Pacific Island Countries GIS /RS User Conference

Soil erosion susceptibility and coastal evolution: examples in southern New-Caledonia

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Bridging Information Gaps By Creating Smarter Maps
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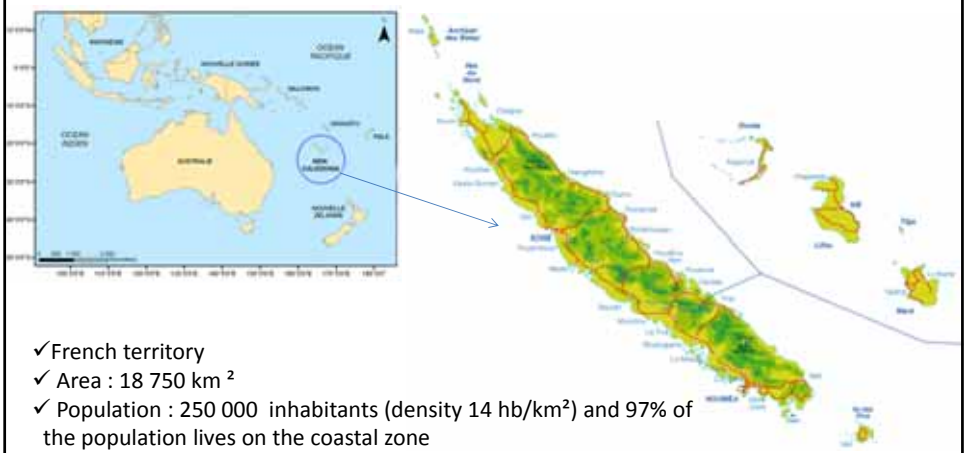
GIS&RS

Study area



✓French territory
✓ Area : 18 750 km ²
✓ Population : 250 000 inhabitants (density 14 hb/km²) and 97% of the population lives on the coastal zone
✓ From North to South of the main island a mountain range, the Central Chain, runs the length of the island, with five peaks over 1500 meters.
✓ Lagon declared a UNESCO World Heritage Site

Soils erosion : a major problem in New-Caledonia

Favorable natural environment :
- Agressive tropical climate (abundant rainfall and cyclones each year)
- Fragile soil (altered and broken ultrabasic rock)…
- Steep slopes on mountain range on the main island

Accelerated by progressive and continuous human pressure :
- mining activity
- bush fires
- agricultural practices
- Urbanization

Context Objectives Methods Results

Impacts of sediment inputs on the shore

✓ Raising of riverbeds causing floods and depletion of floodplain soils ;

✓ Changes in river and shore morphology, mudding of riverbeds, estuaries, mangroves and delta progadation ;

✓ Turbidity and oversedimentation in bays, causing coral mortality and degradation of marine biodiversity ...

- 1/ Identify and classify the most productive sectors of terrigenous sediments and evaluate sediment supply could being discharged into the lagoon.
- 2/ Detect impacts of sediment inputs on the shore evolution at the watershed outlets
- 3/ Linking 1 and 2 to better understand the influence of erosion processes on the evolution of the shore

Issue of Integrated Coastal Zone Management : characterize the pressures on watersheds to better assess their downstream impacts on the coastal zone (hypersedimentation process, decreased coral vitality ...)

- Support tool useful to decision and policy manager for the implementation of management plan (characterization of priority management areas ...)

Methodology for Mapping Potential Erosion Risks using the USLE Model and a GIS

The USLE model

The “Universal Soil Loss Equation” is an empirical model

$$A = R K L S C P$$

-A is the computed soil loss (tons/hectare/year)

- R is the rainfall-runoff erosivity factor (climate)
- K is the soil erodibility factor (soil)
- L is the slope length factor (topography)
- S is the slope steepness factor (topography)
- C is the cover-management factor (land use: cultural practices)
- P is the supporting practices factor

Mapping shoreline evolution

✓ Diachronic analysis of satellites images at very high spatial resolution (Quickbird images at 0,66 m spatial resolution and GeoEye images at 0,42 m)

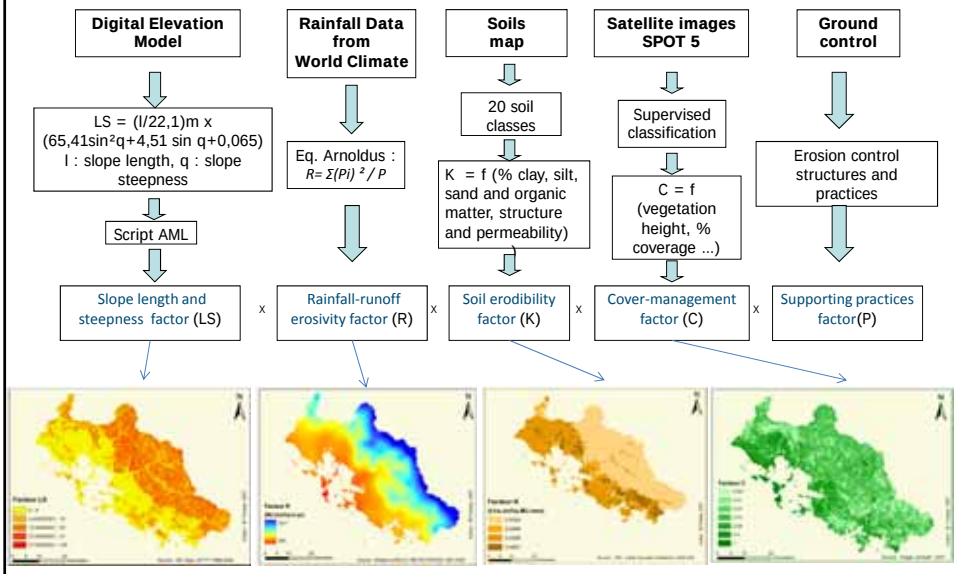
✓ Survey period : 10/11 years from 2002 to 2013 (with 3 to 5 images availables by sites)

✓ 2 indicators taking in account :

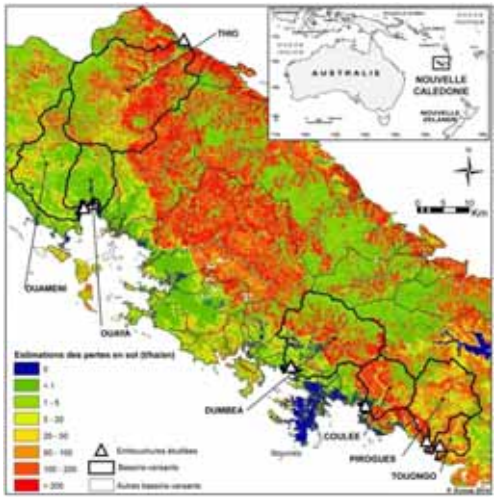
- the variation of sand vegetation limit on the upper beach

- the variation of the magroves areas at the river mouths : good indicator of sediment deposit in coastal environnement (Alonghi 2009)

Context Objectives Methods Results



Spatial distribution map of average annual soil loss



Stydy sites	Area watersheds Km²	Surface of mines and mining dumps (km²)	Soil losses t.10³/an
La Coulée	93	4,05	1057,7
La Dumbéa	231	1,20	1776,7
Ouaya/Ouaméni	277	0,00	521,9
La Thio	396	12,15	4297,1
Rivière des Pirogues	144	3,61	1101,5
Touongo	38	1,30	315,4

The average values of potential sediment production obtained, range between 10,6 à 114 t/ha/an,

⇨ High erosion (FAO)

Significant spatial variability:
- coastal plain erosion is low: <10 t/ha/yr
- mountain range: extreme values: > 150 t /ha/yr

Shoreline evolution survey at the river mouths

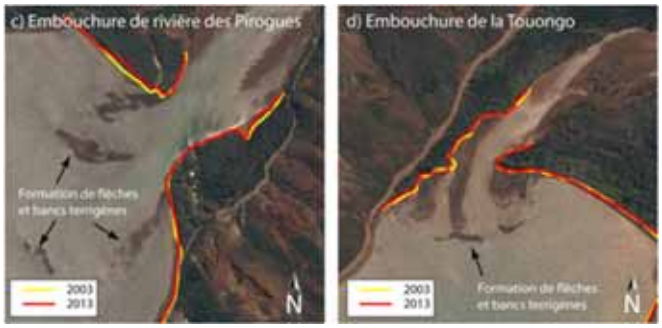
Study site	Soil loss (t.10³/y)	Length of studied coastal stretch (km)	Shoreline evolution (m)	Mangrove evolution (ha)
La Coulée	1057,7	3,94	-	6,85
La Dumbéa	1776,7	6,31	-	5,89
Ouaya/Ouaméni	521,9	5,3	-	18,42
La Thio	4297,1	4,71	2,44/3,88	-
Pirogues river	1101,5	1,14	1,6/0,07	-
Touongo	315,4	0,91	0,78	-

⇨ A clear relation between shoreline evolution (m) et watersheds soil erosion (t.10³/y): correlation coefficient = 0,97 (computed on 3 sites only).

Thio : general evolution = +2,44 m with important longshore variability; e.g.; from +11 m next to a breakwater blocking the sediment drift to -11,5 m on a sandy ridge closing one of the river mouths that broke during a flood. If this measurement is not taken into account the general evolution = +3,88 m.

Shoreline evolution survey at the river mouths

⇨ Diachronic analysis also helps to detect landscape evolutions.



Development of terrigeneous banks and spits on the intertidal zone and shoreface:

- ✓ Pirogues river: two spits on both sides of the river mouth, a bank parallel to the shoreline 500 m offshore (fig.c).
- ✓ Touongo river: similar evolution with smaller features (fig.d).

Context Objectives Methods Results

Shoreline evolution survey at the river mouths

⇨ One of our hypothesis, the correlation between sediment inputs (related to soil loss) and mangroves development was not demonstrated (negative correlation coefficient, r = -0,83).

These results have to be discussed: they were calculated on 3 sites only and on a quite short time period (10 to 11 years).

An increase in mangrove area does not always cause shoreline progression. In the Touaya river mouth, we detected:

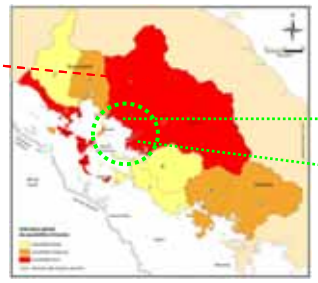
- ✓ A small offshore progression (southward)
- ✓ A development on the bare flats (northward)
- ✓ A densification of the mangrove (increase of number and size of the trees)

Perspectives and conclusions

Erosion modelling helps to estimate soil losses and classify the watersheds related to our study sites depending on their sediment productivity.

⇨ The model is an useful decision-making support for environmental planning, management and conservation of watershed and coastal regions.

Watershed very sensitive to soil erosion



Terrigeneous sedimentation detected by Landsat 7ETM

Oversedimentation in the Tontouta river delta

Limits of the model:

- ✓ Transport and sedimentation processes are not taken into account.
- ✓ Only works with superficial erosion (not with from gully, wind or tillage erosion)

Perceptives et conclusions

We presented preliminary investigations. Some of the results are promising. Statistical analysis has to be develop and validated using:

- ✓ A larger number of study sites
- ✓ A longer time period of observation (30 to 50 years)

Shoreline evolution do not only depend on sediment inputs. At a short time scale some other parameters of the coastal system should also be taken into account, e.g.:

- ✓ Bathymetry (more rapid filling in shallow water)
- ✓ Marine hydrodynamics (more rapid filling in low energy zone, e.g. in protected bays)

⇨ This work should lead to a classification of river mouths depending on land and marine influence.

Thank you for your attention

Using UAV and very high resolution photogrammetry to assess shoreline evolution. Example in Ouvea, Loyalty Island, New-Caledonia

New-Caledonia
Grande Terre
Landsat 7 view

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