Fundación Avina

GREEN CLIMATE FUND

CLIMATE VULNERABILITY ANALYSIS IN ILHA DO MARAJÓ / PA

Executive Summary

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H$_2$O Company

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PRESENTATION

The present study aims to understand the climate vulnerability of small producers residing in the municipalities of Cachoeira do Arari, Salvaterra and Soure, located in the Marajó Archipelago, based on the analysis of the occurrence of climatic events in the region, and the projection of the climatic variables of interest in future scenarios. The current agroforestry practices adopted by the target population of the study were also evaluated, aiming to identify opportunities to adapt to the effects of climate change and to propose the use of agroforestry systems to increase the resilience of communities and the landscape.

CHARACTERIZATION: TERRITORY, POPULATION AND AGROFORESTRY ACTIVITIES

The Marajó Archipelago is the largest fluviomarine archipelago in the world, located in the northeast of the state of Pará, in the delta of the Amazon and Tocantins rivers, in Brazil. It comprises 16 municipalities, among which are Cachoeira do Arari, Salvaterra and Soure, located in the eastern portion. Together, the 3 municipalities have 74,499 inhabitants, which corresponds to 13% of the total population of Marajó, with a significant part residing in rural areas. There is also low economic performance in these cities, with an average GDP per capita of R$ 7,583.74, approximately 40% lower than the state and with a large part of the population unemployed or working informally. As a result, in 2020 the municipalities had low human development indices (IDHM).

CACHOEIRA DO ARARI	• Target public: 1 quilombola community and 2 settlements • About 727 families • Main productive activity is the extraction of açaí and fishing • Income between half a minimum wage
SALVATERRA	• Target public: 16 quilombola communities • About 1,839 families • Main productive activity is agriculture (cassava and pineapple), followed by fishing and raising small animals
SOURE	• Target public: 6 communities • About 1,839 families • Main productive activity is fishing (fish, crabs, shrimp and shellfish), exploitation of non-timber forest resources and small animal breeding • Income between half and 1 minimum wage

CLIMATE DIAGNOSIS

From the analysis of the historical series of 53 years (1968-2020) obtained from meteorological stations close to the study region, four main climate changes were identified, they are:

TEMPERATURE INCREASE

Between 1968-1997 the maximum temperature was 32.8°C and between 1991-2020 this value was 33.1°C. The annual average temperature also had an increase of 0.3 ºC, going from 27.3 ºC to 27.6 ºC. The temperature rise is greater from May to August, with July already showing a difference of 0.5ºC.

PRECIPITATION REDUCTION

Between 1968-1997 the average annual rainfall was 3,247 mm, while in the last 30 years (1991-2020) the value was 2,896 mm, a reduction of 11% (351 mm). The greatest reductions in precipitation occurred in the months of January, February, April and May, which are relevant months for the region's agricultural calendar. The historical data series (1968-2020) shows a predominance of years with rainfall below the historical average from the 2000s onwards.

INCREASE IN EXTREME EVENTS

The increase in the period of prolonged droughts is already being observed in the municipalities, in 2009 more than 2 months were registered in the region without intense rains, which resulted in a reduction in the flow of rivers and difficulty in accessing drinking water, especially for riverside populations. In Cachoeira do Arari, the drought lasted until the beginning of 2010, registering the worst drought in the last 30 years. The drought caused the loss of cattle herds, withered vegetation and the relocation of families to other municipalities, as they no longer had access to drinking water. In addition, there was an increase of 10.5% on days of very intense rainfall, when rainfall exceeds 150 mm/day, and a reduction in the time intervals between these episodes. In March 2009, the municipality of Cachoeira do Arari declared a situation of emergency due to flooding caused by heavy rains that hit the region (PARÁ, 2009). Between 1968 and 1997, 10.4% of the days had temperatures above 32ºC, while between 1991 - 2020 this value rose to 18.6%.

SEA LEVEL INCREASE

The effects of sea level advance on the study region are already observed, with impacts on fluviomarine dynamics, mainly in Soure and Salvaterra. In 2017, the municipality of Salvaterra declared a situation of emergency due to the high risk of river erosion with the influence of waves and tides in the Centro neighborhood and risk of river erosion in the regions of Bairro do Caju, Caldeirão, Porto do Camará and the Condeixa community (SALVATERRA, 2017).

CLIMATE SCENARIOS

For this study, 2 scenarios proposed by the IPCC (Intergovernmental Panel on Climate Change) were adopted through its Special Report on Emissions Scenarios - RCP's (Representative Concentration Pathways) 4.5 and 8.5 - in order to contrast two scenarios, one being realistic and the other pessimistic. The projections for the region were made using scenario data from the HadGEM model, regionalized using the ETA model. The Baseline used for the elaboration of climate scenarios is the period 1961-1990.

Figure 1 indicates that in the RCP 4.5 scenario, annual precipitation volumes are projected to decrease by around 23% by the end of the century, and in the RCP 8.5 scenario, by around 43%, with Cachoeira do Arari and Salvaterra showing the greatest precipitation reductions. The rains of greater daily intensity should continue to occur in the vicinity of the urban areas of Soure and Salvaterra, as shown in figure 2.

Regarding the increase in temperature (Figure 3), in the RCP 4.5 scenario, an average increase of 2.7ºC is projected by the end of the century, in relation to the average value of 1961-1990. In the RCP 8.5 scenario, the increase can

reach 4.9 °C. The central portion of Salvaterra and south of Cachoeira do Arari, where quilombola communities are located, may be more affected by periods of water scarcity (Figure 4).

Future scenarios indicate the trend of sea level rise. In Figure 5, it is possible to notice that the municipality of Soure is the one with most of its territory flooded due to the advance of the sea. In the RCP 4.5 scenario, the municipality would have more than half of its territory submerged, and above 60% in the RCP 8.5 scenario. In Salvaterra, in the RCP 8.5 scenario, up to 7% of the municipality's area would be submerged, with the urban area being the most affected. In Cachoeira do Arari, in the RCP 4.5 scenario, less than 1% of its area would be submerged, while in the RCP 8.5 scenario, these areas would exceed 5% of the municipality's area. The most affected regions coincide with the areas where the settlements under study are located.

Figure1: Total annual rainfall (a) 1961-1990 (b) RCP 4.5 scenario (2021-2050) (c) RCP 8.5 scenario (2021-2050)

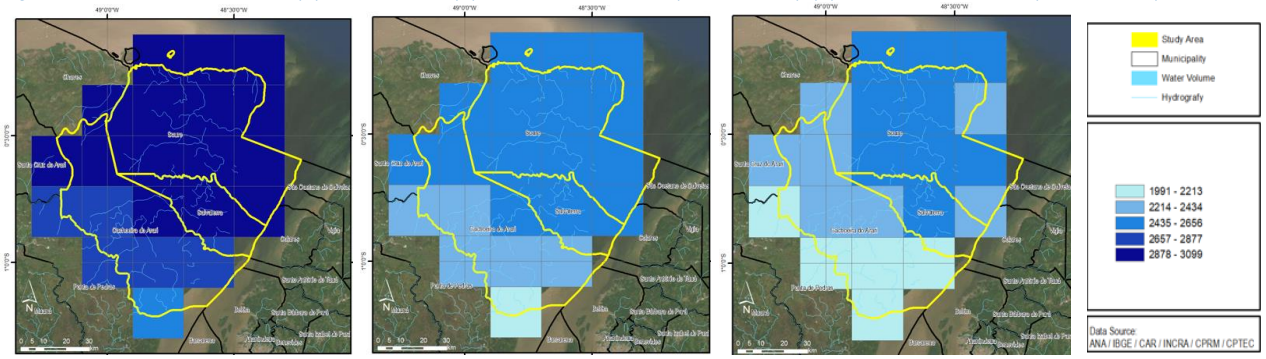


Figure 2: Maximum daily rainfall (a) 1961-1990 (b) RCP 4.5 scenario (2021-2050) (c) RCP 8.5 scenario (2021-2050)

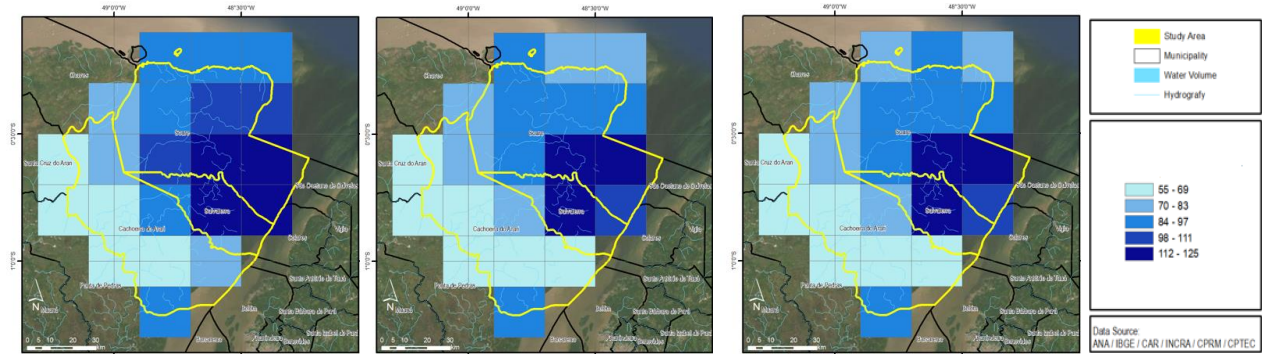


Figure 3: Air temperature at 2 meters (a) 1961-1990 (b) scenario RCP 4.5 (2021-2050) (c) scenario RCP 8.5 (2021-2050)

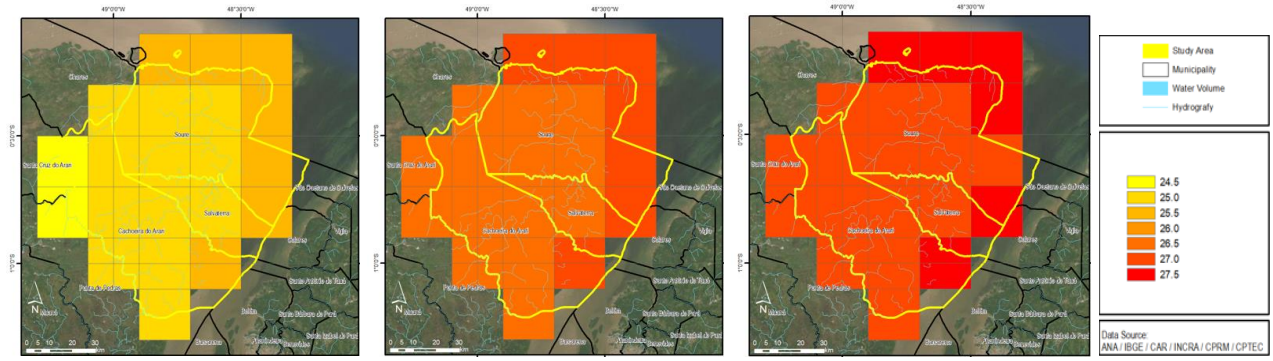


Figure 4: Consecutive days without rain (a) 1961-1990 (b) scenario RCP 4.5 (2021-2050) (c) scenario RCP 8.5 (2021-2050)

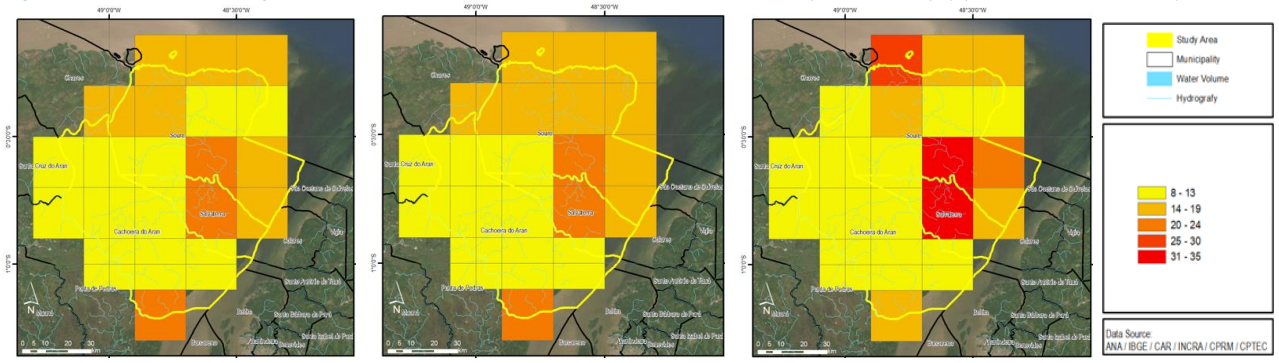
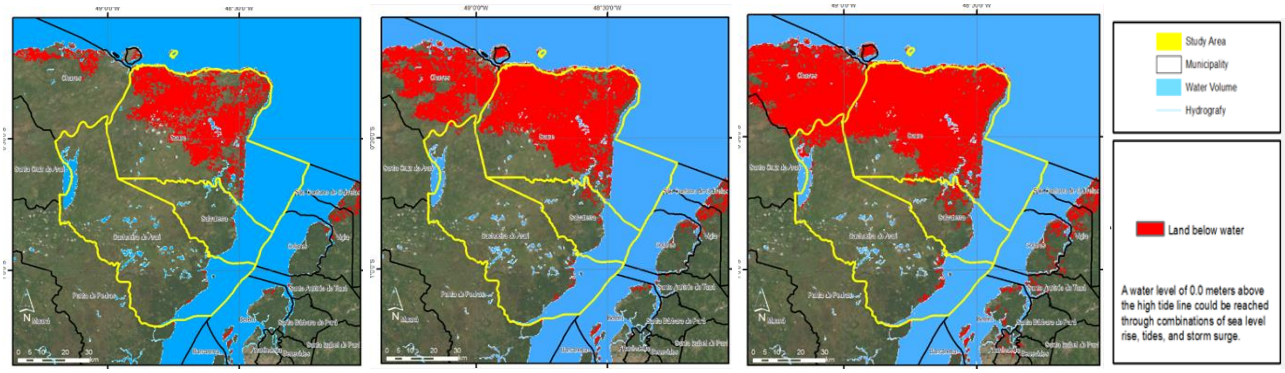


Figure 5: Sea level rise (a) 1961-1990 (b) RCP 4.5 scenario (2021-2050) (c) RCP 8.5 scenario (2021-2050)



ADAPTATION STRATEGY: AGROFORESTRY SYSTEMS

Climate change is already affecting agroforestry activities carried out by small producers in the three municipalities, which tend to worsen if forecasts are confirmed. To counterbalance the impacts in the three municipalities in the Marajó region, it is necessary to adapt agricultural systems, which implies the adoption of adequate management practices, such as the use of agroforestry systems (AFS). In this system, the high diversity of species combined in a spatial and temporal arrangement promotes ecological interactions and synergies between biological components that help to increase the adaptability of crops to climate change and variations. The table below summarizes the main impacts already observed, the adaptation strategy.

Figure 6: Climate trends for the study region, main impacts, adaptation strategy and expected benefits

Adaptation to climate change is the result of implementing a balanced agroforestry system. The layout and species selected may vary according to the criteria applied (climate, economic or gender) and family affinity, without prejudice to the resilience of the system. Below are 3 models that can be implemented in the 3 municipalities.

AGROFORESTRY BACKYARD

Implemented in the areas adjacent to the residences, that is, in the backyard. Composed of several fruit, agricultural, medicinal and ornamental species, and the creation of small animals. It aims to contain erosion processes, contain winds, create a mild microclimate and retain water in the soil.

Municipality	Soure	Salvaterra	Cachoeira do Arari
Management	Family unit	Family unit	Family unit
Area/unit (ha)	0.1	0.1	0.1
Units	200	200	200
Total area (ha)	20	20	20
Families/unit	1	1	1
Benefited families	200	200	200

DIVERSE AGROFORESTRY SYSTEM

Indicated for implementation in upland areas, it combines the cultivation of forestry and agricultural crops in order to contain erosive processes, contain winds, create a mild microclimate and retain water in the soil.

Municipality	Soure	Salvaterra	Cachoeira do Arari
Management	Community	Community	Community
Area/unit (ha)	10	10	10
Units	11	45	20
Total area (ha)	110	450	200
Families/unit	10	10	10
Benefited families	110	450	200

SIMPLIFIED MANAGEMENT DIVERSE AGROFORESTRY SYSTEM

Composed of forest crops aimed at restoring coastal areas and riverbanks using species that are economically attractive to the population

Municipality	Soure	Salvaterra	Cachoeira do Arari
Management	Community	Community	Community
Area/unit (ha)	3	3	3
Units	20	20	20
Total area (ha)	60	60	60
Families/unit	2	2	2
Benefited families	40	40	40

CORRELATION OF AGROFORESTRY SYSTEMS

From the systems RBAs, UBAs, SBAs and CBAs presented by Vogt et al. (2016), a correlation with the Agroforestry Home Garden, Diverse Agroforestry System and Simplified Management Systems is identified in table 1, considering the species that constitute each system and the benefits linked to them in order to mitigate the environmental impacts from climate change.

Table 1: Correlation between Agroforestry Systems (Vogt et al., 2016) and Agroforestry Systems of the proposed Layouts

Sistemas Agroflorestais (Vogt et, 2016)	Function	Benefits	Correlation	Species of the Agroforestry System	Justification
Umbrella based agroforest (UBAs)	Mitigate and regulate the effects of severe wind and rainstorms	Secure annual or seasonal production of fruits and other products, reduce risk of damages from felling trees	Diverse Agroforestry System	Açaí, guava, tucumã, bacuri, andiroba, banana, cassava, beans, pumpkin, corn, pineapple, cumaru, cocoa and cupuaçu	It is considered the presence of canopy tree species in the suggested agroforestry systems that contribute to the mitigation of strong winds and storms
			Simplified Management	Acai, ingá, Murici, moriche palm, andiroba	
Shade based agroforestry (SBAs)	Manages moisture and prevents the soil from drying out during droughts. Mitigate and regulate the effects of impact waves and periods of drought	Protect pollinators and pollination of açai and other market value fruits, reduce soil compaction	Diverse Agroforestry System	Açaí, guava, tucumã, bacuri, andiroba, banana, cassava, beans, pumpkin, corn, pineapple, cumaru, cocoa and cupuaçu	Palm species are considered in the suggested agroforestry systems that contribute to the mitigation of periods with great drought
			Agroforestry Home Garden	Murici, açaí, guava, banana, papaya, cassava, coffee, gliricidia, corn, vegetables	
Cluster based agroforest (CBAs)	Helps to filtrate, retain and store fresh water during droughts and sea-water-incursion	Maintain water pools to provide fresh water and refuge for fish and wildlife	Simplified Management	Acai, ingá, Murici, moriche palm, andiroba	It was considered that the species in its composition will provide the filtration and storage of water in the soil

CONCLUSION

From the diagnosis of municipalities and analysis of climate scenarios, considering RCP 4.5 and RCP 8.5, it appears that the communities that live in this region are already being impacted by the effects of climate change. It was observed that there is a tendency to reduce the volume of annual precipitation, mainly in the rainy season (January to June), and there is an out-of-season rainfall, in the dry period (July to December), in addition, the municipality of Cachoeira do Arari has already registered a prolonged period of drought in 2009 and 2010. In relation to temperature, the tendency is for the average and maximum values of this variable to rise in the region, as well as, there is a trend of rising sea level and advancing of these waters, triggering a greater risk of salinization of soils and waters near the coastal region. The climate changes in the region and future projections indicate that there will be, mainly, an increase in the incidence of extreme weather events.

In view of this, the strategy of adapting agricultural systems through the adoption of agroforestry systems (AFS) aims to counterbalance the impacts on the municipalities of the Marajo region. The three types of agroforestry systems (Backyard Agroforestry, Diverse Agroforestry System, Diverse Agroforestry System and Simplified Management) provide different benefits that include mitigation of the effects of winds and storm surges; manages moisture and prevents soil from drying out during droughts; freshwater filtration and retention during droughts and seawater incursions; reduction of surface runoff; erosion control and reduction of production losses. These benefits are obtained through the diverse arrangement of species in each system, which combined are essential to help local communities adapt to climate change.

The areas to be implemented in the municipality must be defined according to field studies and agreements with the families that will receive the project and will be responsible for the maintenance and management of the Agroforestry Systems. The implementation areas may vary according to the AFS selection criteria presented in the A.2 report and complemented by the WRI economic feasibility study.

Therefore, the results demonstrate that the implementation of the AFS project is favorable to the reduction of climate vulnerability in the municipalities, regardless of the RCP 4.5 or RCP 8.5 scenario.