

# Module: 1

## Unit: 1.2



## Water Science, Management & Governance

# HYDRAULIC PLANNING IN INSULAR URBAN TERRITORIES: THE CASE OF MADEIRA ISLAND—RIBEIRA BRAVA

Sérgio António Neves Lousada <sup>1, 2, 3, 4, 5, 6</sup>.

1. Faculty of Exact Sciences and Engineering (FCEE), Department of Civil Engineering and Geology (DECG), University of Madeira (UMa), Funchal, Portugal;
2. CITUR - Madeira - Centre for Tourism Research, Development and Innovation, Madeira, Portugal;
3. VALORIZA - Research Centre for Endogenous Resource Valorization, Portalegre, Portugal;
4. Research Group on Environment and Spatial Planning (MAOT), University of Extremadura (Uex), Badajoz, Spain;
5. CERIS - Civil Engineering Department of University of Aveiro, 3810-193 Aveiro, Portugal;
6. OSEAN - Outermost Regions Sustainable Ecosystem for Entrepreneurship and Innovation, Funchal, Portugal.



# Index



- **Introduction**
- **Materials and Methods**
- **Results**
- **Discussion**
- **Conclusions**

# Introduction

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

- **Warmer & 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 Ribeira Brava's watershed, being located on the southern slope of Madeira Island between the latitudes  $30^{\circ}01'$  N and  $33^{\circ}08'$  N and longitudes  $15^{\circ}51'$  W and  $17^{\circ}30'$  W

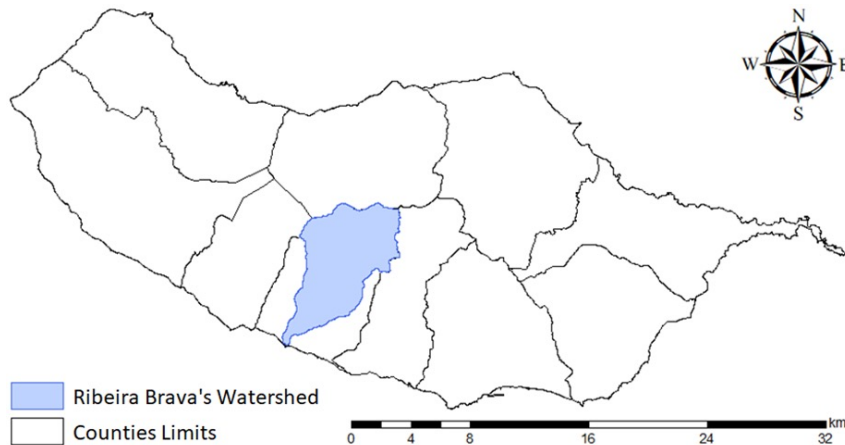
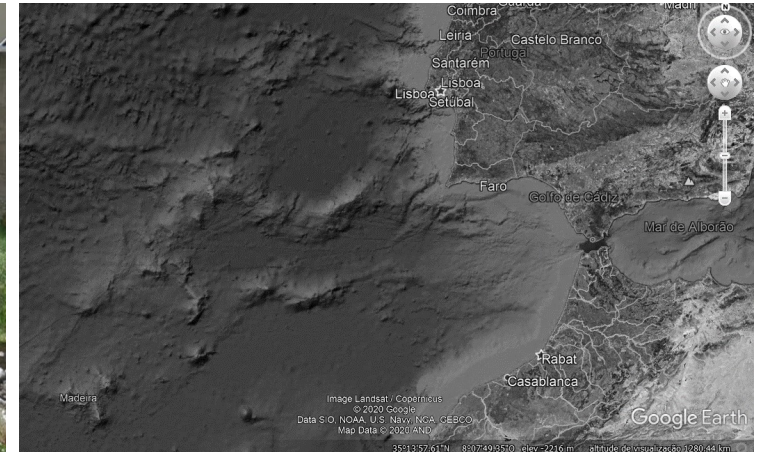
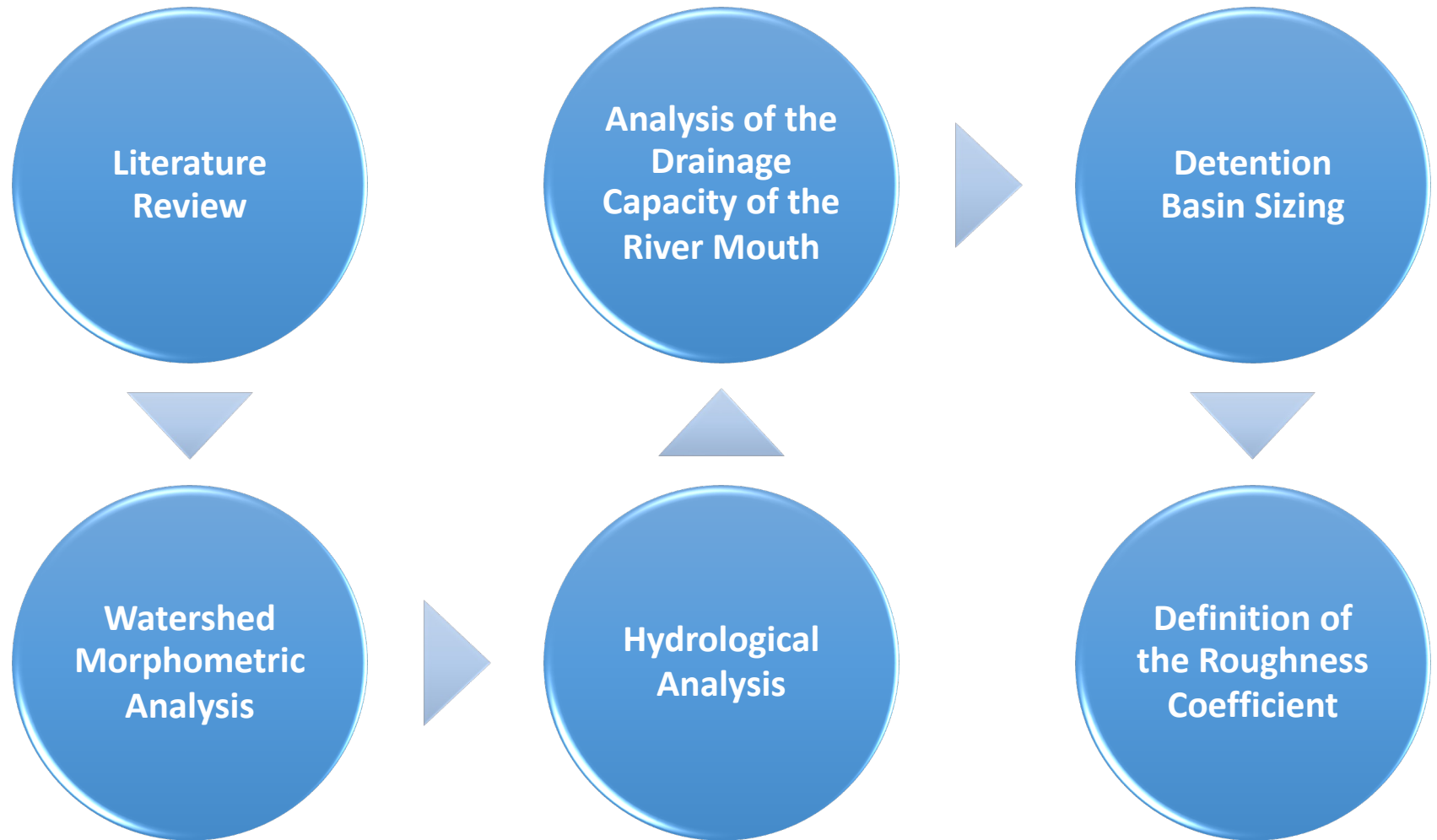


Figure 1. The Ribeira Brava watershed. (Source: Authors by ESRI ArcGIS, 2020).

# 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

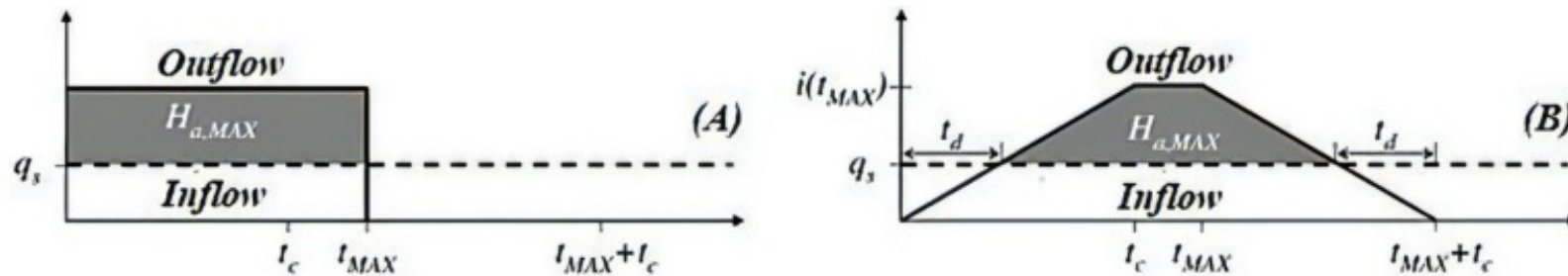


Figure 2. (A) Dutch method; (B) STH method (Source: [22])

- Modification of the Roughness Coefficient

# Results

Parameter	Unit of Measurement	Value
Area	km <sup>2</sup>	41.059
Perimeter	km	42.430
Length of Main Watercourse	km	14.619
Maximum Height of Main Watercourse	m	1316.030
Minimum Height of Main Watercourse	m	0.000
Average Concentration Time	hours	2.362
Gravelius Coefficient of Compactness	dimensionless	1.868
Elongation Factor	dimensionless	8.856
Shape Factor	dimensionless	0.298
Number of Watercourses	units	1668.000
Average Bifurcation Ratio	dimensionless	4.286
Strahler Classification	dimensionless	6.000

Table 1. Parameters calculated or extracted from ArcGIS.

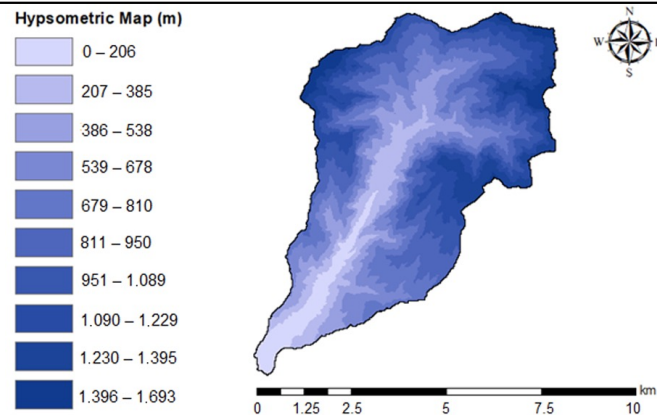


Figure 3. Hypsometric map—DEM file (Source: Authors by ESRI ArcGIS, 2020).

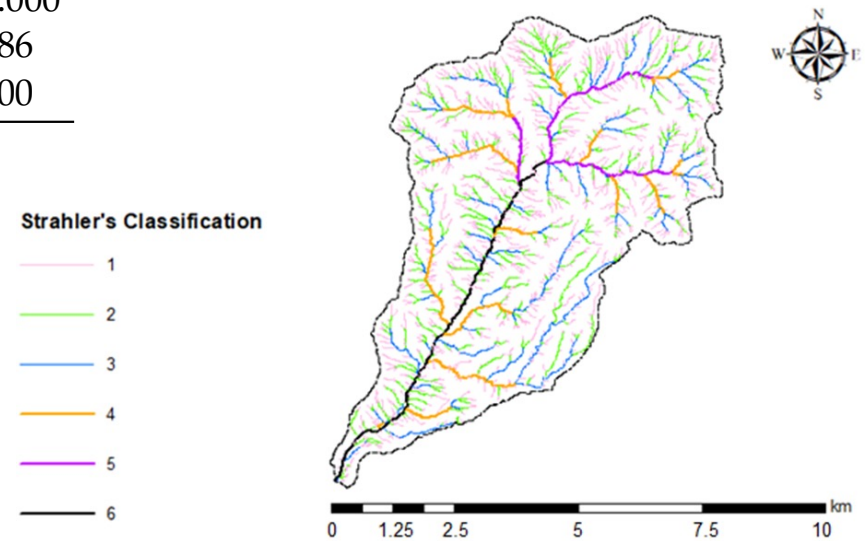


Figure 4. Strahler classification (Source: Authors by ESRI ArcGIS, 2020)

# 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	0.592
Annual Maximum Daily Precipitation	$P_{EST}$	mm	366.521
Precipitation Intensity	$I$	mm/h	91.920

Table 2. Precipitation parameters.

Methodology	Flow ( $m^3/s$ )
Forti	442.849
Rational	531.782
Giandotti	560.848
Mockus	529.792

Table 3. Peak flow rate.

Parameter	Unit of Measurement	Value
Width	m	20.000
Height	m	4.500
Length—Dutch Method (Rational)	m	20,047.874
Length—STH Method (Rational)	m	7999.198
Length—Dutch Method (Giandotti)	m	22,794.149
Length—STH Method (Giandotti)	m	9,804.940
Length—Dutch Method (Mockus)	m	19,859.934
Length—STH Method (Mockus)	m	7879.396

Table 4. Detention basin sizing.

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	$m^3/s$	488.881
Fill Rate—Rational (post-modification)	%	68
Fill Rate—Giandotti (post-modification)	%	72
Fill Rate—Mockus (post-modification)	%	68

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 Ribeira Brava'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 94%, 99% and 93%, respectively for Rational, Giandotti, and Mocku's methodologies, which ultimately decreased to only 56% 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 Ribeira Brava'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.
- After all, 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.

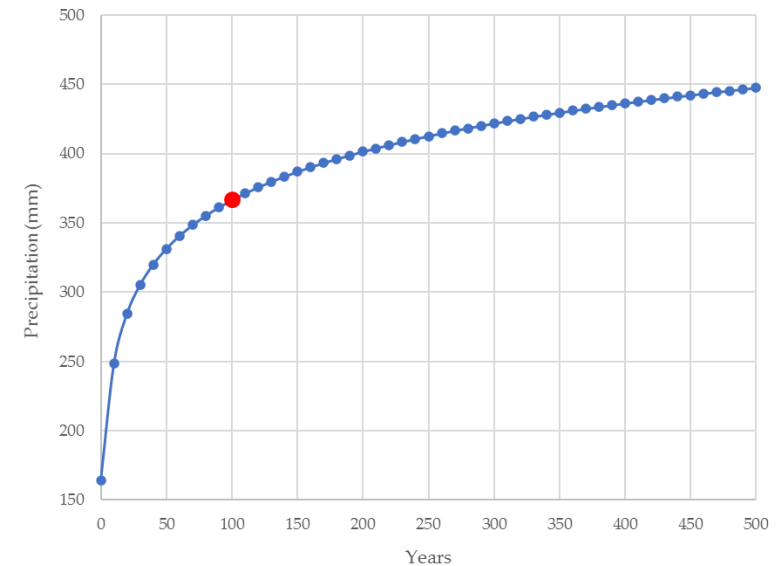
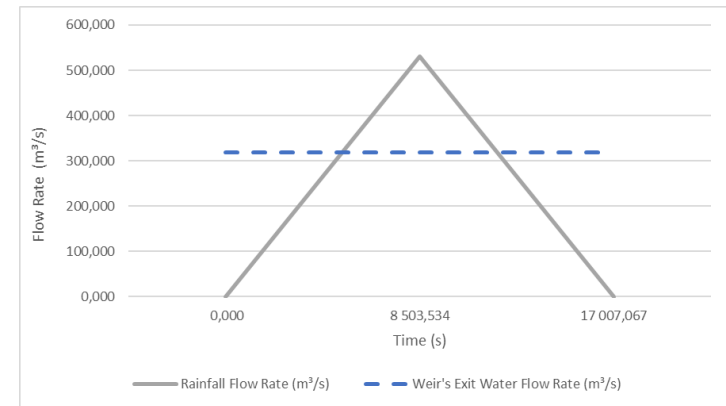


Figure A2. Expected rainfall for Ribeira's watershed.

Module: 1  
Unit: 1.2



## HYDRAULIC PLANNING IN INSULAR URBAN TERRITORIES: THE CASE OF MADEIRA ISLAND—RIBEIRA BRAVA

END

THANK YOU FOR YOUR ATTENTION!

