Un cadre méthodologique pour donner la priorité à des tronçons routiers critiques en vue d'investissements dans la résilience climatique

Karim SELOUANE et Philippe SOHOUENOU

Fondateur/CEO et Responsable du pôle mobilités urbaines et infrastructures de transport, RESALLIENCE

VIABILITÉ HIVERNALE & RÉSILIENCE DES ROUTES FACE AU CHANGEMENT CLIMATIQUE

Chambéry, 26 et 27 septembre 2022

Agenda

- Introduction de RESALLIENCE
- Etudes de cas: Résilience des réseaux routiers
  - Méthodes
  - Etude de cas 1: Réseau Cofiroute (France)
  - Etude de cas 2: BRT de Ouagadougou (Burkina Faso)
  - Ouverture: Plateforme de gestion d'un territoire (Dominique)

CONSULTING

- Vulnerability assessments and impact studies
- Technical and financial evaluation
- Training, audits and compliance

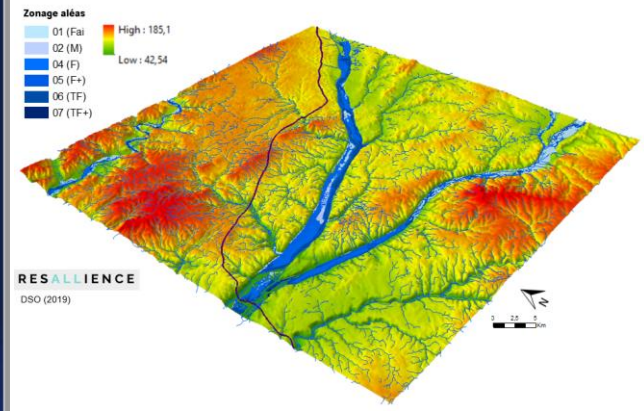
MODELLING

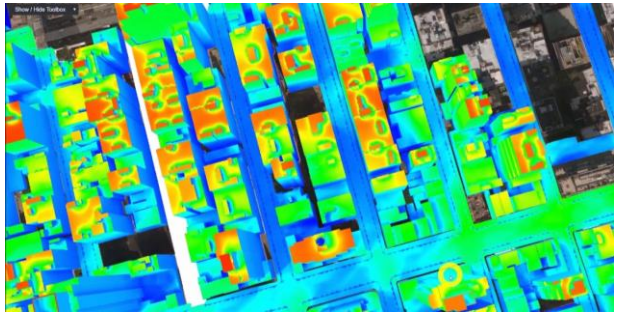
- Predictive maintenance and monitoring
- Weather and climate data services
- Functional engineering through stress tests

PROJECT COORDINATION

- Project management assistance
- Integration of technical solutions
- Coordination and collaborative engineering

RESALLIENCE





RESALLIENCE

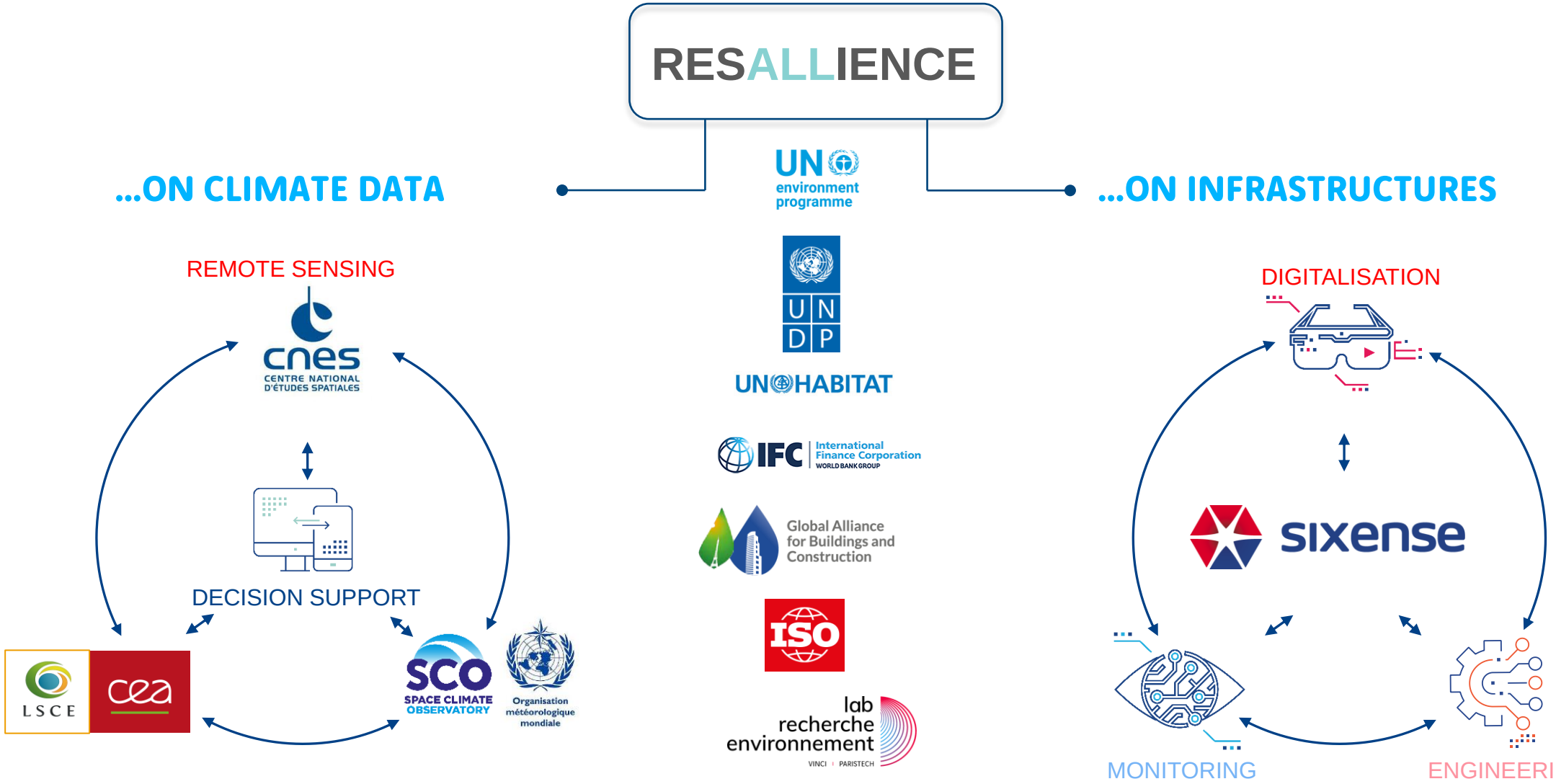
&

DES SATELLITES AU SERVICE DE LA TERRE

« Ils témoignent en temps réel des changements climatiques »

(France TV)

Partenaires



NOTRE APPROCHE

Climate hazard
Current and future risks levels

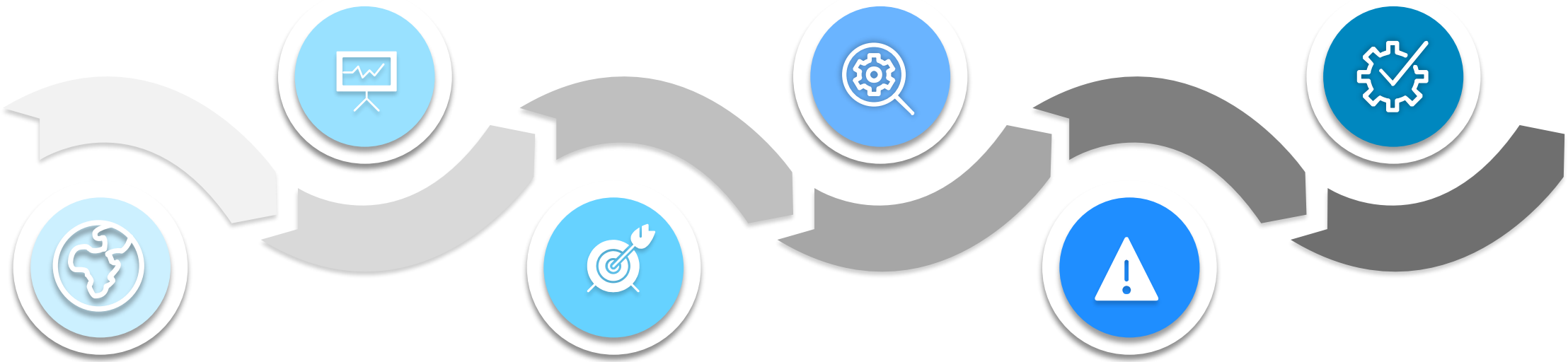
Issues
Activities / Infrastructures impacted by hazards

Impacts
On infrastructures / Operations

Consequences
For Concessions / Operations

Risk categories
Financial / Safety / Continuity of activities / Environment

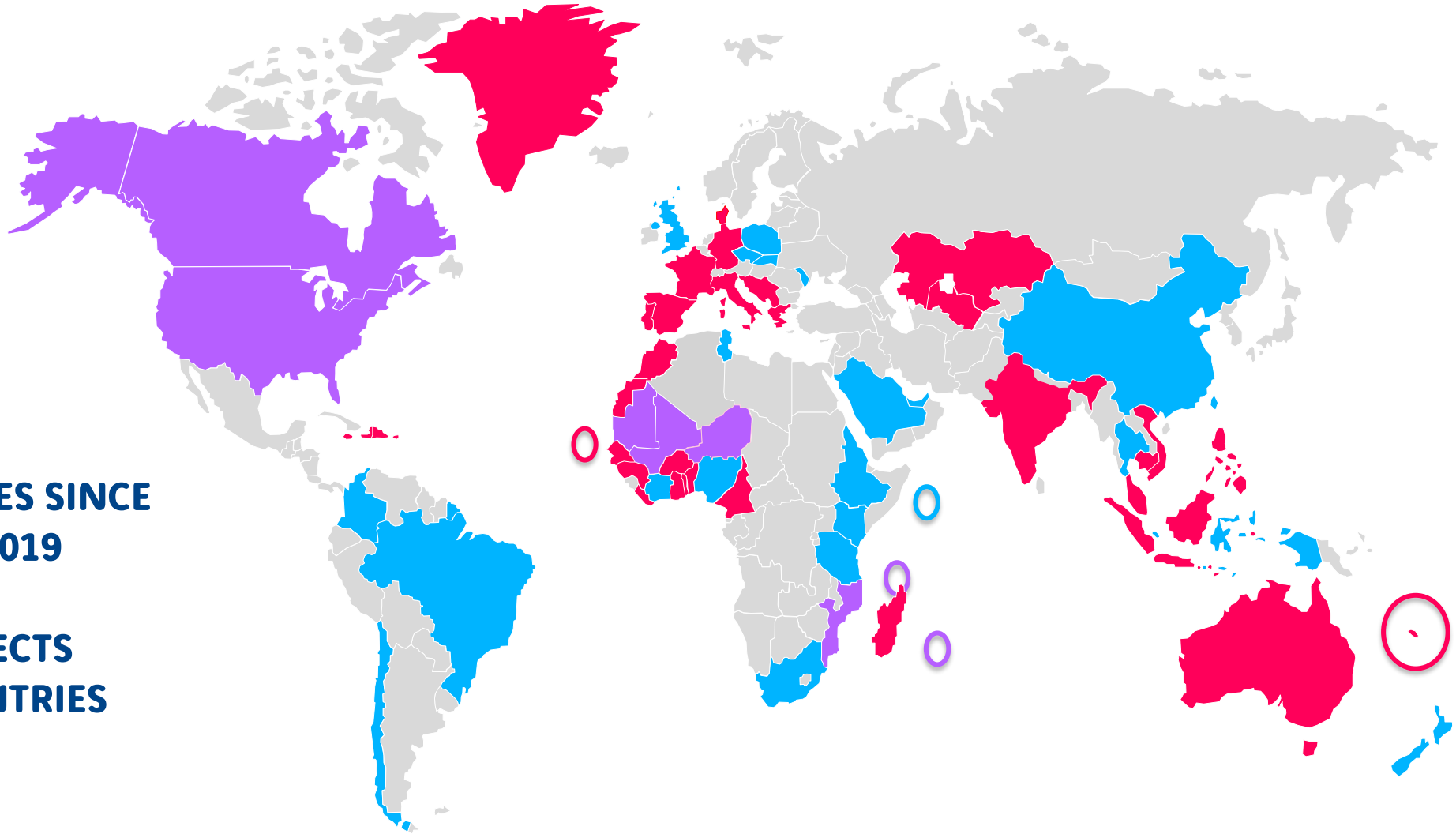
Monitoring - Mitigation - adaptation measures



Projets

LOCATION OF PROJECTS

REALIZED, IN PROGRESS, FUTURE & UNDER DEVELOPMENT



KEY FIGURES SINCE JANUARY 2019

- **80 PROJECTS**
- **60 COUNTRIES**

Clients

RESALLIENCE

International Funders

Cities & States

Real Estate

Network Operators

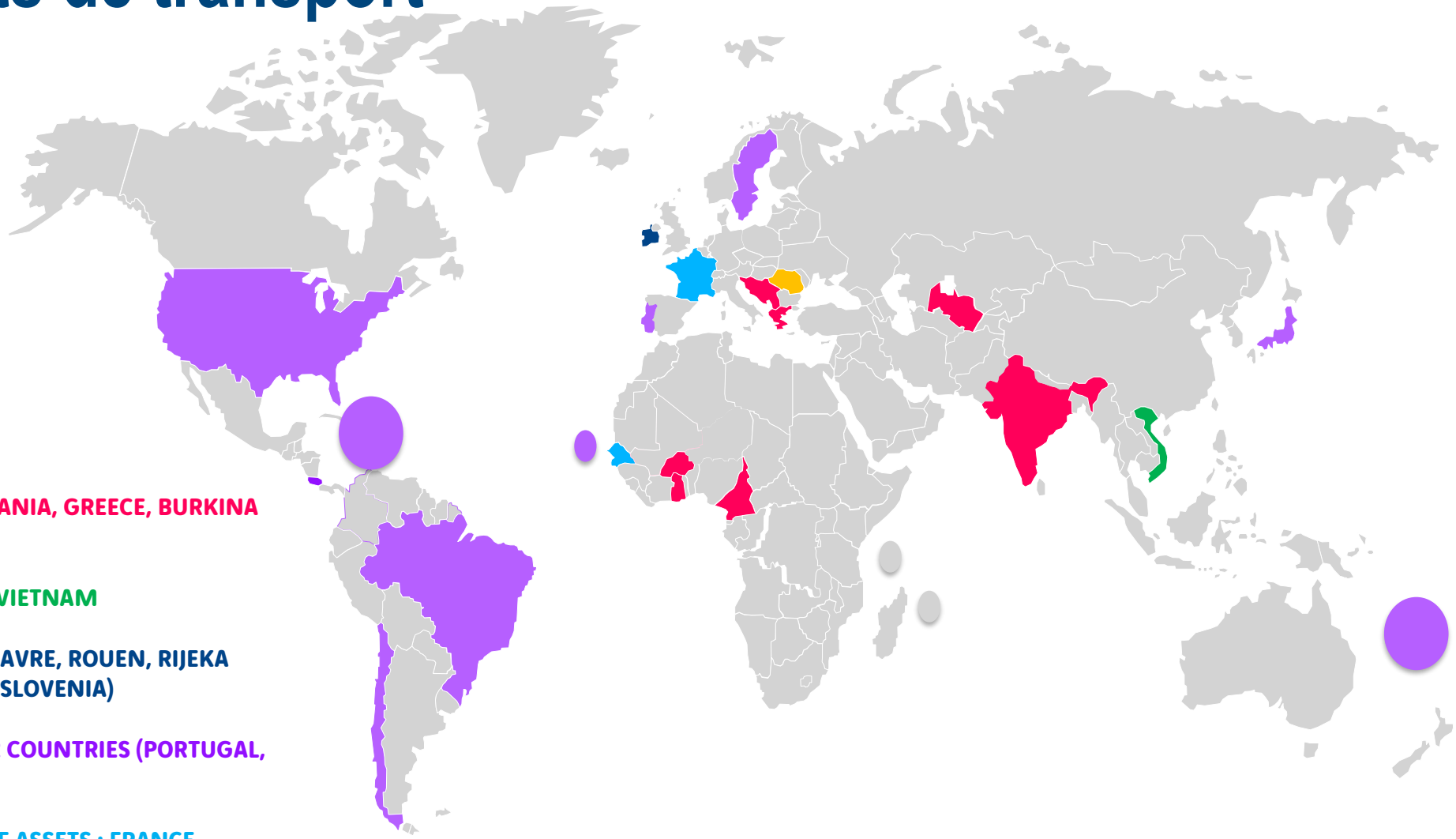
Construction & Industry

Projects

- Buildings – Housing, Sport facilities, health facilities, etc.
- Bridges
- Road infrastructures (roads, bridges, tunnels,…)
- Railway infrastructures (rail, bridges, tunnels, …)
- Airports (buildings, runway, etc.)

Transport assets

Projets de transport



- ROAD ASSETS : ALBANIA, GREECE, BURKINA FASO …
- RAILWAY ASSETS : VIETNAM
- PORTS: IRELAND, HAVRE, ROUEN, RIJEKA (CROATIA), KOPER (SLOVENIA)
- AIRPORTS: 55 IN 12 COUNTRIES (PORTUGAL, JAPAN, UK, …)
- MULTIPLE TYPES OF ASSETS : FRANCE, DOMINICA, SENEGAL, LIBERIA ETC
- ROMANIA

Background

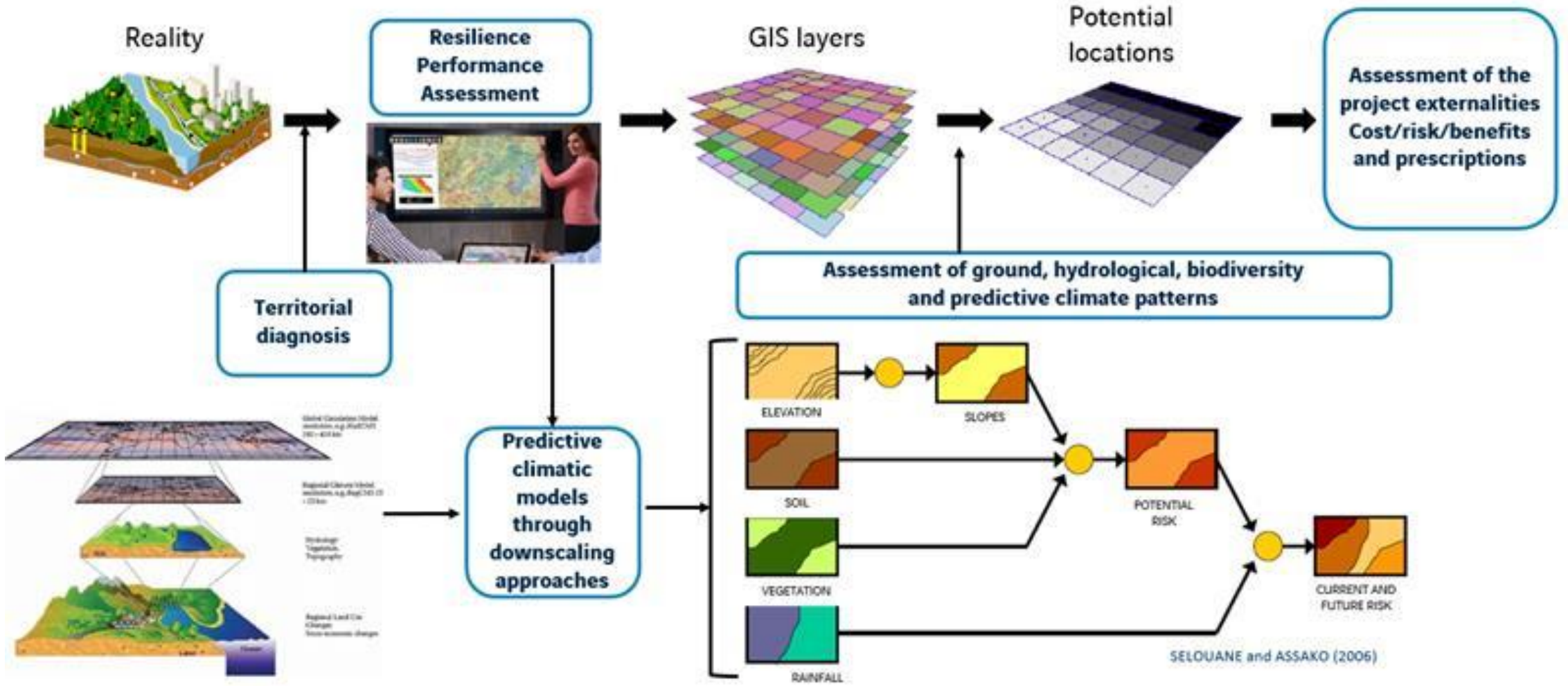
⇨ **Strengthening the resilience of road infrastructures** is more critical than ever before
⇨ Local & international investment programs are developed to reach this objective
⇨ However, **resources are limited**

To optimize resilience investments, decision-makers need to **identify critical roads & prioritize measures to improve their resilience**

- Resilience = ability to sustain &recover from hazards
- Critical roads = whose unavailability would result in the highest impacts on the transport system & surrounding territory

⇨ **Theoretical framework for identifying critical road segments** considering :
  - road infrastructure's **vulnerability**
  - road infrastructure's **resilience**
  - **criticality of the territorial services supported** by the road infrastructure

Methods


Reality
Resilience Performance Assessment
GIS layers
Potential locations
Assessment of the project externalities Cost/risk/benefits and prescriptions
Territorial diagnosis
Assessment of ground, hydrological, biodiversity and predictive climate patterns
Predictive climatic models through downscaling approaches
ELEVATION
SLOPES
SOIL
POTENTIAL RISK
VEGETATION
CURRENT AND FUTURE RISK
RAINFALL
SELOUANE and ASSAKO (2006)

Methods

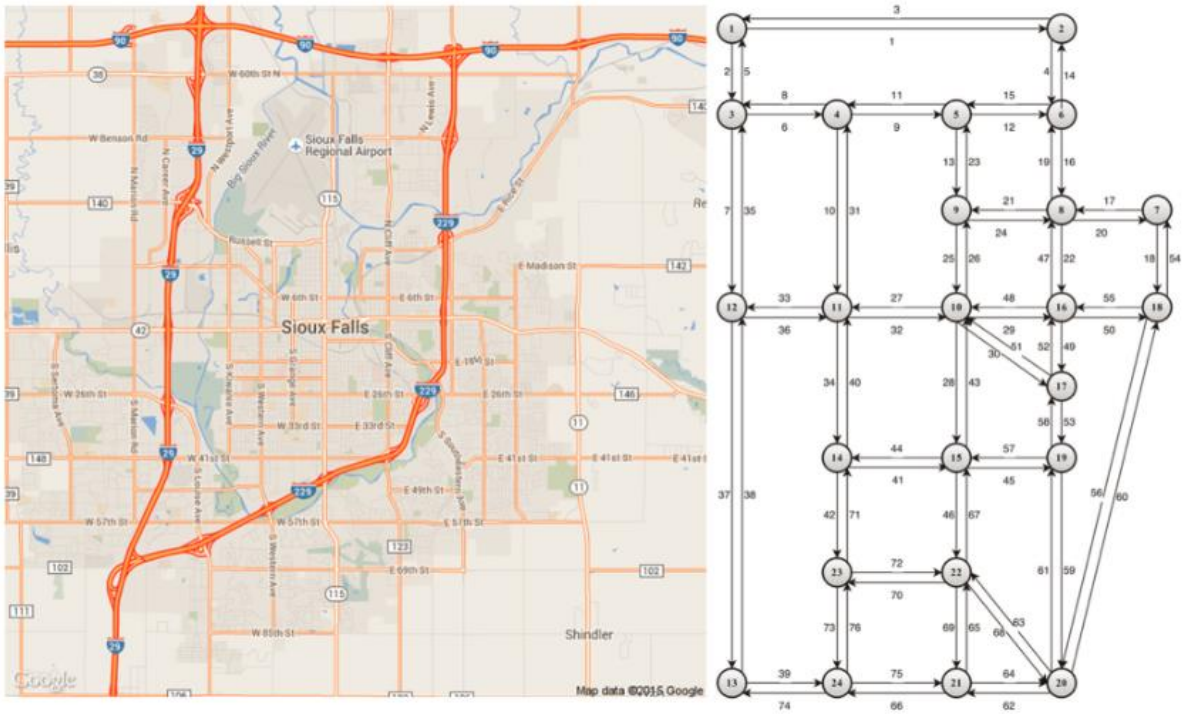
Proposed Framework

- Step 1: Divide the road network into road segments
- Step 2: Assess the Criticality Components
- Step 3: Assess the Composite Criticality

Methods

Step 1: Divide the road network into road segments

- according to network characteristics & stakeholders' objectives
- e.g. urban road networks can be divided into functional elements, using intersections & dead-ends to divide the network into segments



Source: Bhavathrathan BK, Patil GR. Algorithm to Compute Urban Road Network Resilience. Transportation Research Record. 2018;2672(48):104-115. doi:10.1177/0361198118793329

Methods

Step 2: Assess the criticality components

2.1 Vulnerability

- Def: degree to which the infrastructure is likely to experience harm due to exposure to a hazard
- Data: climate hazard (location, intensity & frequency); infrastructure location & sensitivity to a hazard (depends on the infrastructures' physical characteristics)

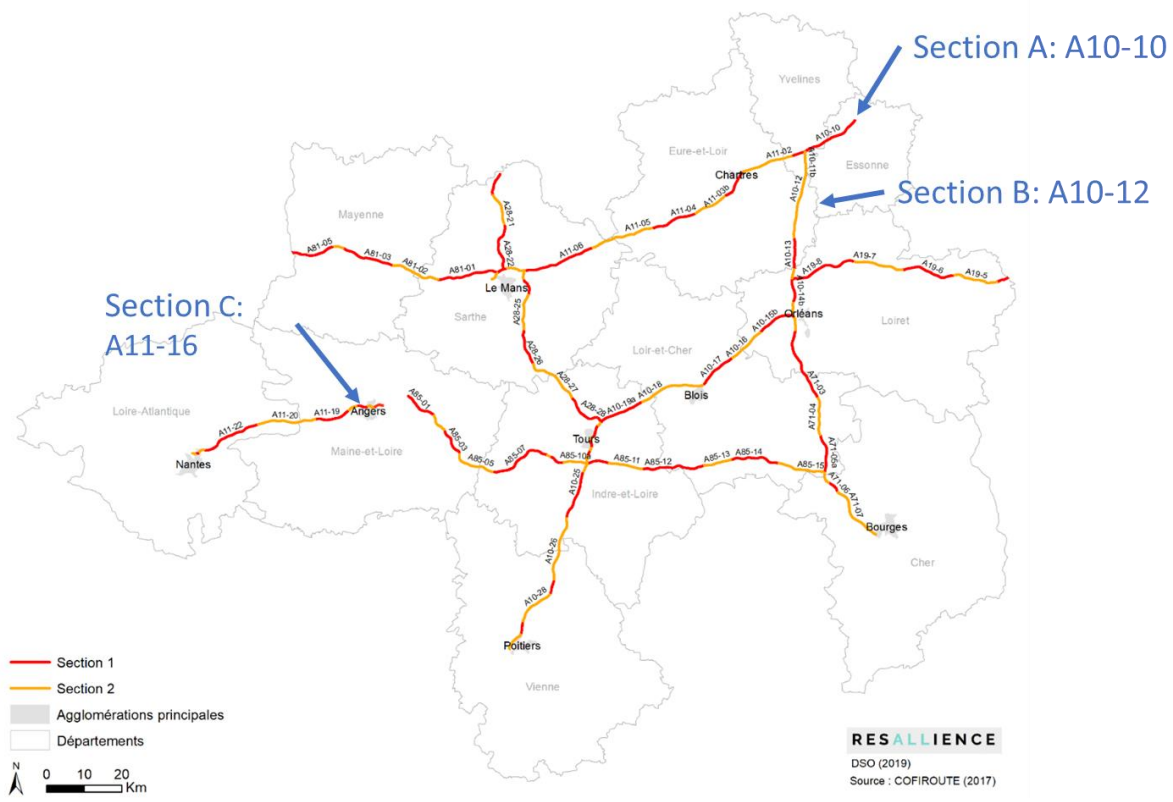
2.2 Resilience

- Def: ability of the infrastructure to continue to deliver or rapidly recover its functionality
- Data: expected evolution of the infrastructure physical & operational damages through a recovery process; hazard, recovery & repair duration

2.3 Territorial criticality

- Def: importance of the infrastructure for the functioning of the territory
- Data: traffic, land use

Case study: Cofiroute network

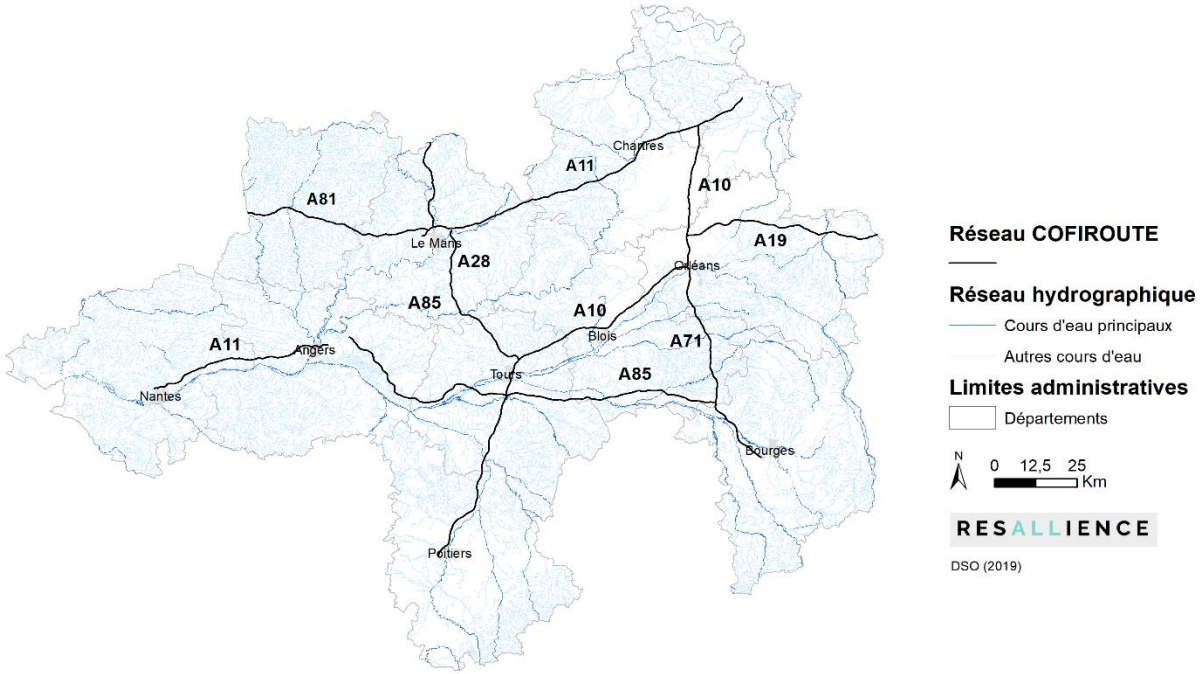


- highway network in central-western France, privately managed
- Circa 1 200 km of road
- OBJ: select a set of highway segments that should be analyzed in detail for future climate-resilience investments
- focus on 3 arbitrarily chosen highway segments (A, B and C)
- Resilience out of the scope

Case study: Cofiroute network

Vulnerability

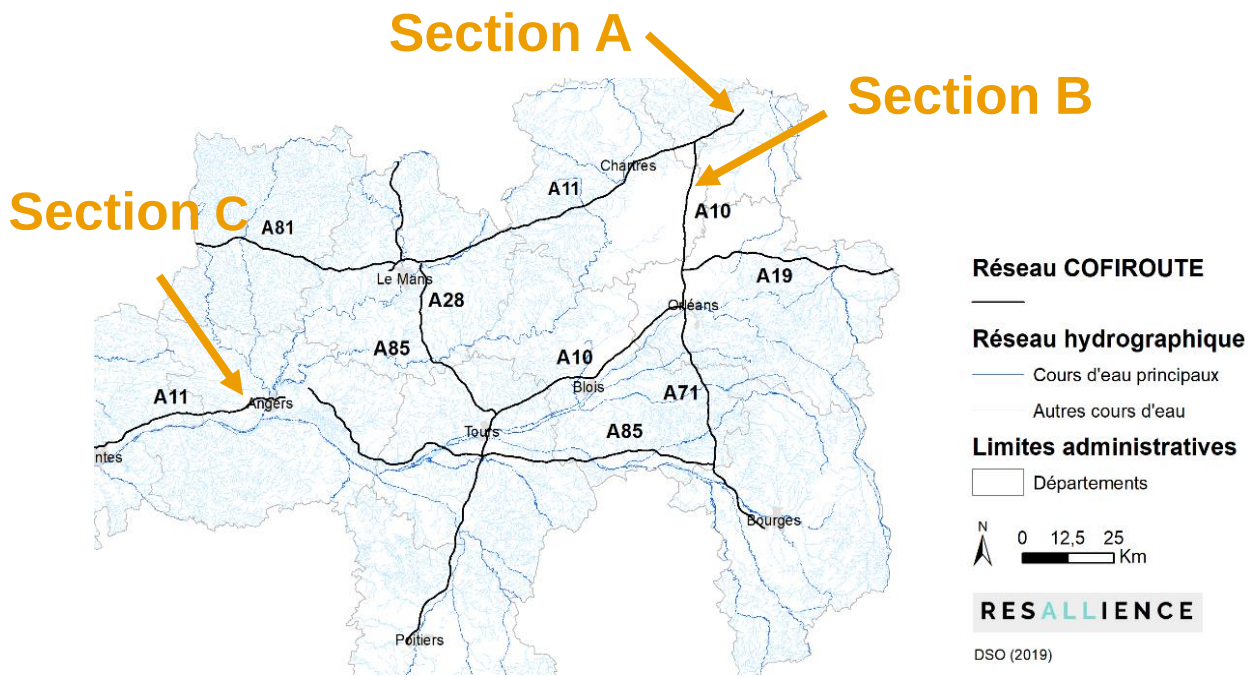
- Vulnerability = Exposure x Sensitivity
- Exposure: scale in [0,4]
  - 0: no watercourse along or intersecting the highway
  - 4: presence of a watercourse subject to a regulatory system and whose hazard intensity is strong
- Sensitivity: 0 or 1
  - 0: elevation differential with the surrounding natural terrain is > 2m
  - 1: elevation differential with the surrounding natural terrain is < 2m



Case study: Cofiroute network

Vulnerability

ID	Exposure (from 0 to 5)	Sensitivity (0 or 1)	Vulnerability (from 0 to 4)
A	1	0	0
B	0	1	0
C	4	1	4



Case study: Cofiroute network

Territorial criticality

- No. of Habitants, Establishments open to the public, Economic activity buildings & Critical Infrastructures (e.g. electrical transformers, water treatment plants) within a 4km radius
- Average annual daily traffic on each motorway section
- In [5, 25]
- $TCr = I_{pop} + I_{ERP} + I_{ECO} + I_{CI} + I_{Traffic}$

	Score				
Indicator	1 pt	2 pts	3 pts	4 pts	5 pts
Pop (Habitants)	Pop<16374	16 375< Pop <33590	33591<Pop<66137	66138<Pop<119905	Pop >119906
ERP (Number)	ERP<50	51<ERP < 104	105<ERP<176	177<ERP<296	ERP>297
Eco (Number)	Eco<580	581<Eco<1066	1067<Eco<1512	1513<Eco<2211	Eco>2212
CI (Number)	IC<36	37<IC<56	57<IC<77	78<IC<127	IC>128
Traffic (Vehicules)	Traffic<16500	16501<Traffic< 29100	29101<Traffic <39000	39001<Traffic< 55000	Traffic>55 001

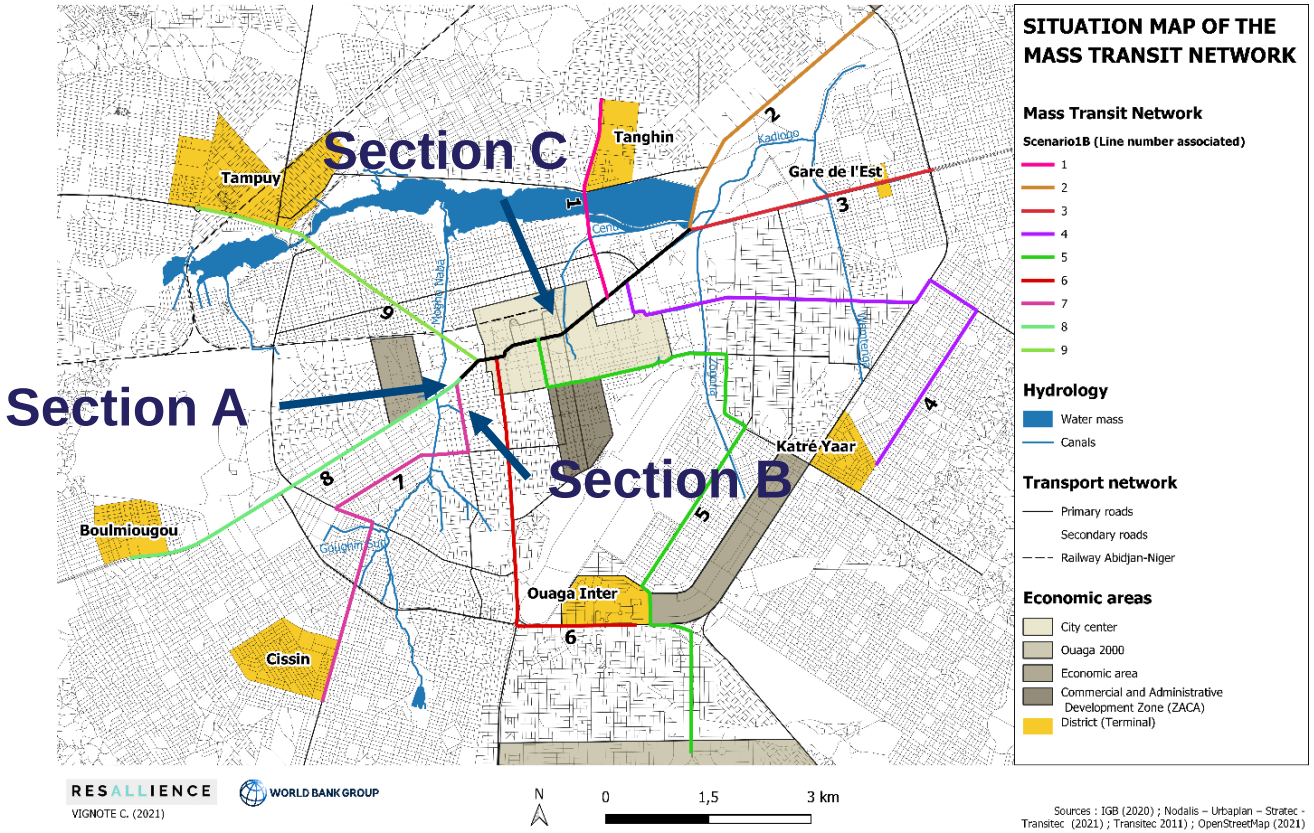
Case study: Cofiroute network

Composite criticality

- $Cr = V * T_{CR}$

ID	Infrastructure vulnerability (from 0 to 4)	Territorial criticality (from 5 to 25)	Composite Criticality (from 0 to 100)
A	0	20	0
B	0	14	0
C	4	20	80

Case study: Ouagadougou BRT project

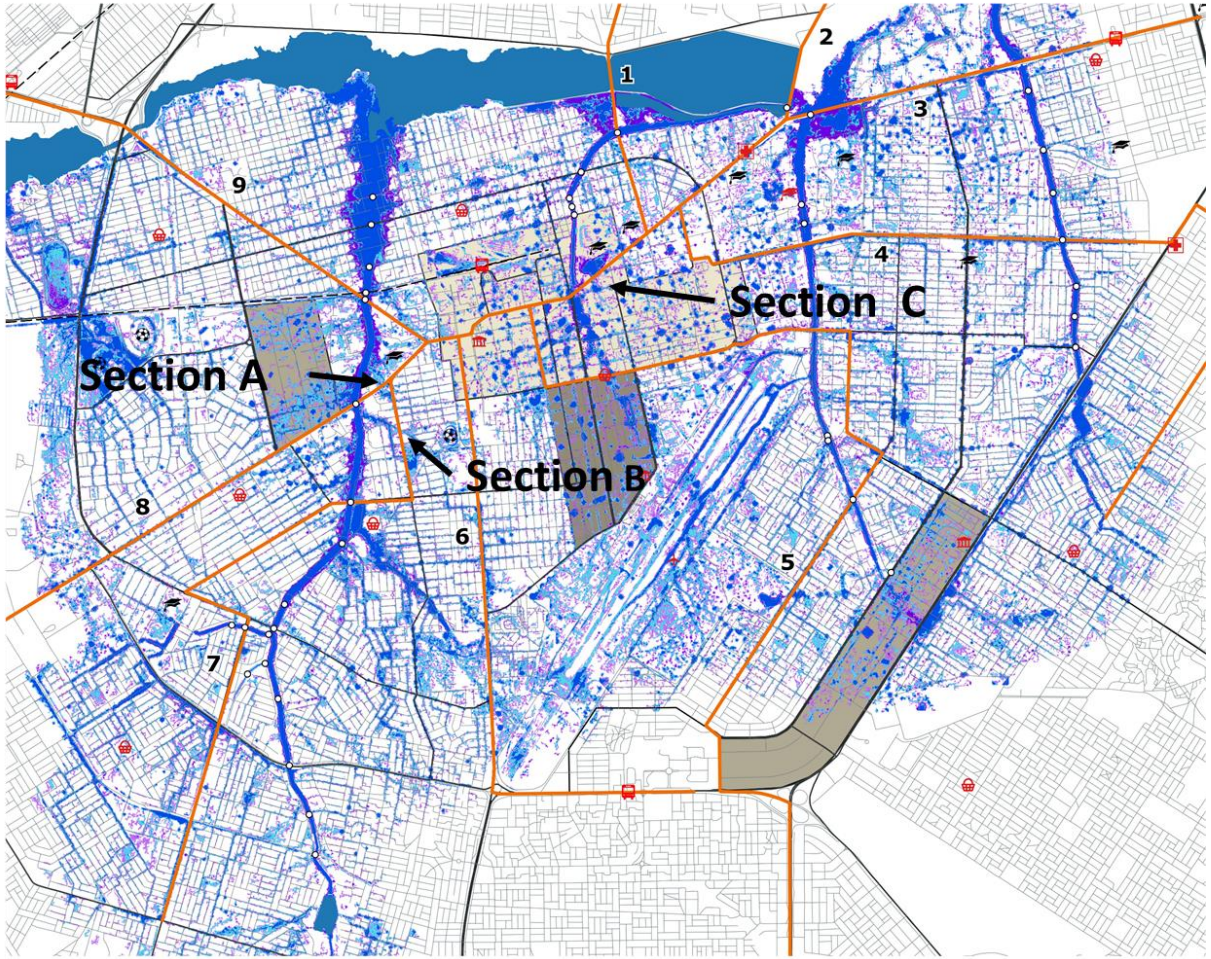


- 9 lines of high-capacity buses that will act as the primary network of a multimodal transport system
- OBJ: identify the critical road sections on the layout of the BRT system that should be prioritized for flood resilience investments
- Focus on 3 sections of Line 7 (A,B, C)

Case study: Ouagadougou BRT project

Vulnerability

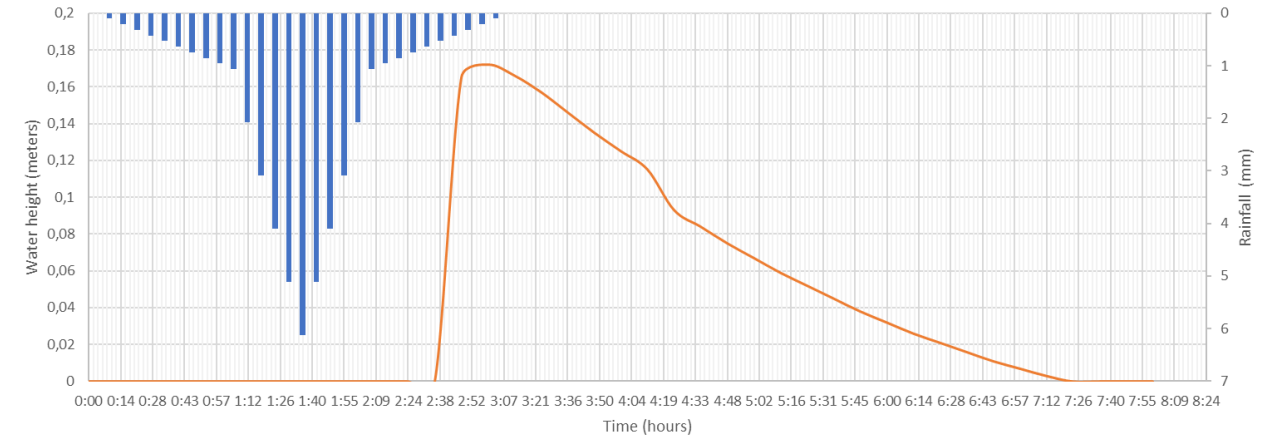
- hydraulic flood model
- Scale in [0,2]
  - Value 0: no impacts
  - Value 1: flooded with slowed traffic (water height below 15 cm)
  - Value 2: flooded with blocked traffic (water height above 15 cm)



Case study: Ouagadougou BRT project

Resilience

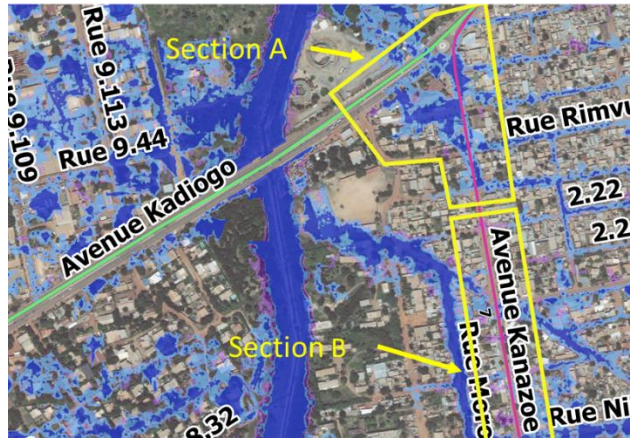
- hydraulic flood model (dynamic)
- Scale in [0,5]
  - Value 0: no impacts
  - Value 1: flooded with slowed traffic and **rapid recovery**
  - Value 2: flooded with slowed traffic and slow recovery
  - Value 3: flooded with blocked traffic and **rapid recovery**
  - Value 4: flooded with blocked traffic and slow recover

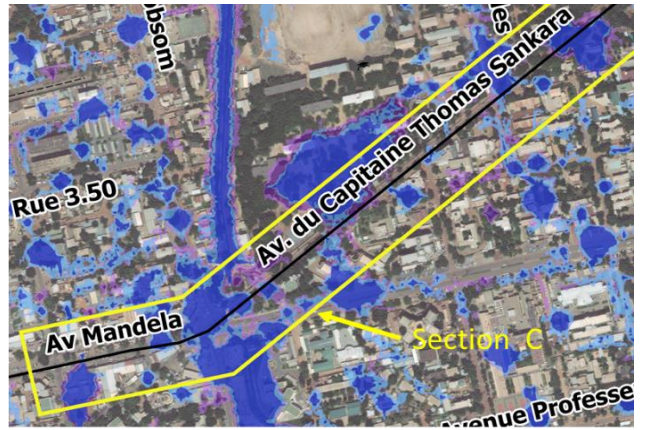


Case study: Ouagadougou BRT project

Resilience

ID	Description of the flood	Infrastructure vulnerability (0 to 2)	Infrastructure resilience (0 to 4)
A	surface run-off coming from the streets to the east. flood depth reaches 30cm.	2	3
B		2	3
C	overflow of the canal as the capacity of the latter is insufficient. flood depth over **40cm and takes several hours to decrease**.	2	**4**





Case study: Ouagadougou BRT project

Territorial criticality

- Projected bus traffic & qualitative assessment of urban issues related to mobility
- In [2,10]
- $TCr = I_{UI} + I_{Traffic}$

	Score				
Indicator	1 pt	2 pts	3 pts	4 pts	5 pts
Traffic (passenger)	Traffic<16500	16501<Traffic< 29100	29101<Traffic <39000	39001<Traffic< 55000	Traffic>55 001
Urban issues	Residential areas with no particular accessibility issues	Mixed residential & commercial areas	Mixed residential & commercial areas, including a few critical facilities (universities, hospitals, etc.)	Business areas, including critical facilities (universities, hospitals, etc.)	Areas with a high concentration of activities (e.g. city center)

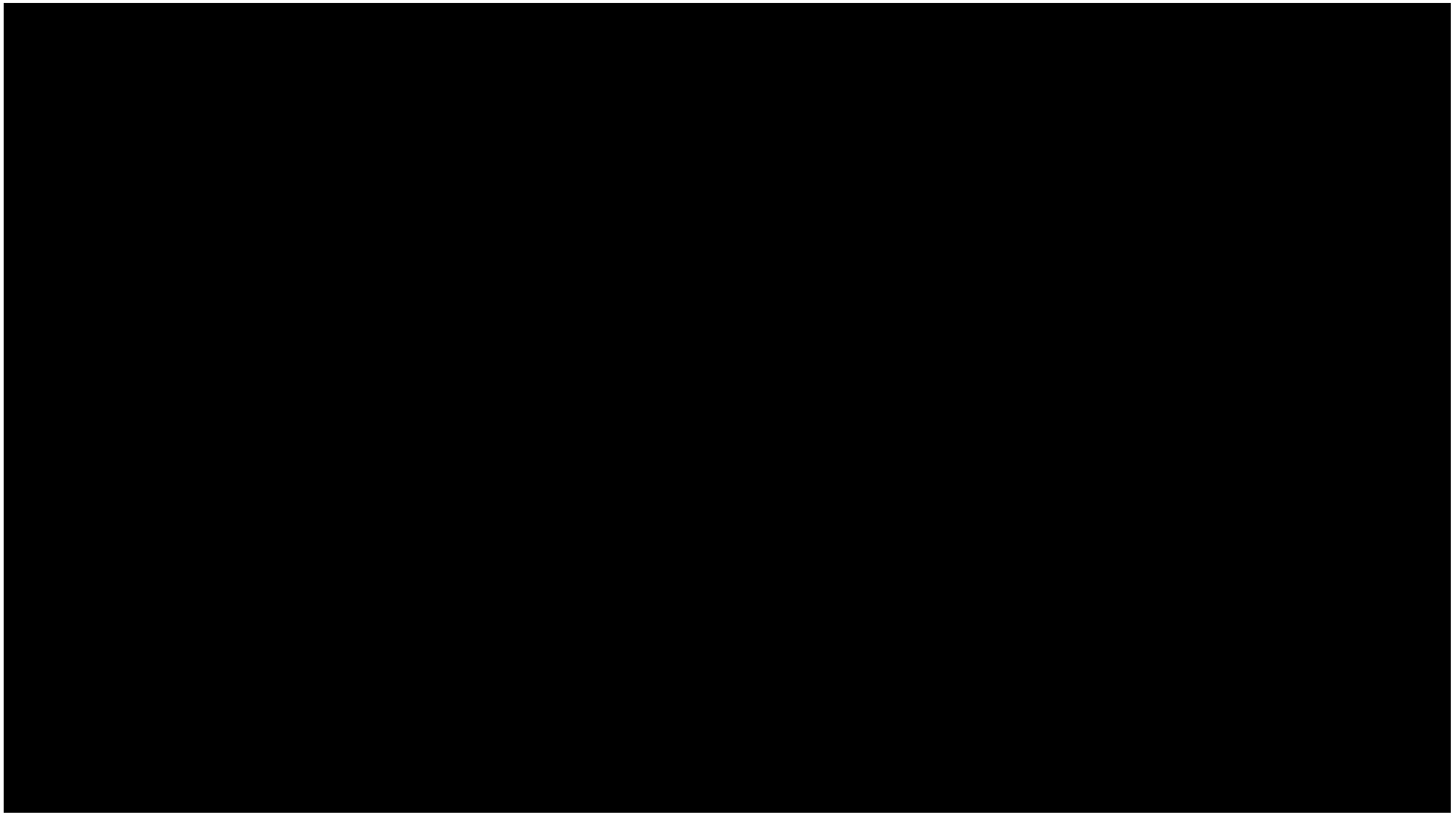
Case study: Ouagadougou BRT project

Composite criticality

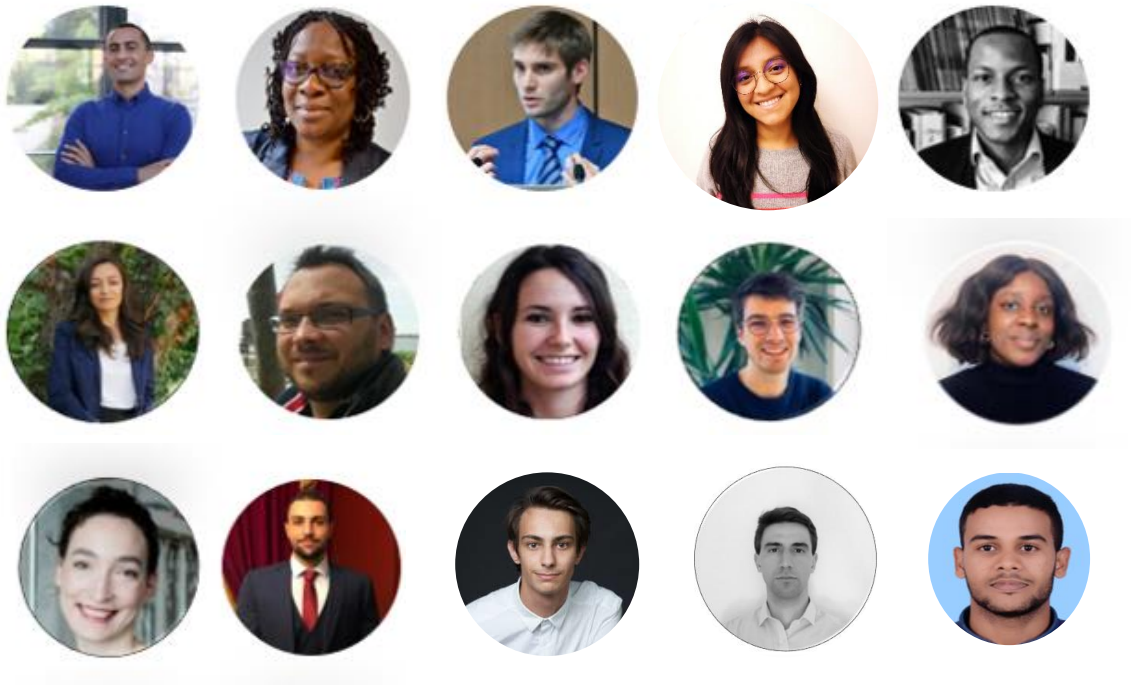
- $Cr = R * TCr$

ID	Bus line(s) affected	Urban issues related to the transport system	Territorial criticality score (from 2 to 10)	Composite criticality score (from 0 to 40)
A	Line 7 & Line 8	**Commercial & residential area**. Line 8 serves the national road N1 towards Bobo-Dioulasso	5	15
B	Line 7	Serves residential areas. Line 7 is the **least important line of the BRT system for transit & accessibility**.	2	10
C	Section shared by most lines	**City center**, Administrative district. Central market, schools, public services, embassies, military camps.	9	36

SYSTEMIC ASSESSMENT OF THE RESILIENCE OF TERRITORY: IFC DOMINICA



Thank you



www.resallience.com

RESALLIENCE