# COMPLEMENTARY INFORMATION FOR DIVERSIFIED AGROFORESTRY SYSTEMS IN MARAJO

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# AN OVERVIEW ON HYDRO-CLIMATIC DISTURBANCES AT THE AMAZON DELTA AND ESTUARE

Herein are included information: (i) on the frequency, intensity and severity of extreme rainstorms and drought spells; and (ii) extreme tidal floods, locally known as l*ançantes* that are associated to sea level rise and weather anomalies produced by climate change at the Amazon Delta and Estuary (ADE). The above hydroclimatic disturbances are shaping transitions from agriculture to agroforest at the three selected municipalities as well as other regions of the ADE. Extreme tidal floods, severe rainstorms and drought spells are directly influencing smallholder's decisions to engage in agroforest and stop practicing agriculture activities. All information included in this overview are complementing the climate information provide by consultants. The overview focuses on changes in: (i) the frequency, intensity and duration of extreme rainfall events as well as extreme drought spells during the year; and (ii) the number of extreme tidal floods (higher than 3m) during each month in 2019 and 2020 that was recorded at the fluviometric stations of Belem and Santana. Severe rainfall and drought spells as well as extreme tidal floods are mentioned by most smallholders as the reason why they are dis-engaging in agriculture and engaging in agroforest activities to produce food and income.

1. **Changes in rainfall patterns at the Amazon Delta and Estuary (ADE)**. Rainfall distribution at the ADE are seasonal: (i) a few rainstorms during the dry season that last four months: August, September, October, and November (ASON) and (ii) abundant rainfall events during the wet season that last four months: February, March, April, and May (FMAM) (Figure 1).

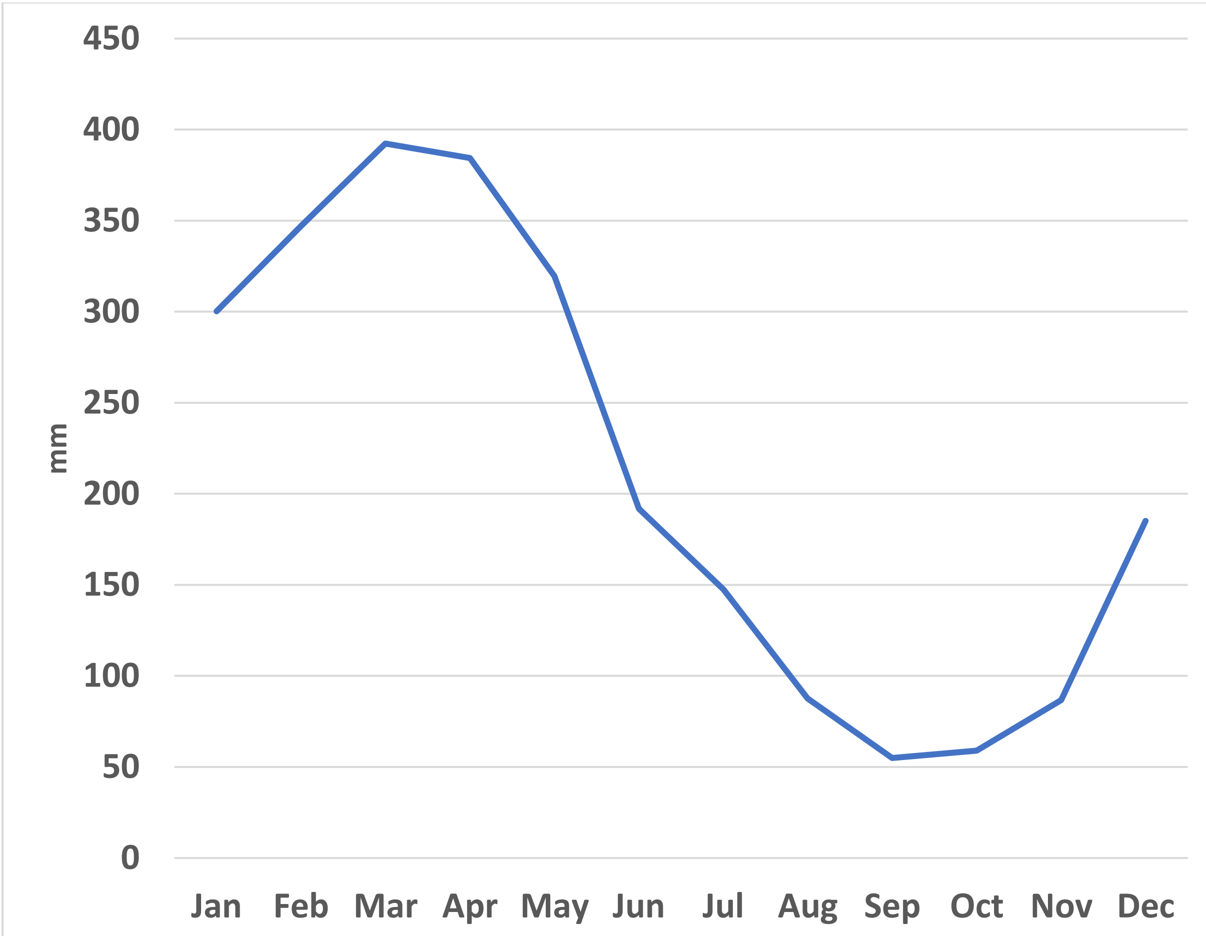



**Figure 1**: Annual cycle of precipitation estimating using climatological historical data. Values are representing the mean monthly precipitation in the last 30 years (IRI-Columbia University MAPROOM)

Smallholder's agriculture calendar have fallowed the seasons where planting and growing crops were done during the wet season and harvesting and land preparation during the dry season. Historical data shows a clear distinctive wet and dry season at the three selected municipalities (Figure 2).

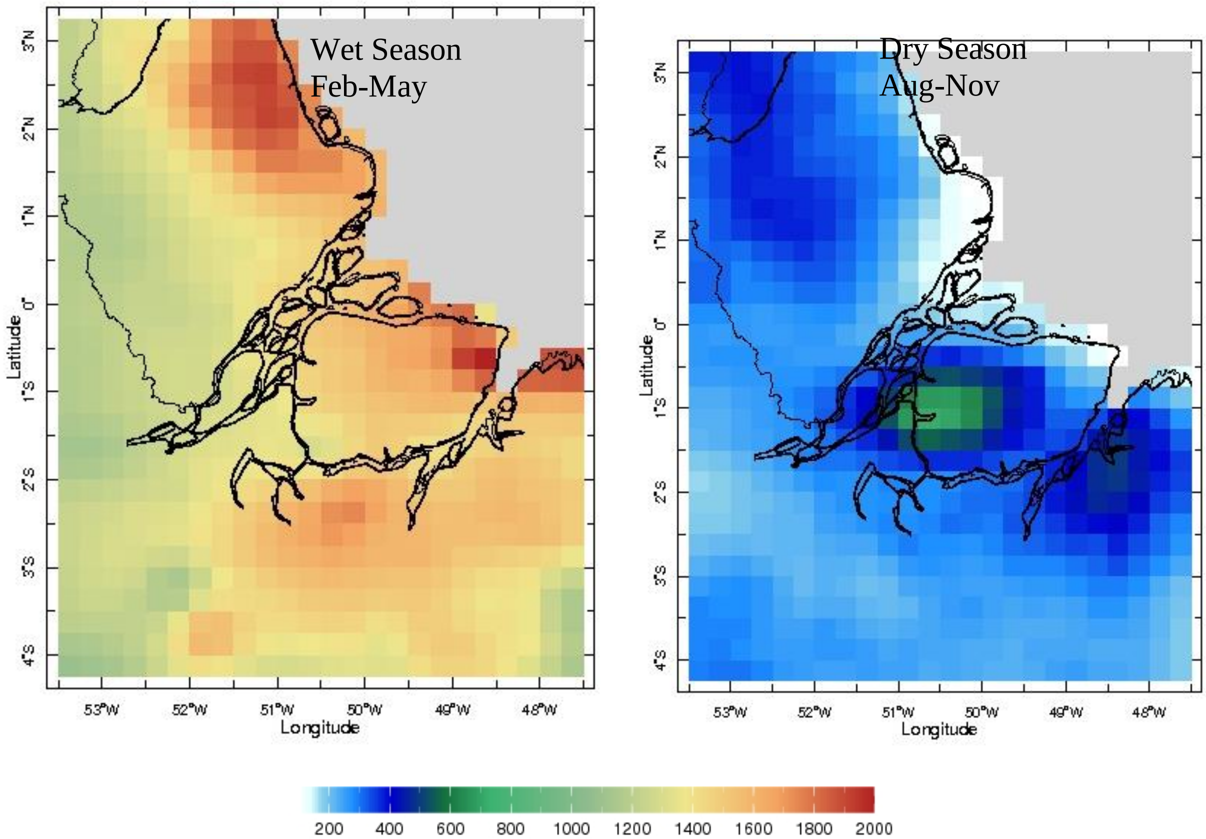



**Figure 2**: Precipitation patterns in the dry and wet months at Marajo. Data shows that the three municipalities are experiencing severe wet-season as well as severe dry-season. Values are representing the mean monthly precipitation in millimeters for both seasons (Source: IRI-Columbia University MAPROOM)

While the wet season and dry season continue to be clearly defined during the year (Figure 2), smallholders have reported extreme rainfall, drought spells and other weather anomalies during both wet and dry season. Extreme rainfall events and drought spells are syndicated by local farmers to be the main hazards affecting their agriculture activities, particularly to produce cash crops, such as cassava and corn. Smallholders have also reported changes in the timing, frequency and severity during both dry and wet seasons. Changes in rainfall patterns during the wet and dry season are mentioned by smallholders to be the main reason why they are not making agriculture fields to plant annual crops and why they are converting their agriculture fields into agroforest fields. Historical data collected by climatological stations located in the Amazon Delta and Estuary corroborate the observations of local smallholders from the three selected municipalities and neighboring areas. Based on observed rainfall data, the number of severe rainstorms is increasing during the dry season (Figure 3).

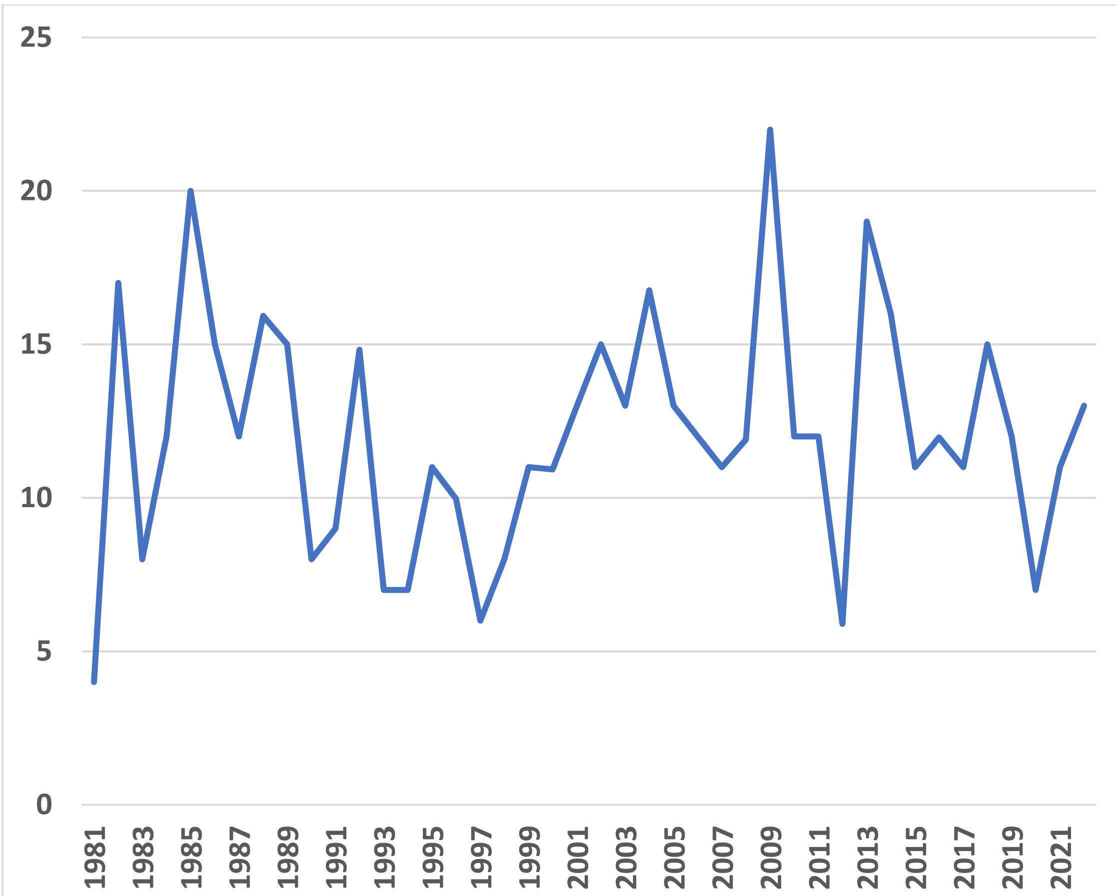



**Figure 3**: Number of extreme precipitations in the dry season (ASON). Values are above 90% (IRI-Columbia University MAPROOM)

Similarly, observed rainfall data shows an increased in days without rain and drought spells during the wet season (Figure 4).

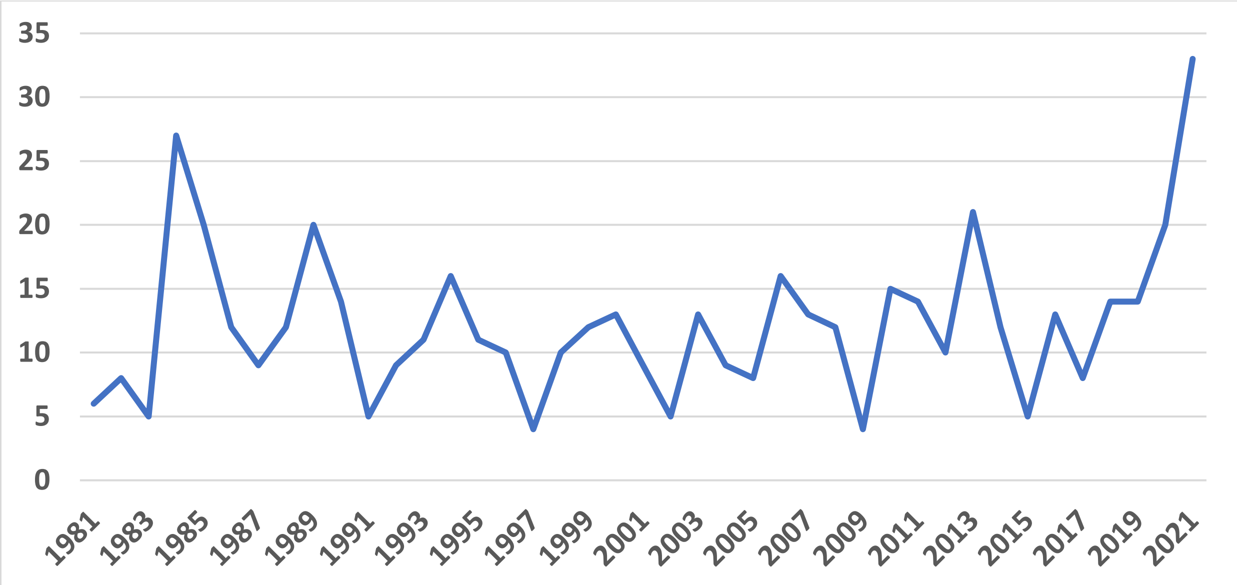


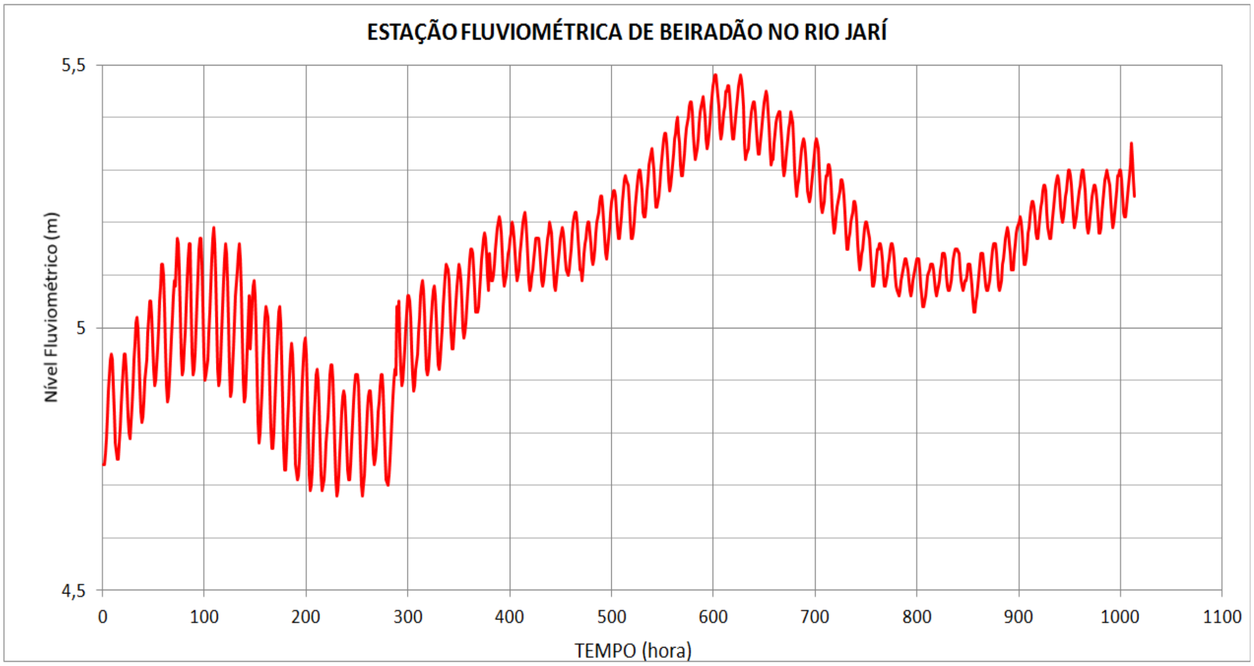

**Figure 4**: Number of days without rain or dry spells during the wet season (FMAM). Values are above 90% (IRI-Columbia University MAPROOM)

The above figure 3 and figure 4 shows that the Amazon Delta and Estuary is not experiencing seasonal changes but rather an increase in the frequency and intensity of rainfall events and dry spells during the wet and dry season. For most smallholders the replacement agriculture by agroforest practices helps them to reduce vulnerability to climate change and to produce food and income under conditions of severe rainfall and drought spells.

2. **Extreme high tidal floods (*lançantes*)**. Anomalous tidal floods produced by sea level rise are also directly impacting smallholder's decisions to transition from agriculture to agroforest practices. Observed tidal data at the Amazon Delta and Estuary shows an increase in extreme tidal floods that are characterized by the duration and strong current (Figure 5).

**Figure 5. High and unusual tidal floods locally know as lançantes are the most important extreme hydro-climatic events in the estuary of the Amazon**

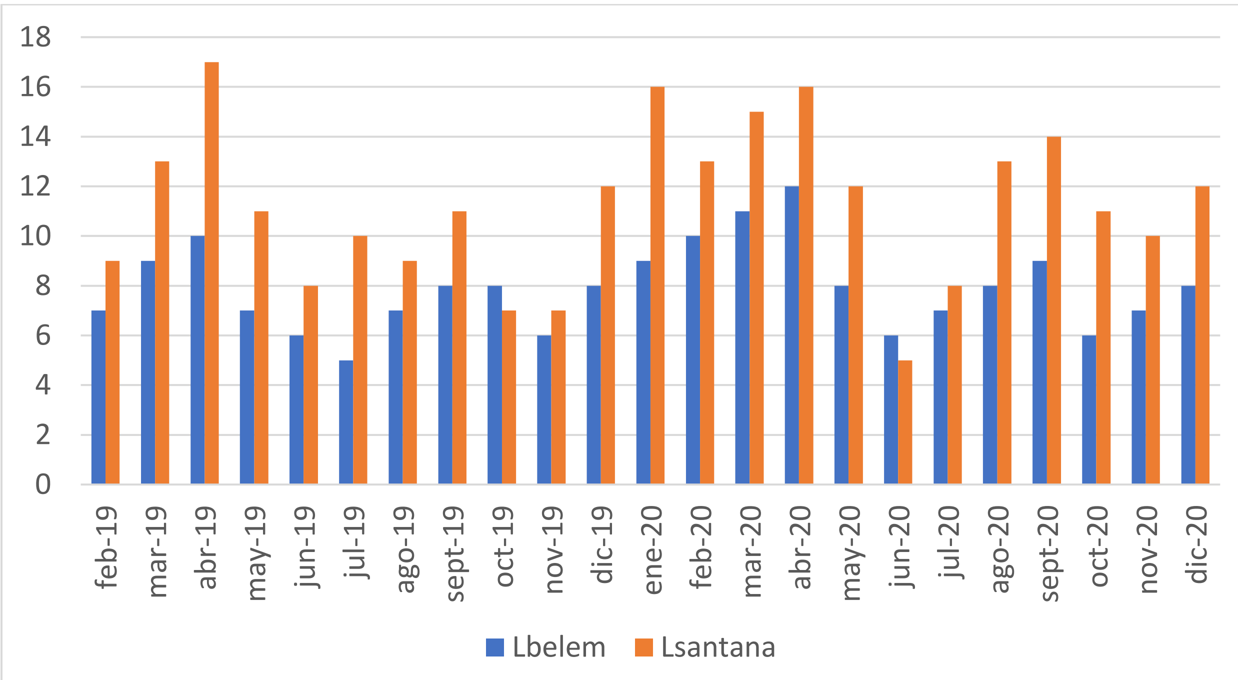
**3 sets of data showing: (1) the frequency and intensity of tidal floods every 12 hours, (2) the effect of astronomical or lunar phases on tidal floods every 28 days and (3) annual floods or normal hydrological cycles (source SUDAM 2013)**




The damage of crops produced by lançantes is the main reason why smallholders are not making agriculture fields in the extensive nutrient rich floodplains or varzeas. Lançantes produce two main disturbances: (i) strong and damaging currents that tend to up-root and wash crops and severe soil erosion and (ii) long-lasting high floods that produce high mortality of crops as well as high soil humidity that spoil the roots and fruits of crops such as cassava, beans, watermelon, and others commercial and food annual crops.

Smallholders have reported that one of the big problems that they are facing is the impossibility to know how height and how long can last lançantes as well as how strong current they can produce. However, most of them agree that lançantes are expected to destroy agriculture fields. Tidal data collected at the fluviometric stations in the South section (Belem) and North section (Santana) shows consistent number of lançantes per month in 2019 and 2020 (Figure 6)

Figure 6. Number of lançantes (tidal floods) above the 3m the average of aguas vivas (normal high tide) in the cities of Belem and Santana. (Source Estação Fluviométrica de Belem e Santana)




Smallholders, particularly the residents of floodplains, are increasingly converting their agriculture areas into agroforest fields. Most agroforest practices are designed for the provision of diversified ecological and environmental services to manage risk and vulnerability of food and income production to lançantes, extreme rainstorms, drought spells and other weather hazards. The local diversified agroforest systems integrate ADE's ecological attributes and ecosystem functions that help smallholders to increase their adaptive capacity to make a living under sea level rise and extreme weather events produced by climate change.