Consultancy Service for the Development of an Inundation, Flooding and Landslide National Risk Profile, Strategic Framework and Action Plans for Disaster Risk Management for the Republic of Mauritius

Capacity and validation workshop

Swami Vivekananda International Convention Centre, Pailles, Mauritius, August 22-24, 2012

SGI Studio Galli S.p.a.

Economic and social impact of natural hazard

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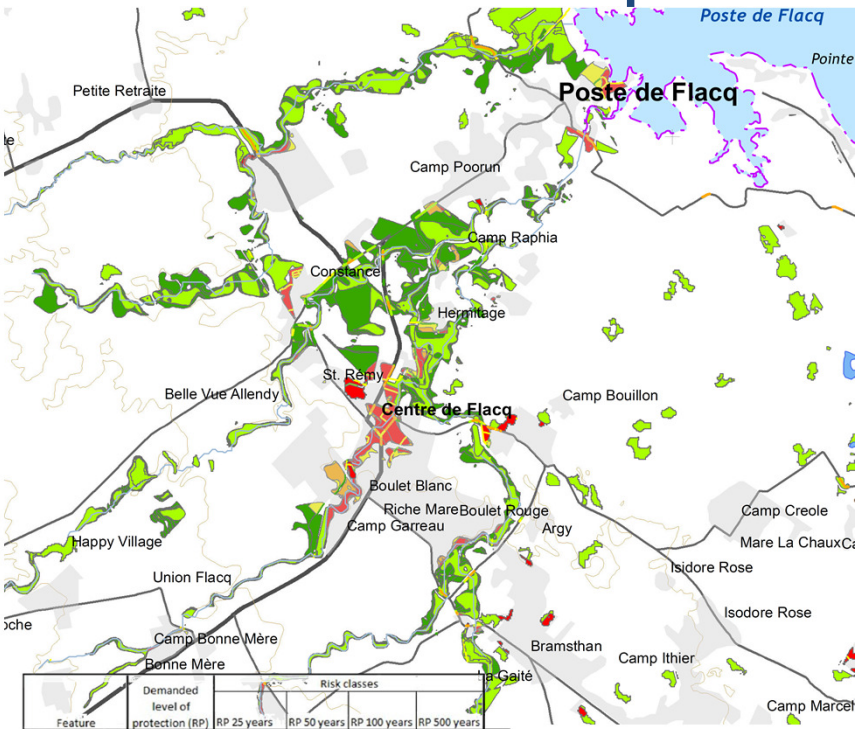
1) Area at flood, inundation and landslide risk

The mapping of the flooded, inundated and landslide risk areas depends on the natural physical characteristics of the territory such as:

- topography
- urban set-up that can interfere with the river network

Flood risk map

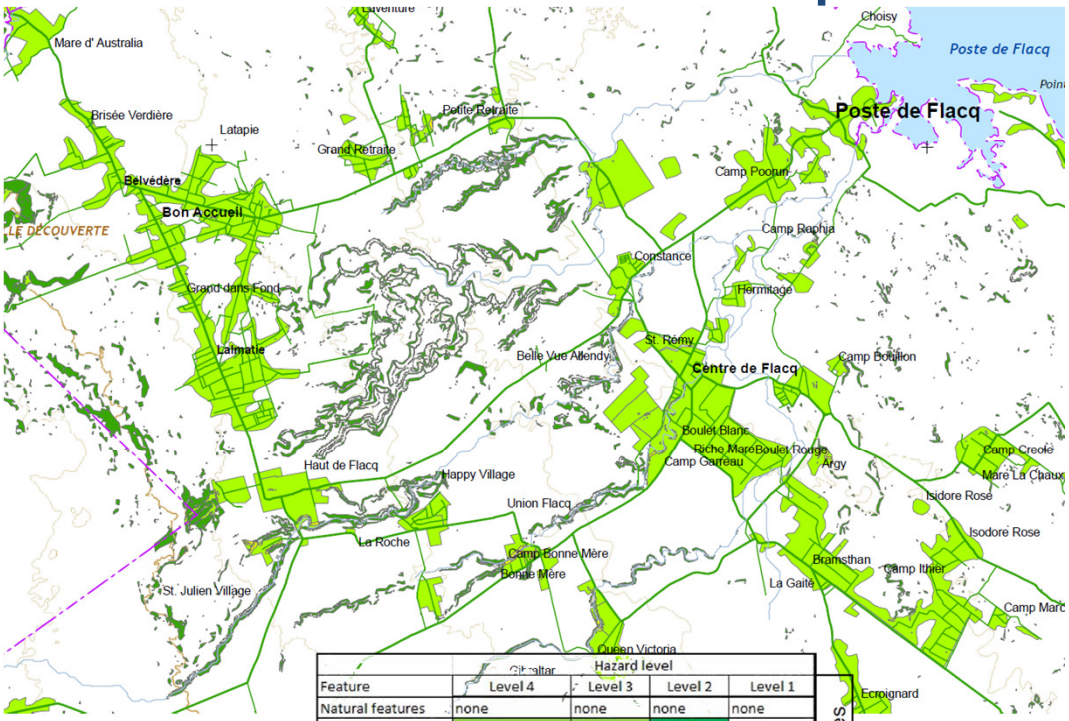


Feature	Demanded level of protection (RP)	Risk classes			
		RP 25 years	RP 50 years	RP 100 years	RP 500 years
Natural features	none	none	none	none	none
Agricultural fields	RP 25	low	very low	very low	very low
Built up area	RP 500	very high	very high	high	medium
Expansion area	RP 500	very high	very high	high	medium
Motorway	RP 500	very high	very high	high	medium
Main road	RP 100	high	medium	low	very low
Secondary road	RP 50	medium	low	very low	very low

Risk Classes

Risk Classes

Landslide risk map



Feature	Hazard level			
	Level 4	Level 3	Level 2	Level 1
Natural features	none	none	none	none
Agricultural fields	low	low	very low	none
Built up area	very high	very high	medium	low
Expansion area	very high	very high	medium	low
Motorway	very high	very high	medium	low
Main road	high	medium	low	very low
Secondary road	medium	low	very low	very low

Risk Classes

Risk Classes

1) Area at flood, inundation and landslide risk

Mauritius island: overall results obtained from study

Percentage of flooding area and their risk class

Landuse	RP 25	RP 50	RP 100	RP 500
Built up area	4.1%	4.7%	5.3%	6.6%
Expansion area	10.0%	10.2%	13.3%	15.4%
Agricutural fields	2.7%	3.4%	3.5%	4.2%
Motorway	3.6%	3.8%	4.5%	4.9%
Main road	0.9%	1.0%	1.2%	1.4%
Secondary road	13.5%	15.9%	17.9%	21.5%

Risk classes

Risk Class legend:

- *red* very high,
- *orange* high,
- *yellow* medium
- green low
- *light green* very low.

Percentage of landslide area and their risk class

Landuse	Hazard level 4	Hazard level 3
Agricultural fields	1%	5%
Built up area	1%	3%
Expansion area	4%	11%
Motorway	1%	3%
Main road	1%	4%
Secondary road	1%	4%

Risk classes

Risk classes					
very high	high	medium	low	very low	none

The percentage of landslide risk area have been refereed to whole islands

1) Area at flood, inundation and landslide risk

Mauritius island: overall results obtained from study

Risk Class legend:

- *red* very high,
- *orange* high,
- *yellow* medium
- green low
- *light green* very low.

Percentage of inundation area and their risk class

Feature	Hazard Level & Return Period of Event					
	Level 5	Level 4 [RP 25 years]	Level 3 [RP 50 years]	Level 2 [RP 100 years]	Level 1 [Extreme]	
Agricultural fields	0.5%	0.7%	0,7%	0,9%	1%	Risk classes
Built up area	4%	7%	7%	9%	10%	
Expansion area	14%	22%	22%	27%	31%	
Motorway	4%	5%	5%	7%	7%	
Main road	5%	8%	8%	11%	12%	
Secondary road	4%	6%	6%	7%	9%	

1) Area at flood, inundation and landslide risk

Rodrigues island : overall results obtained from study

Percentage of flooding area and their risk class

Landuse	RP 25	RP 50	RP 100	RP 500	
Built up area	8.4%	8.8%	9.0%	9.4%	Risk classes
Agricutural fields	6.0%	6.5%	6.5%	7.1%	
Main road	5.0%	5.5%	10.0%	10.7%	
Secondary road					
Risk classes					
very high	high	medium	low	very low	none

Risk Class legend:

- *red* very high,
- *orange* high,
- *yellow* medium
- green low
- *light green* very low.

Percentage of landslide area and their risk class

Landuse	Hazard level 4	Hazard level 3	
Agricultural fields	1%	6%	Risk classes
Built up area	1%	6%	
Main road	0%	4%	

Risk classes					
very high	high	medium	low	very low	none

The percentage of landslide risk area have been refereed to whole islands

1) Area at flood, inundation and landslide risk

Rodrigues island: overall results obtained from study

Risk Class legend:

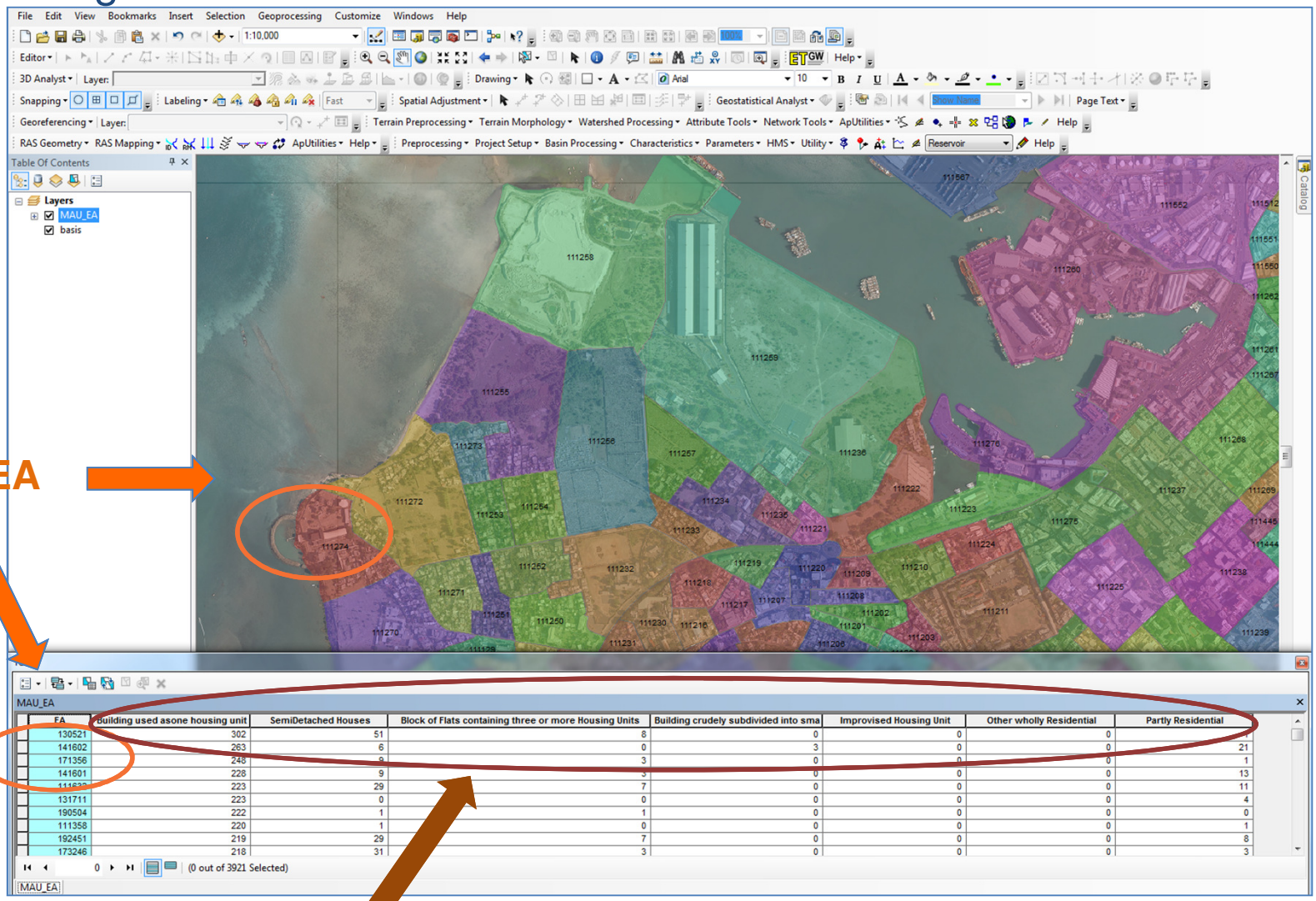
- *red* very high,
- *orange* high,
- *yellow* medium
- green low
- *light green* very low.

Percentage of inundation area and their risk class

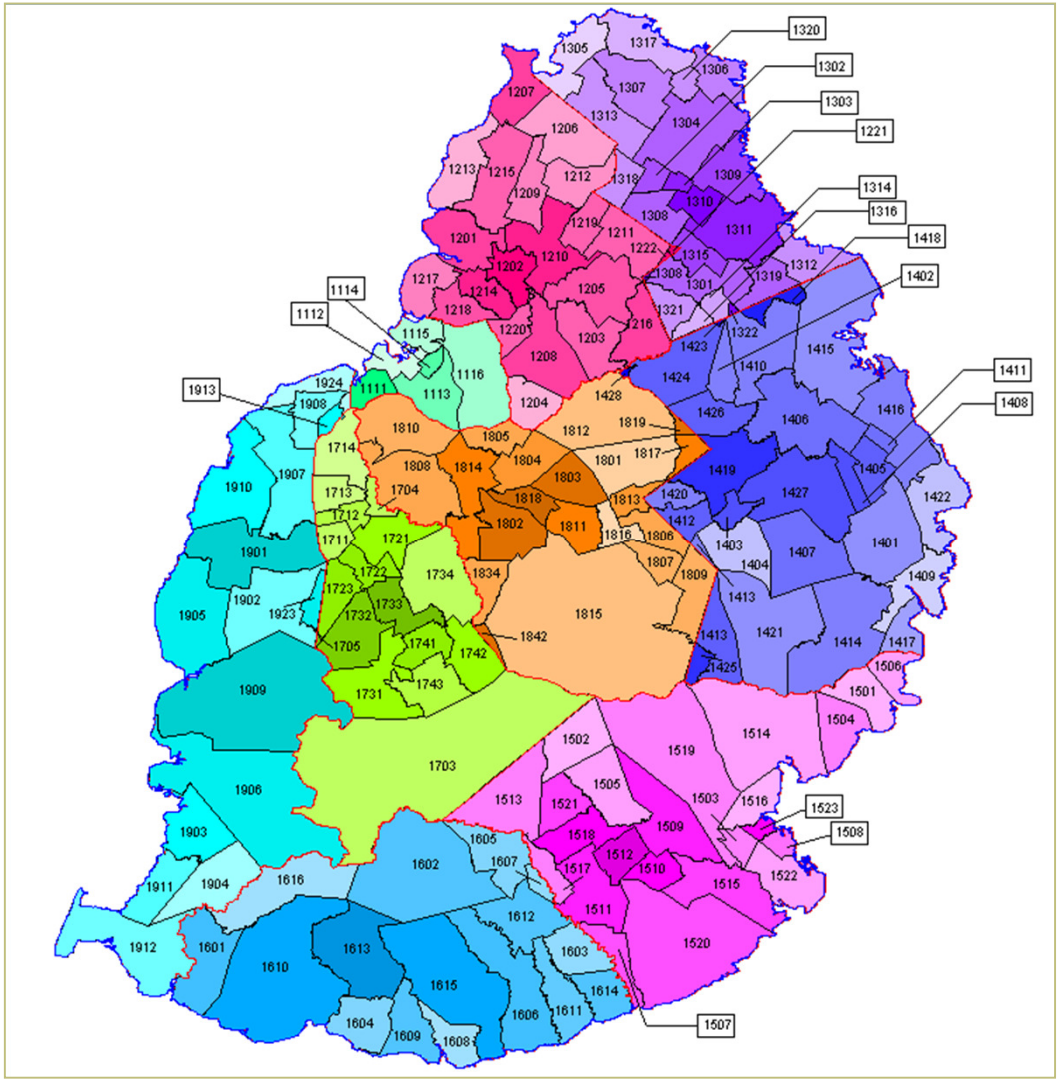
Feature	Hazard Level & Return Period of Event					
	Level 5	Level 4 [RP 25 years]	Level 3 [RP 50 years]	Level 2 [RP 100 years]	Level 1 [Extreme]	
Agricultural fields	3%	4%	4%	5%	6%	Risk classes
Built up area	5%	6%	7%	8%	8%	
Main road	7%	9%	10%	11%	13%	
Secondary road	5%	6%	7%	7%	8%	

2) Social impact and values of exposed elements

Through GIS procedure (INTERSECT of flood area with EA) overall flood and inundation damage has been defined



2) Social impact and values of exposed elements

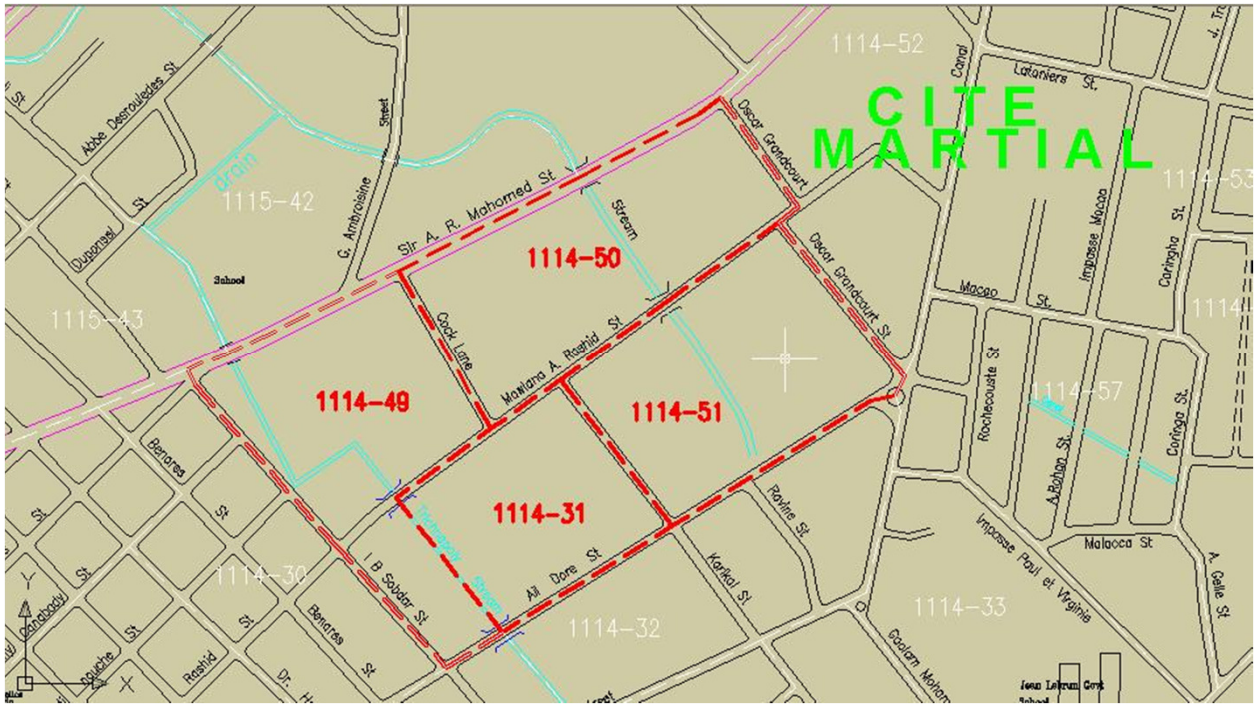


Map of Mauritius showing all the MVCAs* with their respective codes.

***MVCAs – Municipal & Village council Areas**

The Central Statistics Office - Cartography Unit Mauritius (2007)

2) Social impact and values of exposed elements



Enumeration Area (EA) maps for censuses

The Central Statistics Office - Cartography Unit Mauritius

2) Social impact

Preliminary analysis of social impact in Mauritius island:

Flood risk

Return period [years]	Exposed population
RP 25	19,800
RP50	23,000
RP 100	28,000
RP 500	34,000

Inundation risk

Assumed level [m.s.l]	Exposed population [inhabitants]
2.5	22,800
3.5	39,200
4	39,200
5	52,200
6	63,400

Landslide risk

Hazard class	Exposed population [inhabitants]
Level 3	15,000
Level 4	4,300

2) Social impact

Preliminary analysis of social impact in Rodrigues island:

Flood risk

Return period [years]	Exposed population
RP 25	880
RP50	900
RP 100	960
RP 500	1000

Inundation risk

Assumed level [m.s.l]	Exposed population [inhabitants]
2.5	820
3.5	1150
4	1300
5	1500
6	1800

Landslide risk

Hazard class	Exposed population [inhabitants]
Level 3	2,850
Level 4	780

2) Social impact and values of exposed elements

VALUES OF EXPOSED ELEMENTS

Unit costs are given from the new construction value for buildings and infrastructures in ROM

Type	UNIT AMOUNTS
Agglomeration (in MUR/m^2)	
Residential buildings	
One-dwelling houses	8500.00 to 10,000.00
- wood-framed	20.000,00
- concrete-framed	12.000,00
- steel-framed	15.000,00
Commercial buildings	18.000,00
Industrial building	15.000,00
Sugar factory	Depends on size/capacity
Holiday residence	25.000,00
Hotels/Apartment hotels	25,000.00 to 30,000.00
Hospitals	20.000,00
Hangars	10.000,00
Transport facilities (in MUR/line meters)	
Motorways	30.000,00
Major roads	25.000,00
Municipal roads	20.000,00
Forest tracks and roads	8.000,00

Type of building	Economic value (thousand MUR/m^2)
Building used as one Housing Unit	see following table with cost related to material
Semi-Detached Houses	
Block of Flats containing three or more Housing Units	
Building crudely subdivided into smaller Housing Units	
Improvised Housing Unit	
Other wholly Residential	
Partly Residential	
Commercial buildings	18
Industrial building	15
Hotels	27.5
Hospitals	20

Type of wall and roof materials	Economic value (thousand MUR/m^2)
Concrete wall and Concrete roof	12
Concrete wall and iron or tin roof	13.5
Iron or tin wall and iron or tin roof	15
Wood wall and iron or tin roof	17.5
Wood wall and shingle roof	20
Other	10

Transport facilities	Economic value (thousand MUR/m^2)
Motorways	30
Major roads	25
Municipal roads	20

2) Social impact and values of exposed elements

VALUES OF EXPOSED ELEMENTS IN **ROM**

	Value of exposed elements for flood (millions MUR)			
Zone	**Tr 25 year**	**Tr 50 year**	**Tr 100 year**	**Tr 500 year**
MAURITIUS	57,098	57,097	69,732	78,007
RODRIGUES	902	955	985	1,000

	Value of exposed elements for inundation (millions MUR)				
Zone	**Level 5**	**Level 4**	**Level 3**	**Level 2**	**Level 1**
MAURITIUS	31,520	59,375	59,478	75,588	88,168
RODRIGUES	216	531	658	935	1,207

	Value of the exposed element for landslide risk Level 3 and 4 (milions MUR)		
	Built up area	Expansion area	Road
MAURITIUS	217,000	19,300	5,900
RODRIGUES	10,600		1,200

2) Damage estimation

Flood and inundation damages estimation methodology:

- **Direct costs**= physical damage to capital assets;
- **Indirect costs** = losses on earnings, business interruption; environmental damages, evacuation costs;
- **Relief costs** = refer to the provision of life supporting services (e.g. food aid, health care, safe water and sanitation).

5) Flood damage estimation

The damage values are based on the average price per m^2 for a building. Real estate damage function (buildings structures and excluding furniture and plants):

$$Y = 2x^2 + 2x$$

in which the percentage of damage degree “y” is a function of flood depth “x”

According to the water depth, different percentages of damage degree, considering only buildings, are identified as quoted in the following table:

Water depth [m]	Damage factor [%]
0	≈ 0
1	≈ 4
2	≈ 12
3	≈ 24

Damage functions used in calculations of the Commissie Watersnood Maas (in Kok, 2001)

2) Flood damage estimation

References study, available in literature, to estimate relative damage function:

ICPR (2002), International commission for the protection of the Rhine

Damage functions for the Meuse River floodplain (Kok M. 2001)

Flood damage assessment in urban areas_UE_JRC
“A methodological approach to land use-based flood damage assessment in urban area: Prague case study” (Genovese E. 2006)

2) Damage estimation

Flood and inundation damages estimation methodology:

Assess the expected annual damage depending on the return periods and the width of the probability classes.

The expected annual can be calculated on the basis of the next equation:

$$E(D)= \sum_{i=1}^{K} \frac{\left[P_i'' - P_i'\right] x \left[D(P_i') + D(P_i'')\right]}{2}$$

Where:

- E(D) = expected yearly damage
- K = number of the probability class
- $\left[P_i'' - P_i'\right]$ = width of the probability class
- $D(P_i'')\ and\ D(P_i')$ = damage values relative to the classes' extremes

Damage estimation

VALUES OF POTENTIAL DAMAGE IN **ROM**

	Potential damage to buildings and infrastructures for flood (millions MUR)	
Zone	**Annual (statistical average)**	**Tr 100 year**
MAURITIUS	1,175	117,500
RODRIGUES	51	5,100

2) Damage estimation and social impact

Considerations:

• The proposed methodology has the aim to offer a approach to land use-based damage assessment.

• Combined with existing information on land use and flood depth, maps of the flooded, inundation, landslide areas provide important information that can be used for flood, inundation, landslide damage assessment in urban areas.

• The results provide an average damage estimate and should not be considered as a detailed cost assessment of the damage, since they are strongly depending on the quality of the damage functions and the availability of detailed datasets.

Thank you for your attention