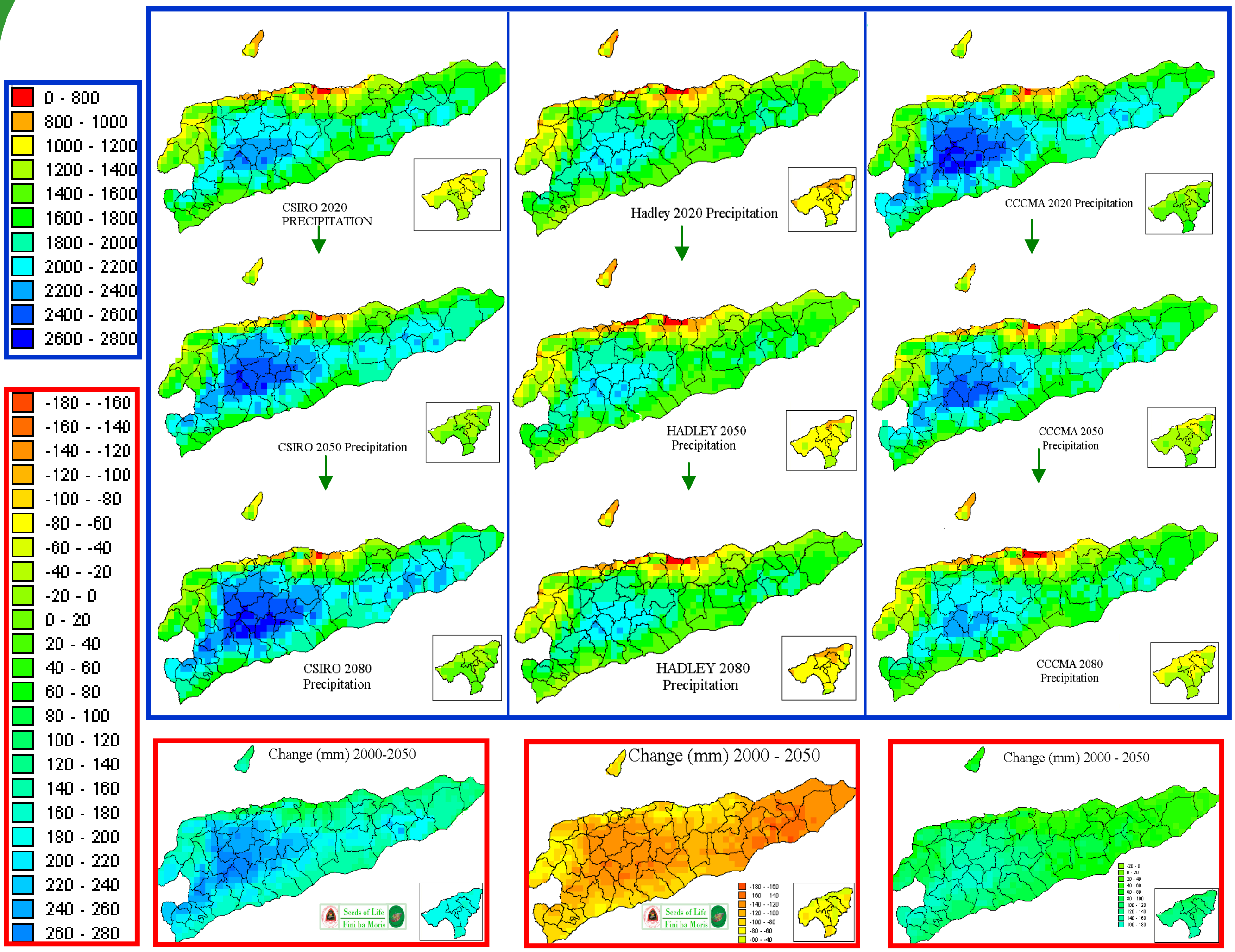

Figure 9. Annual rainfall projections to at 2020, 2050 and 2080 are shown above. The 4 models (3 shown plus CCM 2xCO_2) produced varying results, though 3 out of 4 predict 2020 and 2050 to be wetter than current conditions, and 2 out of 4 predict 2080 to be wetter than current conditions. The consensus prediction is for overall wetter conditions in 2050 than in 2000.

From figure 10 we can see that across the country the difference (increase or decrease) in total annual rainfall from one year to the next i.e. 'rainfall variability' is approximately 33%.

We can also see that the average difference between current levels and 2080 levels is approximately +13%. We know that current levels in Dili for example are about 900 mm of rain per year, and the variability is 38% (from the graph).

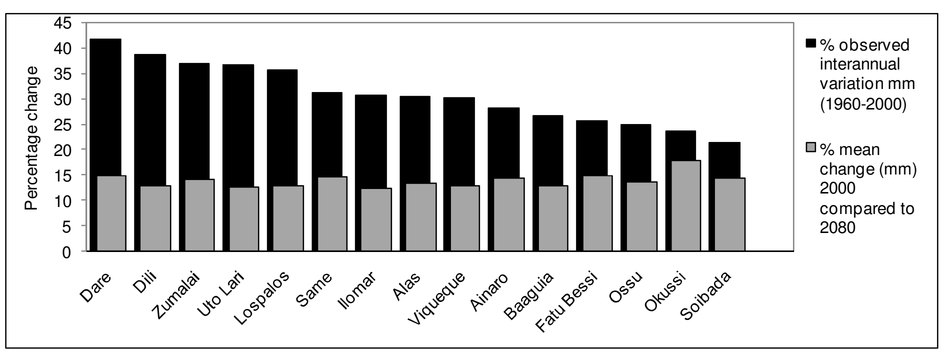

Figure 10.This graph displays the average variability in quantity of precipitation between consecutive years from 1960 to 2000, and compares it with the difference between current average observed precipitation and that predicted for 2080 (i.e. the average between all years during 1960-2000, and 2000 Vs 2080).

By 2080 we can expect an average of 1017 mm of rain (900 + 13%). The current average inter-annual range is from 729mm up to 1071mm. This means we are already experiencing rainfall conditions greater than the mean predicted increase. 15 out of the last 65 recorded years (1914 –2009) received greater rainfall than the average predicted for 2080.

This indicates that the mean increase in rainfall between now and as far into the future as 2080 will remain less than the inter-annual variability that farmers are experiencing now. With this information we can start to think about some aspects of climate change as processes that we are already addressing and managing, rather than as unprecedented contemporary issues that will require completely new solutions. Adapting to current variability will help us adapt to climate change.

Through ensuring farmers are provided with the right support and information, interventions that can help them to cope with current inter-annual variation (an approximate 30% change in precipitation from year to year) will build good foundations for adapting to most of the changes that are likely to develop through long-term climate change (a 10% increase in mean annual precipitation).

Consideration must however be given to a 2050 scenario where the +10% mean precipitation combines with a year where the 30% (or more) inter-annual variability manifests into unprecedented amounts of rainfall. These events may cause 'threshold effects'. This happens when critical levels are surpassed (river banks being breached etc) presenting farmers with conditions they have not been exposed to previously and may require different coping mechanisms to those that have been historically appropriate under current conditions.

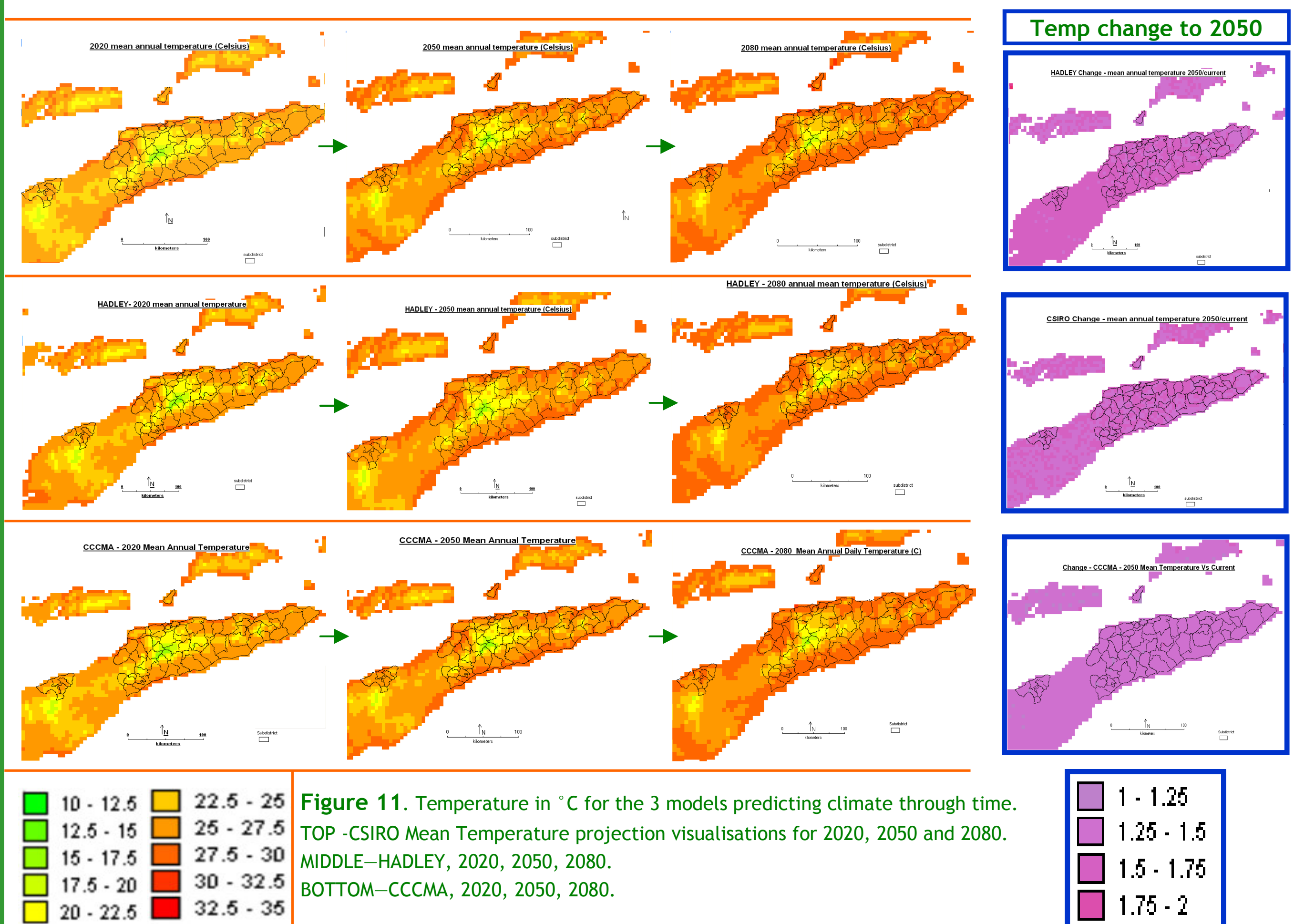

Figure 11. Temperature in °C for the 3 models predicting climate through time.
TOP -CSIRO Mean Temperature projection visualisations for 2020, 2050 and 2080.
MIDDLE—HADLEY, 2020, 2050, 2080.
BOTTOM—CCCMA, 2020, 2050, 2080.

All models show an increase in temperature through each time period 2000-2020, 2020 -2050 and 2050 -2080. All 3 have a change range of between 1.25 and 1.75 degrees Celsius between 2000 and 2050.

Temperature is very strongly correlated with altitude, this is reflected in the maps above. These maps were created by interpolating data from various weather stations and data sets against longitude, latitude and altitude. Temperature values in areas where there is little or no data can be calculated in this way, however these calculations may not always be accurate.

In order to check whether we can be confident with the accuracy of projections for Timor-Leste, Worldclim generated data for Timor-Leste was plotted against observed data collected in Timor during Portuguese, Indonesian and post independence times. These graphs show us that the generated data fits very closely with observed temperature recordings, and we can therefore have some confidence in its ability to interpolate (predict) the current baseline temperatures for places where no data has been recorded.

The projections (2020, 2050, 2080) take this baseline data and push it through various climate 'layers' depending on the model used (CSIRO, CCCMA, CCM3, HADLEY) and generate a final prediction which takes into account many of the factors that determine climate throughout the globe. The resolution for these predictions is 2.5 arc minute squares or approximately 5km x 5km pixels on the map of Timor-Leste. The different models predict very similar changes for temperature (+ 1.25 and 1.75°C), and as such planning for an increase in temperature for Timor is the most logical step to take to adapt to future climate change.

Summary:

Total annual rainfall for Timor-Leste is likely to increase by 7-13% (average 10 %) across all districts by 2050.

Most of this increase will fall in just 3 months—January, February and May. Dry season rainfall is largely unchanged.

While percentage rainfall increase is relatively uniform across the country, variability in absolute rainfall is large (60-300mm) with higher altitudes generally receiving the greatest increase in precipitation.

One of the four models predicts a decrease in March and April rainfall, but an over all increase across the wet season (stronger bi-modal characteristics).

One of the four models however predicts Timor Leste will become drier towards 2050.

Timor Leste is almost certainly going to become warmer. All available climate change models calculate an increase between 1.25 and 1.75 °C by 2050.

The models do not predict a great degree of temperature variability spatially or away from current monthly trend patterns, i.e. All places and all months within the year will increase by about the same amount 1.25 –1.75 °C . The hottest regions, as now, will be the north and south coast low lying areas.

Most of the predicted increase expected up to 2050 is already being experienced within the current variation. However the increase in mean rainfall of approximately 10% will most likely push all measurements up by at least 10%, making wetter conditions more common and extreme rainfall events more likely.

Addressing variability now may be the best way to adapt to future climate change.

Implications for Agriculture in Timor Leste:

Increased rainfall can increase run-off, flooding and nutrient leaching, may reduce general soil structural quality and can damage infrastructure such as roads, affecting access to markets and inputs.

...however it may also replenish aquifers more readily and hence improve continuity of spring flow.

Increased precipitation can directly affect yields through promoting rotting, pests and fungal infections of grain.

...but also may reduce overall transpiration stresses associated with higher temperatures.

Decreased rainfall, especially during grain-filling and pollination stages (if coupled with high temperatures) can drastically reduce yields of rice

Increased temperatures will 'push' species towards higher altitudes as higher temperature impact on the upper end of species temperature tolerance limits. Species that require lower temperatures to survive and reproduce will be forced to colonize high altitudes where temperatures are lower.

Higher temperatures are generally expected to be beneficial for tropical species but bad for more temperate species.

Increased temperatures can have an effect on the pollination capabilities of species such as rice and maize. Higher temperatures coupled with less rainfall can negatively affect pollination through desiccation of the pollen and anthers.

Increased temperatures can have phenological effects on plants, affecting their life cycles, time to maturity and yields.

The most important climate issues farmers are currently facing are based on inability to predict rainfall, i.e inter-annual variability and intra-annual fluctuations of rainfall, especially during planting time (false starts, rain followed by drought).

Unfortunately climate change models cannot calculate a change in variability between years in the future, and the latest scientific information concludes that we cannot yet predict with any accuracy whether variability will increase or decrease in the future.

What we can do now is begin to address farmers needs through focusing on coping with the high variability currently being experienced from year to year. In doing so we will build a variability coping strategy - laying foundations that allow farmers to adapt to the climatic change impacts that are most likely to occur in the future.

Seeds of Life

Fini ba Moris

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