Module: 1
Unit: 1.1

Water Science, Management & Governance

HYDRAULIC PLANNING IN INSULAR URBAN TERRITORIES: THE CASE OF MADEIRA ISLAND—SÃO VICENTE

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Introduction

- **How Does Climate Change affect Flood Risk?**

○ **Warmer and Wetter Atmosphere:**
A warmer atmosphere can hold more water – approx. 7% more for every degree of warming.

○ **More Intense Downpours:**
A more energetic atmosphere means we get more of our rainfall in the form of short, intense downpours. This can mean devastating floods.

○ **More Energy For Storms:**
The extra heat and moisture also means there is more energy for weather systems that generate intense rainfall.

○ **Coastal Flooding:**
Climate change also increases risks of coastal flooding due to higher sea levels.

Introduction

- **Flood Reasons**

○ Heavy rainfall caused by natural weather events;

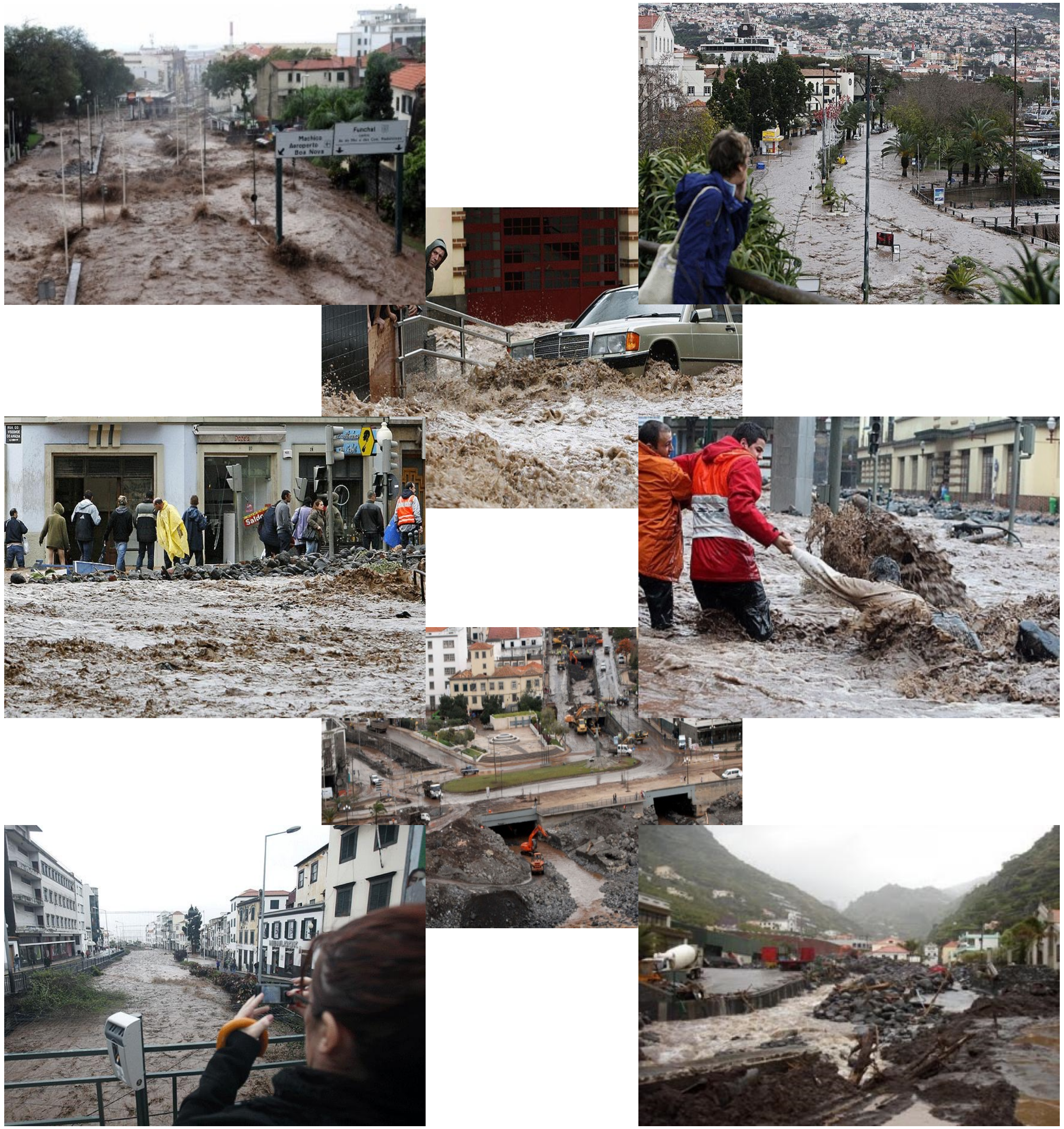
○ Insufficient forest;

○ Incorrect agricultural practices;

○ Inadequate design of drainage channels and structures;

○ Inadequate maintenance of drainage facilities, clogging of rubble brought by flood waters;

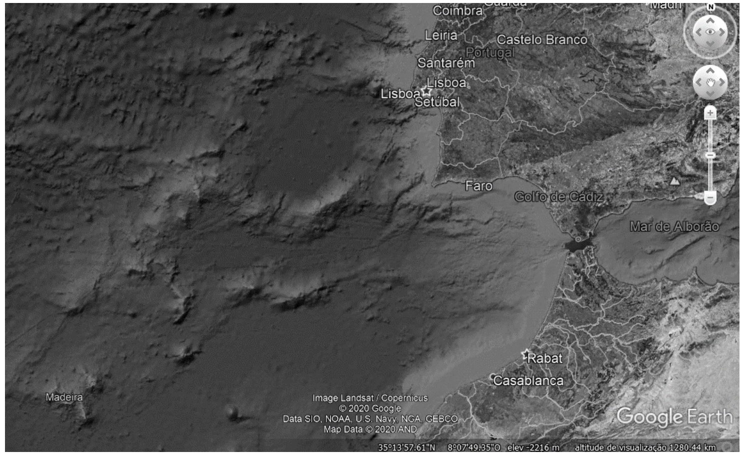
○ Settle down on flood plains.



Materials and Methods

- **Area of Study**

This study focuses on the São Vicente's watershed, being located on the northern side of Madeira Island between the latitudes of 32◦470 N and the longitudes of 17◦2 0 W.



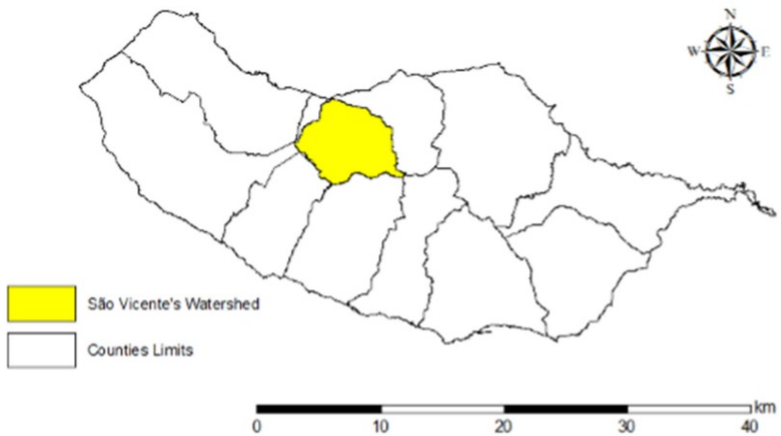
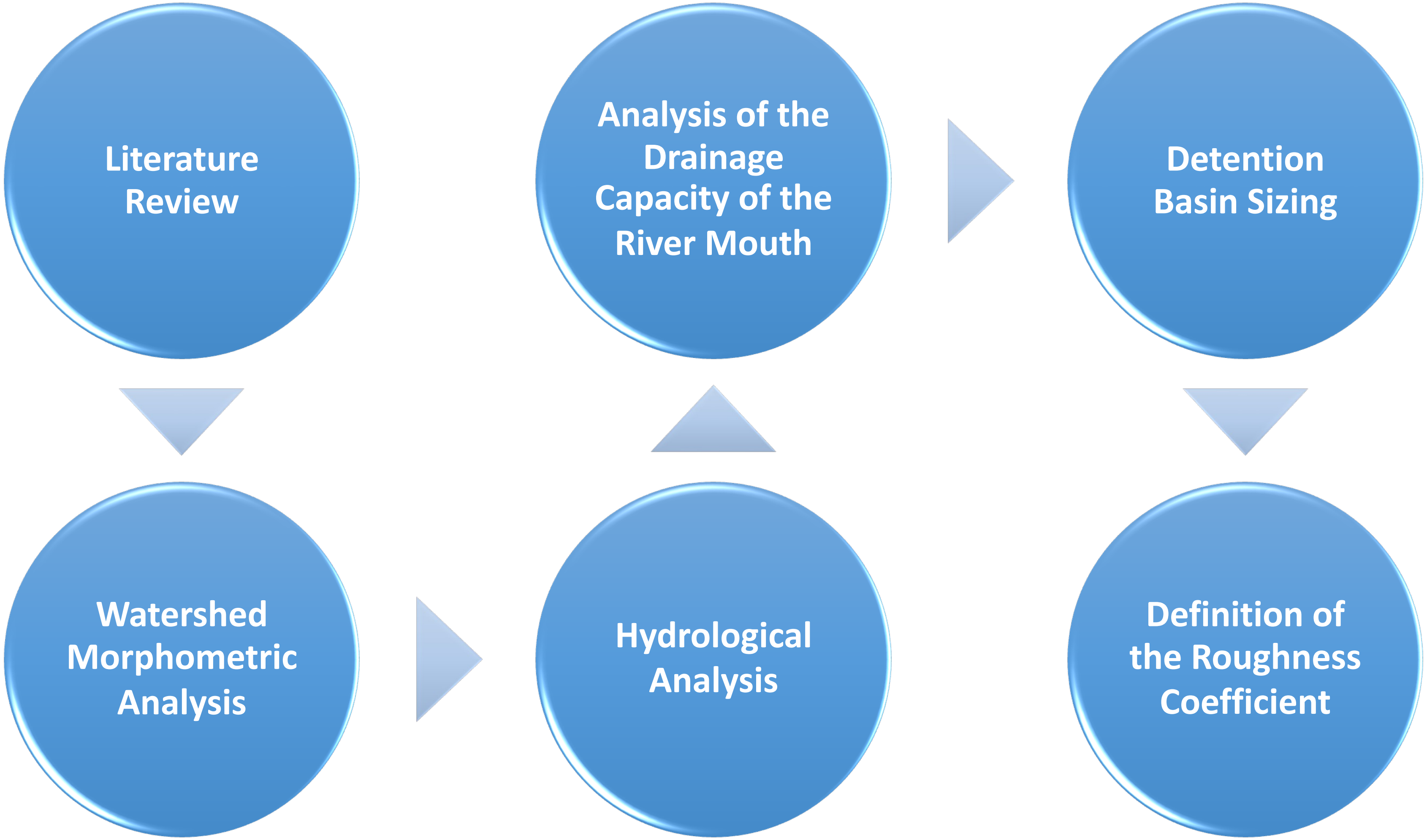


Figure 1. The São Vicente watershed. (Source: Authors by ESRI ArcGIS, 2020).

Materials and Methods

- Schematic of Methodology



Materials and Methods

- Morphometric Characterization of the Watershed
- Precipitation Analysis
- Drainage Capacity of the River Mouth and Peak Flow Rate
- Detention Basin Sizing

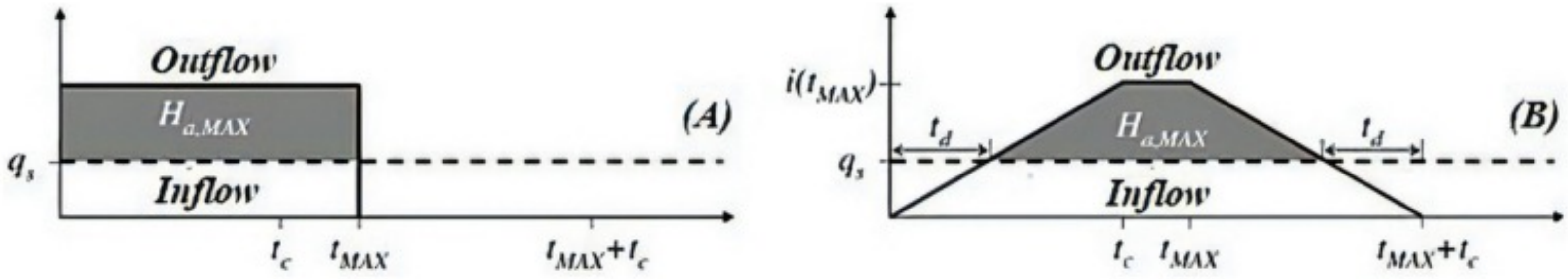


Figure 2. (A) Dutch method; (B) STH method (Source: [22])

- Modification of the Roughness Coefficient

Results

Parameter	Unit of Measurement	Value
Width	m	40.000
Height	m	3.000
Length—Dutch Method (Rational)	m	11,991.486
Length—STH Method (Rational)	m	4483.318
Length—Dutch Method (Giandotti)	m	24,324.279
Length—STH Method (Giandotti)	m	13,324.023
Length—Dutch Method (Mockus)	m	12,431.234
Length—STH Method (Mockus)	m	4753.002

Table 1. Parameters calculated or extracted from ArcGIS.

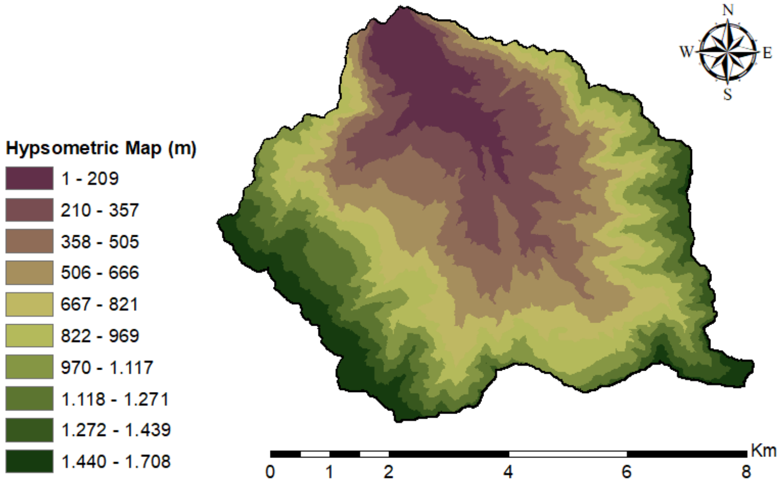


Figure 3. Hypsometric map—DEM file (Source: Authors by ESRI ArcGIS, 2020).

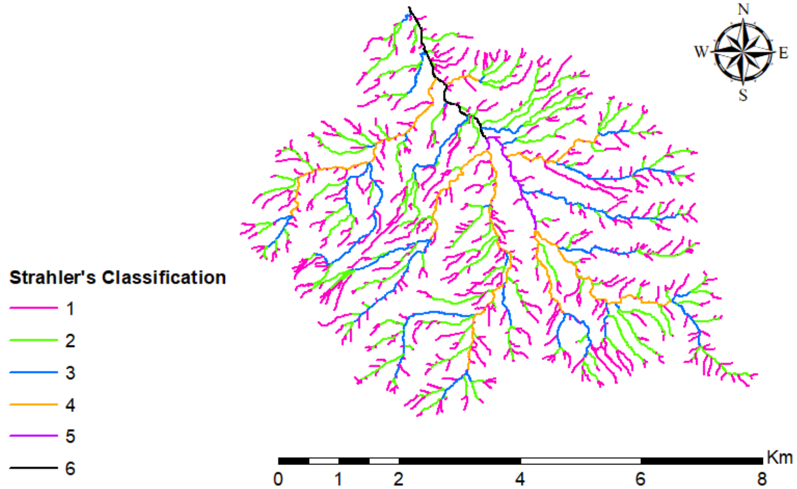


Figure 4. Strahler classification (Source: Authors by ESRI ArcGIS, 2020)

Results

Parameter	Symbol	Unit of Measurement	Value
Average Annual Precipitation	P_M	mm	164.443
Standard Deviation	S′	mm	64.424
Frequency Factor	K_T	dimensionless	3.136
Time Distribution Coefficient	k	dimensionless	0.543
Annual Maximum Daily Precipitation	P_{EST}	mm	366.521
Precipitation Intensity	I	mm/h	110.646

Table 2. Precipitation parameters.

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Methodology	Flow (m^3/s)
Forti	419.096
Rational	594.284
Giandotti	822.796
Mockus	602.432

Table 3. Peak flow rate.

Parameter	Unit of Measurement	Value
Width	m	40.000
Height	m	3.000
Length—Dutch Method (Rational)	m	11,991.486
Length—STH Method (Rational)	m	4483.318
Length—Dutch Method (Giandotti)	m	24,324.279
Length—STH Method (Giandotti)	m	13,324.023
Length—Dutch Method (Mockus)	m	12,431.234
Length—STH Method (Mockus)	m	4753.002

Table 4. Detention basin sizing.

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Parameter	Unit of Measurement	Value
Wall Roughness Coefficient—Modified	$m^{-1/3}$	0.012
Riverbed Roughness Coefficient—Modified	$m^{-1/3}$	0.030
Drainage Capacity of the River Mouth—Modified	m^3/s	822.371
Fill Rate—Rational (post-modification)	%	72
Fill Rate—Giandotti (post-modification)	%	100
Fill Rate—Mockus (post-modification)	%	73

Table 5. Modification of the roughness coefficient.

Discussion

- As this study's main goal was to check if it was needed to put into action flood mitigation measures to further prevent major impacts in São Vicente's watershed, the use of a detention basin revealed itself as valid and useful structural measure towards controlling its river mouth's flowrate.

- At first, the Fill Rate was 98%, 135% and 99%, respectively for Rational, Giandotti, and Mocku's methodologies, which ultimately decreased to only 61% after adopting the detention basin measure.

- This structural measure's outcome is clear evidence that it may enable the river mouth to work below 85% of its full capacity.

- Moreover, this proves the accuracy of the Regional Directorate for Territorial Management and Environment (DROTA) prediction.

- As it was not made any change to the stream's cross section, namely its height and width, the only variable parameter was its length. It was based on this concept that the Dutch Method presented an abnormal oversize of the detention basin's length when compared to the watershed's main course's length.

- Therefore, according to this method it would be needed to change one or both cross section dimensions and so it cannot be considered valid for the aforementioned urban design settings.

- The exact same conditions were imposed for the STH method, with it showing a different and this time valid approach since the detention basin's length was shorter than the watershed's main watercourse length.

Conclusions

- This study revealed how flood-prone São Vicente's watershed is in the event of extreme rainfall occurrence, as it was already predicted by DROTA's own Flood Risk Report. The watershed's drainage capacity is highly decreased by the presence of abundant vegetation and a huge number of sediments throughout the watercourse, resulting in a lower flowrate in an already low-slope stream and river mouth.

- Afterall, this study leaves a clear open-door to others that may complement its contents and methodologies by optimizing its techniques. To improve the often-complex urban hydraulic system and demand, it is also expected that new studies take notice of the need to reduce sediment deposition as it seems to make a huge long-term impact over the watercourse's drainage capacity and ultimately to prevent a major flood impact.

- On the other hand, mechanical abrasion of this stream's walls and the amount of time that often takes to local public authorities to perform any type of maintenance have been two strong reasons for how degraded the main course tributaries are and subsequently by the lower water quality discharged and therefore also need to be studied and improved.

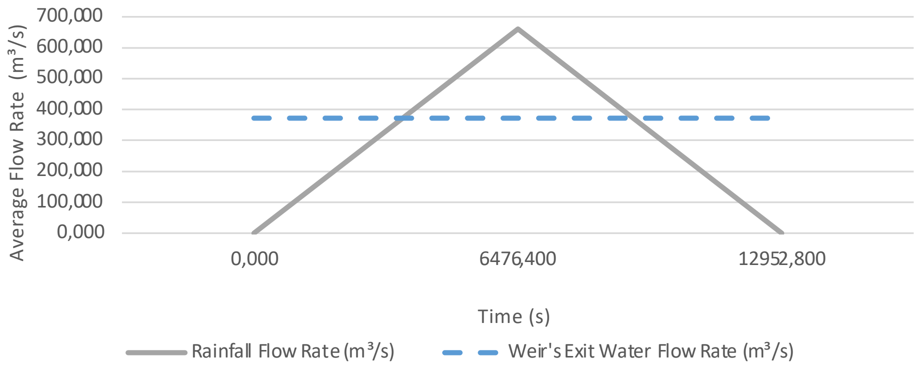

Figure A1. Ternary phase diagram.

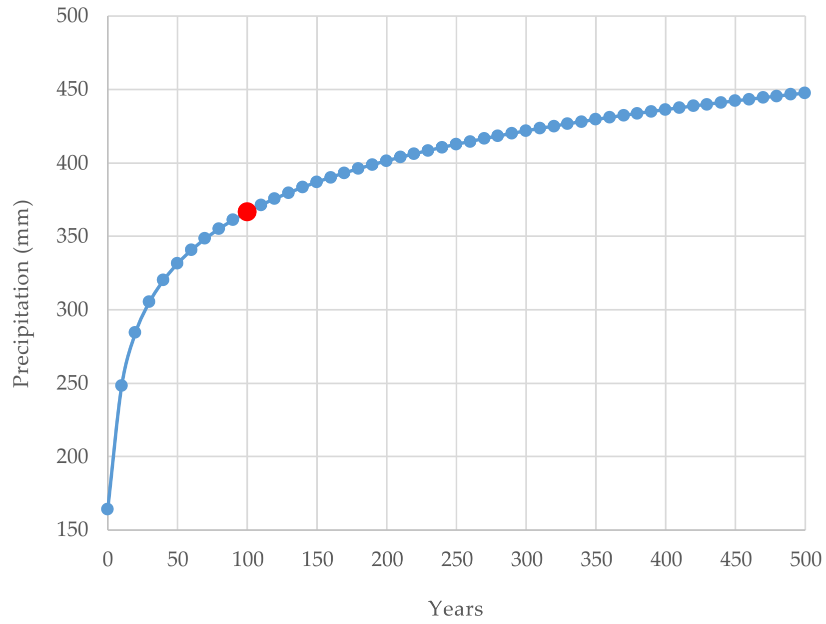

Figure A2. Expected rainfall for São Vicente's watershed.

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END

THANK YOU FOR YOUR ATTENTION!

SÉRGIO LOUSADA

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