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Geographical distribution of ecosystem functions and services in the territorial management of urban municipalities. Case study: La Presidenta Watershed (Medellin, Colombia)

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ISAII

10TH IPWE | 2018
INTERNATIONAL PERSPECTIVE ON WATER RESOURCES AND THE ENVIRONMENT
CARTAGENA, COLOMBIA - DICIEMBRE 4 -7, 2018

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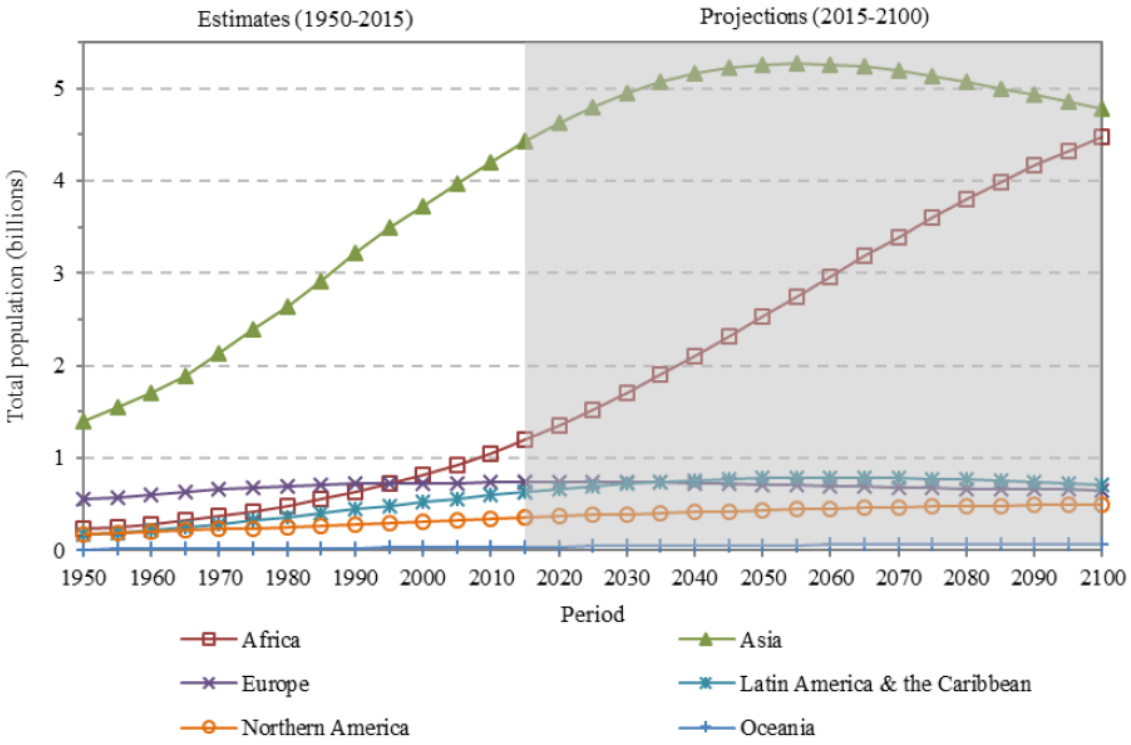
AGENDA

- **The problem:** Territorial planning conditioned by the world context and the local challenges.
- **The tools:** Ecosystem Services (ES) inside the Integrated Water Resources Management (IWRM).
- **Methodology and case of analysis:** Geographical modelling of ES Stability of Hillsides in La Presidenta (Medellin, Colombia).
- **Special remark on Surface runoff**: its importance in the stability of hillsides.
- **Conclusions**

TERRITORIAL PLANNING CONDITIONED BY THE WORLD CONTEXT AND THE LOCAL CHALLENGES

STRESS OVER THE RESOURCES (water, soil, air) : Projections made by United Nations show a clear tendency for the world population to grow, at least, until year 2060 (figure).

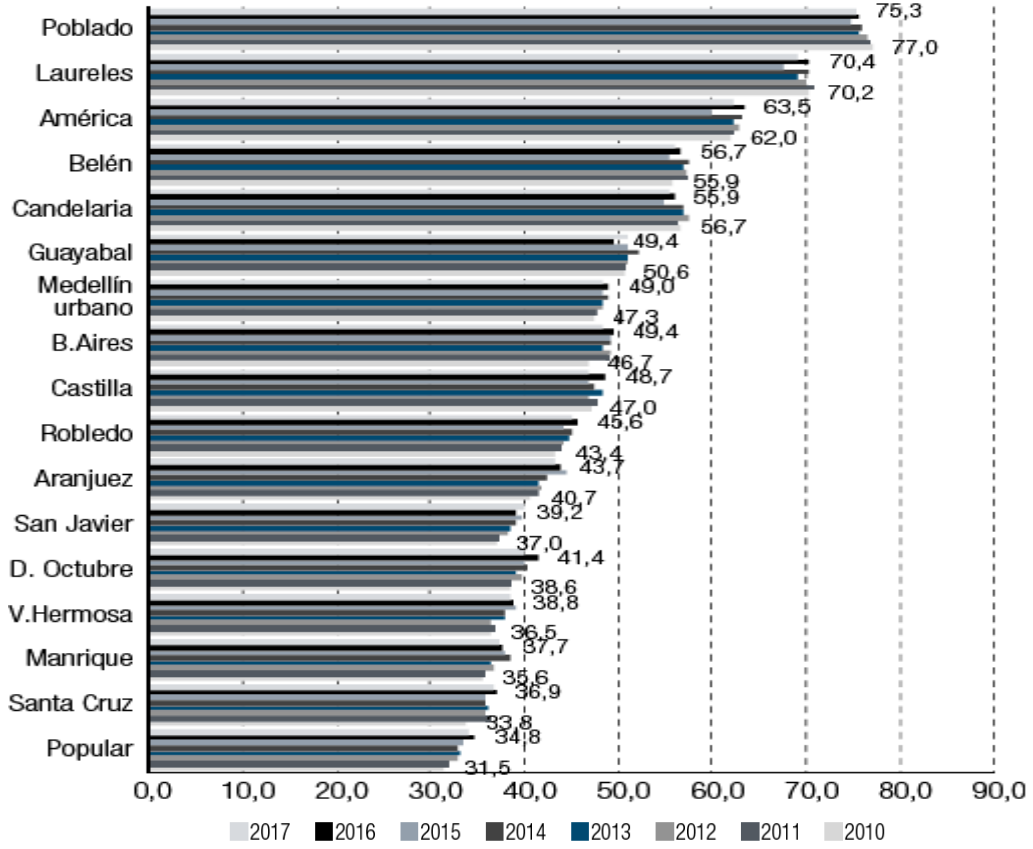


Population by region: estimates, 1950-2015, and medium-variant projection, 2015-2100. Source: United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision. New York: United Nations.

TERRITORIAL PLANNING CONDITIONED BY THE WORLD CONTEXT AND THE LOCAL CHALLENGES

- The scenario is even more pronounced in cases when social conflict is presented in rural areas.
- Violence and abscense of goverment authority, estimulate migration from the field to the city.
- New companies settle down to satisfy necessities of products and services for all the new population.
- As a example of that, the city of Medellín.

TERRITORIAL PLANNING CONDITIONED BY THE WORLD CONTEXT AND THE LOCAL CHALLENGES



GAP IN LIFE CONDITIONS INSIDE MEDELLIN. Multidimensional Indicator of Life Conditions, 2010-2017. Source: 2017 Medellín Quality of Living Report. Information Sub-Direction. Administrative Department of Municipal Planning. Medellín City Hall, 2018.

TERRITORIAL PLANNING CONDITIONED BY THE WORLD CONTEXT AND THE LOCAL CHALLENGES

The City of Medellín and its Metropolitan Area:

- Expands its limits.
- Accommodates new habitants coming from other countries **and from internal regions where violence is present, like Urabá and Chocó**.
- Adopts new land uses.

This, strongly difers with

- The emerging urban and peri-urban planning strategies.
- **The slow velocity as the territory widens its physical infrastructure**.
- The way it brings up to date its integrated risk management system.

TERRITORIAL PLANNING CONDITIONED BY THE WORLD CONTEXT AND THE LOCAL CHALLENGES

The expanding tendency in Medellín brings a high environmental unbalance between

The new hard covers (paviments, concrete, etc.) which produce microclimates.

and

The protected areas responsible for mitigating the greenhouse effect .

TERRITORIAL PLANNING CONDITIONED BY THE WORLD CONTEXT AND THE LOCAL CHALLENGES

In Medellin´s watersheds, where slopes are significantly high and scarps are frequent, some contrasts appear:

In some areas, the natural covers are being protected. Then, soil degradation keeps steady, and the ecosystem service (ES) **Stability of Hillsides is preserved**.

or

But in other sectors, natural covers disappear, this **added to a wrong management of the runoff**, thus generating risk of mass movement and risk of flooding, and finally, disasters.

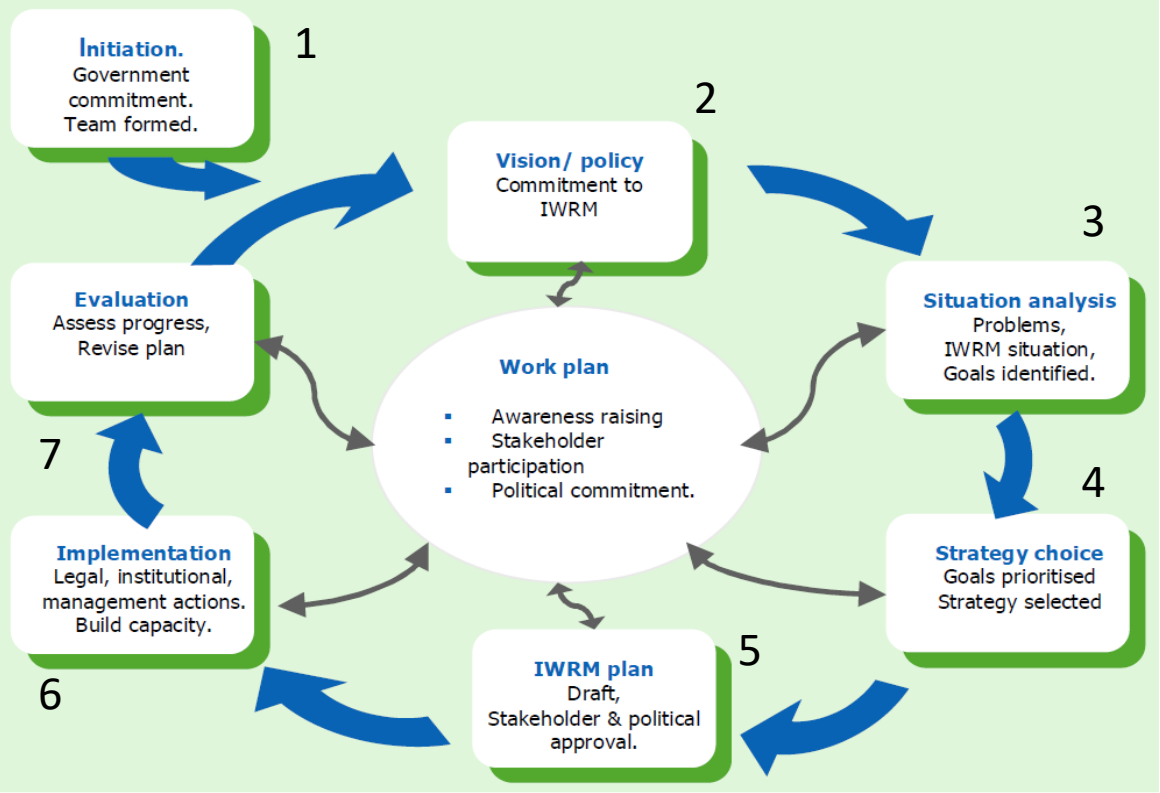
ECOSYSTEM SERVICES (ES) INSIDE THE INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)

In 2010, Colombian government published the National Policy for the Management of Water Resources.

In its concept frame, this Policy acknowledges the definition of **IWRM** made by The Global Water Partnership and United Nations.

But the interpretation of the **ES** in the National Policy **is strongly narrow** (focused only on economic values of environmental services).

ECOSYSTEM SERVICES (ES) INSIDE THE INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)



The cycle for developing and adjusting an IWRM plan. Source. Global Water Partnership, International Network for Capacity Building in Integrated Water Resources Management, United Nations Development Program, 2005.

ECOSYSTEM SERVICES (ES) INSIDE THE INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)

Therefore, connection of **ES** to the IWRM **should consider:**

- The phase (**#2**) of Construction of the Vision (Stablish the Strategic): recognizing a future when environment (through **ES**) can absorb only a fraction of the anthropic impacts.

- In the Strategy Choice Phase (**#4**), a local perspective about **ES** must be adopted in order to prioritize goals and to select strategies .

- Considering the **ES** role from the beginning, will facilitate the Phase of Making the IWRM Plan (**#5**). Here, activities and resources needed to take advantage of the **ES** must be structured.

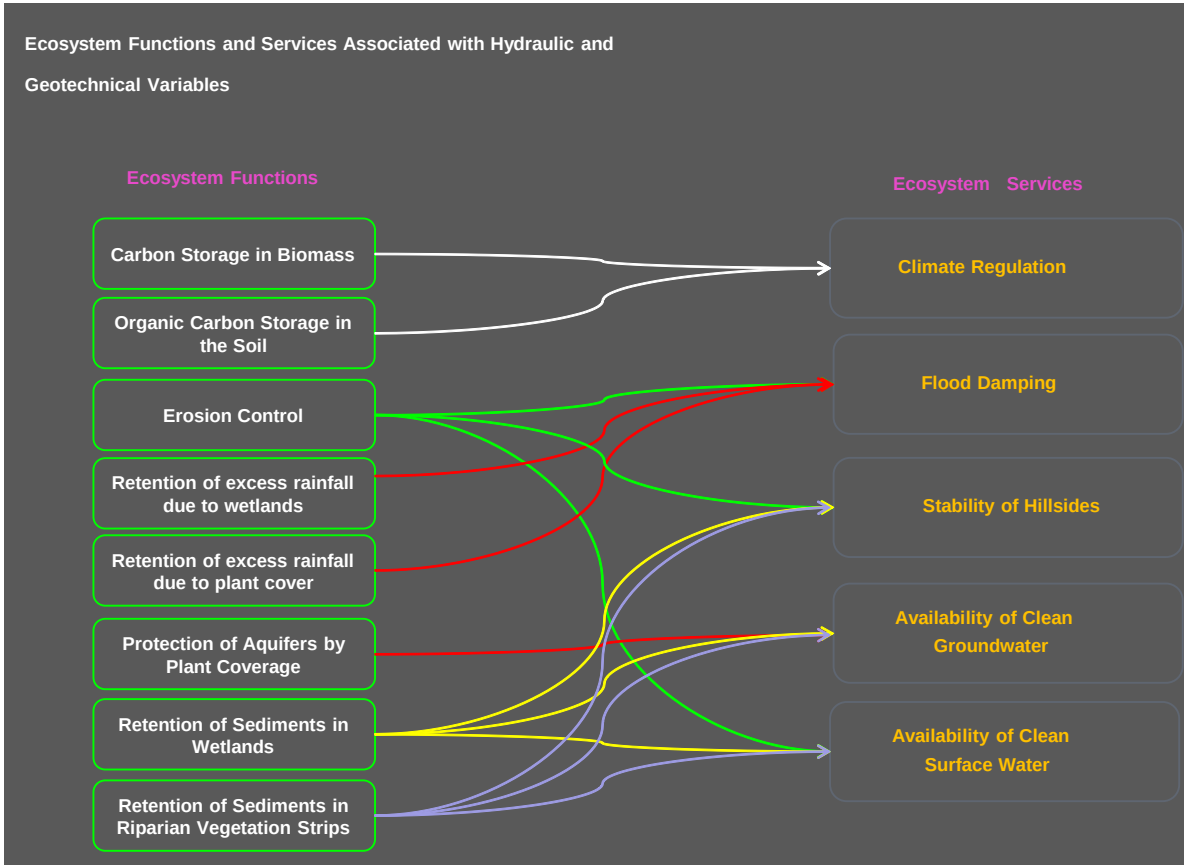
ES STABILITY OF HILLSIDES ASSESSMENT METHODOLOGY AND CASE OF ANALYSIS

- From the set (next figure) of ecosystem functions and services associated to hydraulic and geotechnical variables, **some of them take especial importance in the Los Andes mountain system**.

- Due to the available information, but also pretending to increase the knowledge relevant to **relationship between ecosystem services and risk management** in high slope mountain systems, the **ES Stability of Hillsides** has been modelled.

- In this way, *Stability of hillsides* service **is directly referred to the capacity of ecosystems to minimize landslides**.

ES STABILITY OF HILLSIDES ASSESSMENT METHODOLOGY AND CASE OF ANALYSIS

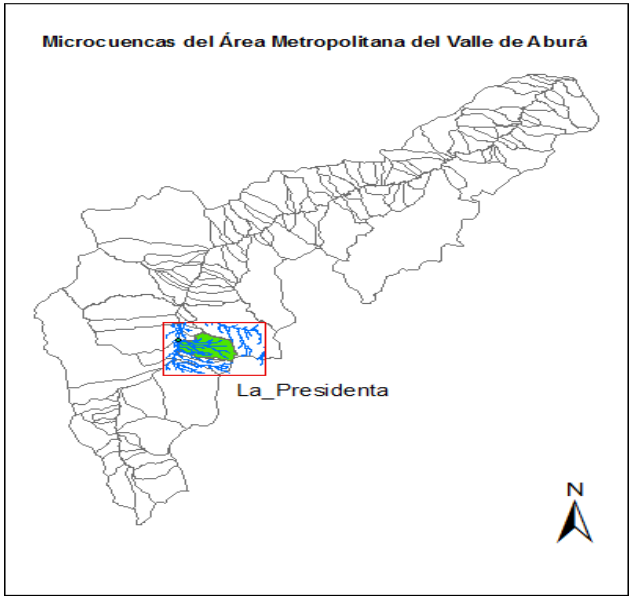


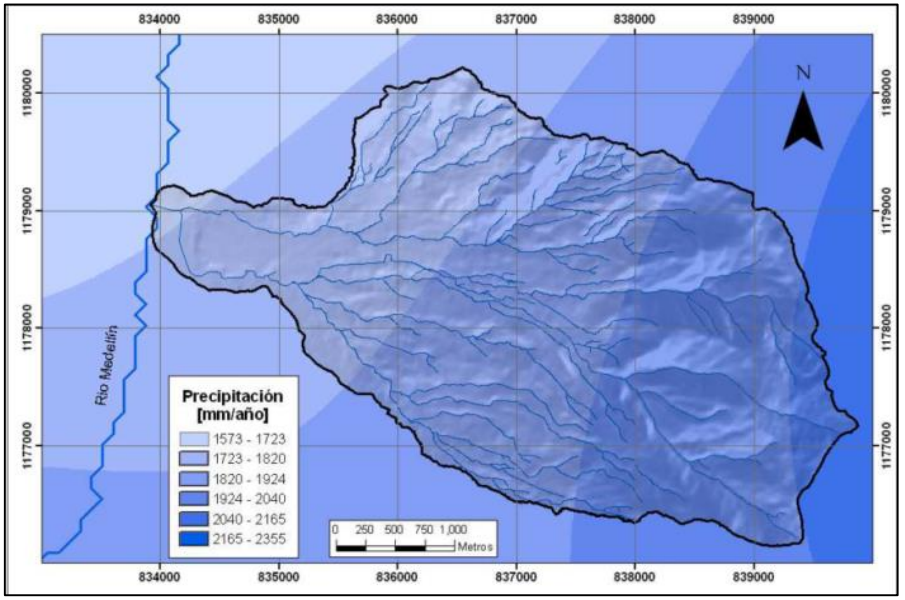
Ecosystem functions and services associated to hydraulic and geotechnical variables

ES STABILITY OF HILLSIDES ASSESSMENT METHODOLOGY AND CASE OF ANALYSIS

The area of study selected for this research is located at the south-east of the Valley of Aburrá (see Figure):

- Surface: 1500 Ha
- Average slope: 17.68%
- Channel slope: 18.33%
- Main channel length: 7.17 km
- Upper zone altitude: 2700 m
- Lower zone altitude: 1488 m





La Presidenta watershed inside Valley of Aburrá. Spatial distribution of annual mean precipitation. Source: Área Metropolitana del Valle de Aburrá, 2007.

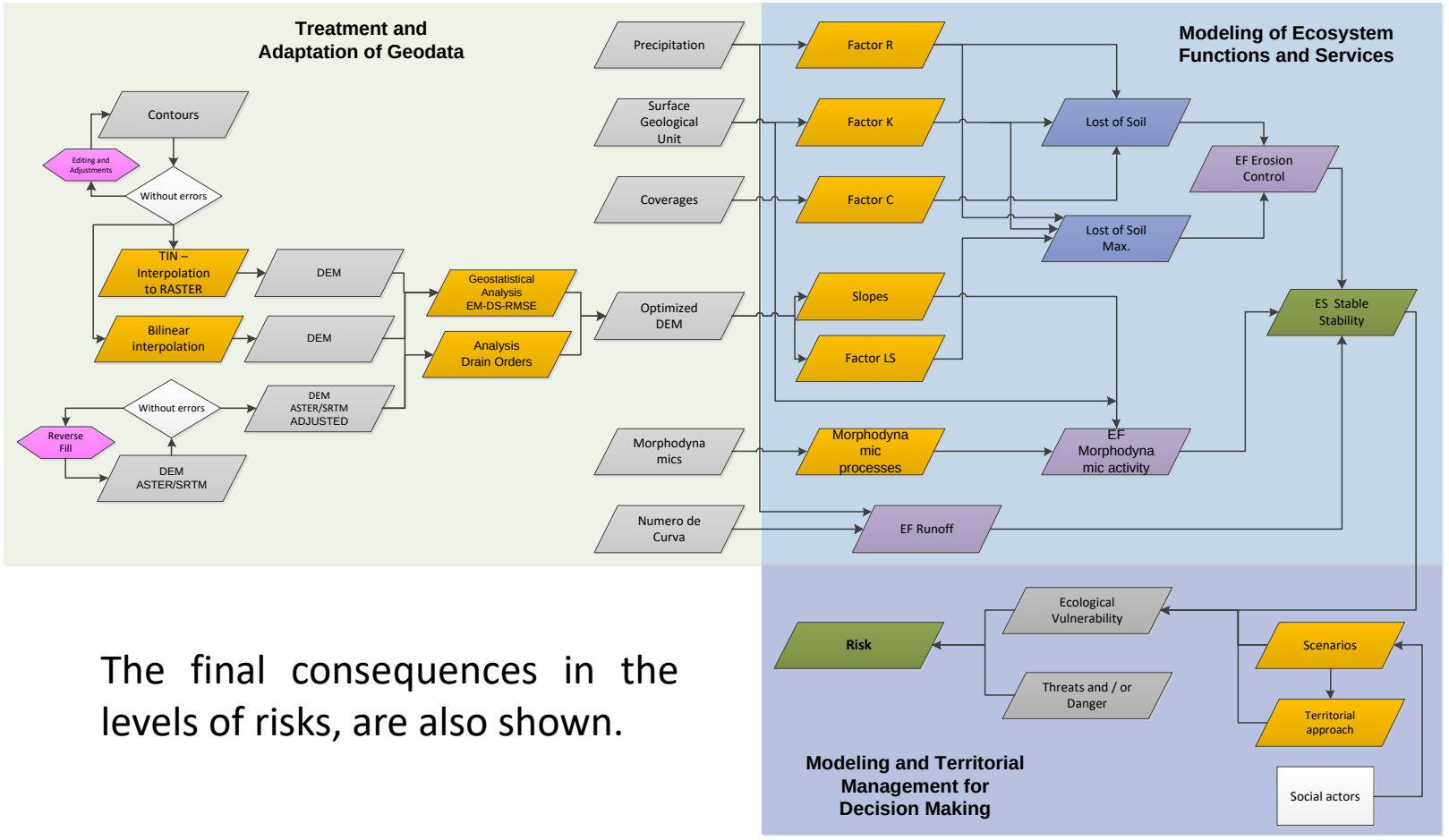
ES STABILITY OF HILLSIDES ASSESSMENT METHODOLOGY AND CASE OF ANALYSIS

Based on the hydraulic modelling (*Área Metropolitana del Valle de Aburrá, 2007*), **some aspects were defined**:

- The modelling for return periods of 100 and 500 years, in the lower zone of the watershed, revealed floods due to lack of hydraulic capacity in the channels.
- The channels which are partially blocked by an important number of crossing infrastructure works (most of them, box culverts) constitute strong hydraulic controls upstream. These controls generate overflows in the flood plain.
- Hard covers, realignments, invasion of flood zones and urban processes which constrict the hydrologic network, cause the loss of natural zones suitable for flood control.

ES STABILITY OF HILLSIDES ASSESSMENT METHODOLOGY AND CASE OF ANALYSIS

The path to model the **ES Stability of Hillsides** is shown in the figure.



The final consequences in the levels of risks, are also shown.

ES STABILITY OF HILLSIDES ASSESSMENT METHODOLOGY AND CASE OF ANALYSIS

The Saaty (Saaty, 2000) Methodology was implemented in the assessment of the **ES Stability of Hillsides**:

	Erosion control	Morphodynamical activity	Surface Runoff
Erosion control	1	5	3
Morphodynamical activity	1/5	1	5
Surface Runoff	1/3	1/5	1

Average weighting of ecosystem functions form expert knowledge.

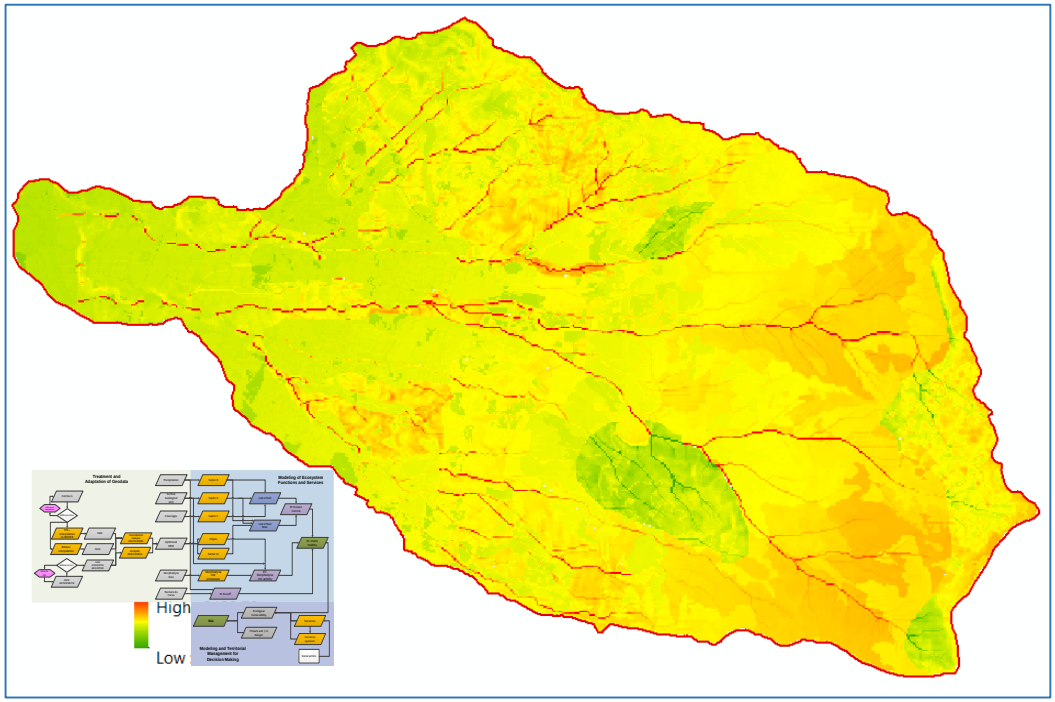
Function	Weight (%)
Erosion control	35
Morphodynamical activity	49
Surface Runoff	16

Final weights for ecosystem functions.

$$SH = 0{,}35 \times \mathrm{EC} + 0{,}49 \times \mathrm{MA} + 0{,}16 \times \mathrm{SR}$$

ES STABILITY OF HILLSIDES ASSESSMENT METHODOLOGY AND CASE OF ANALYSIS

In the figure, it can be observed the result of modelling the **ES Stability of Hillsides** using the methodology described.



Geographical distribution of Ecosystem Service Stability of Hillsides in La Presidenta watershed.

SURFACE RUNOFF AND ITS IMPORTANCE IN THE STABILITY OF HILLSIDES

Direct runoff Q (mm) generated by rain was calculated by using the Natural Resources Conservation Service – NRCS - Methodology:

$$Q = \frac{(I-0{,}2S)^2}{(I+0{,}8S)} \qquad S = \frac{25400}{(CN)} - 254$$

Where:

I: Total rain (mm)

S: Maximum potential difference between total rain and surface runoff (mm)

CN: Curve Number

- CNs consider the probability that the rain can be transformed in runoff as a result of the kind of cover and its interaction with soil properties.
- High CNs imply low infiltrations, which could be associated to eroded hillsides by water erosion

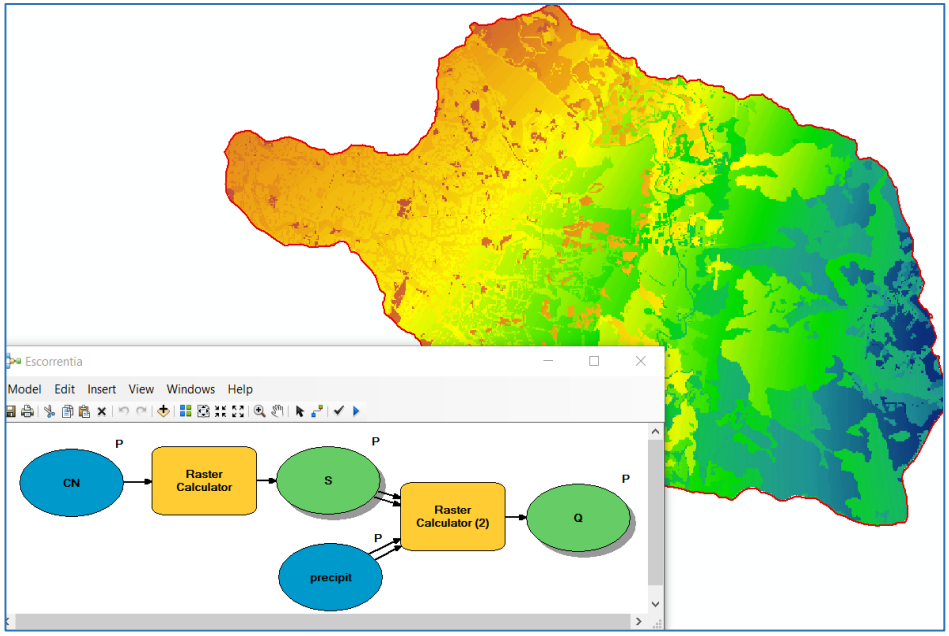
SURFACE RUNOFF AND ITS IMPORTANCE IN STABILITY OF HILLSIDES

- Tables for CN from different authors were analized: Lavao (2014), Juárez-Méndez, Ibáñez-Castillo, Pérez-Nieto and Arellano-Monterrosas (2009).

- Hydrologic group B and Antecedent Moisture Condition II were determined as the closest elections to represent the case.

- To estimate runoff Q, a value of CN was assigned to the vector element of covers according to every specific kind of cover presented in the watershed.

- Then, a raster matrix is obtained and subsequently analyzed with the Model Builder Simulator



Geographical distribution of Ecosystem Function Surface Runoff for La Presidenta watershed.

CONCLUSIONS

- The role of local and national government should consider the provision of a robust structure to prevent disasters through reduction of the vulnerability, and the support to scientific research related to natural hazards.

- Furthermore, national and regional entities must understand and reconsider the prevailing economic model, intentionally to secure sustainability levels in the utilization of natural resources.

- This marks the construction – and discussion - of a series of laws that identify and regulate permitted and avoided land uses based on soil capacities and resilience levels.

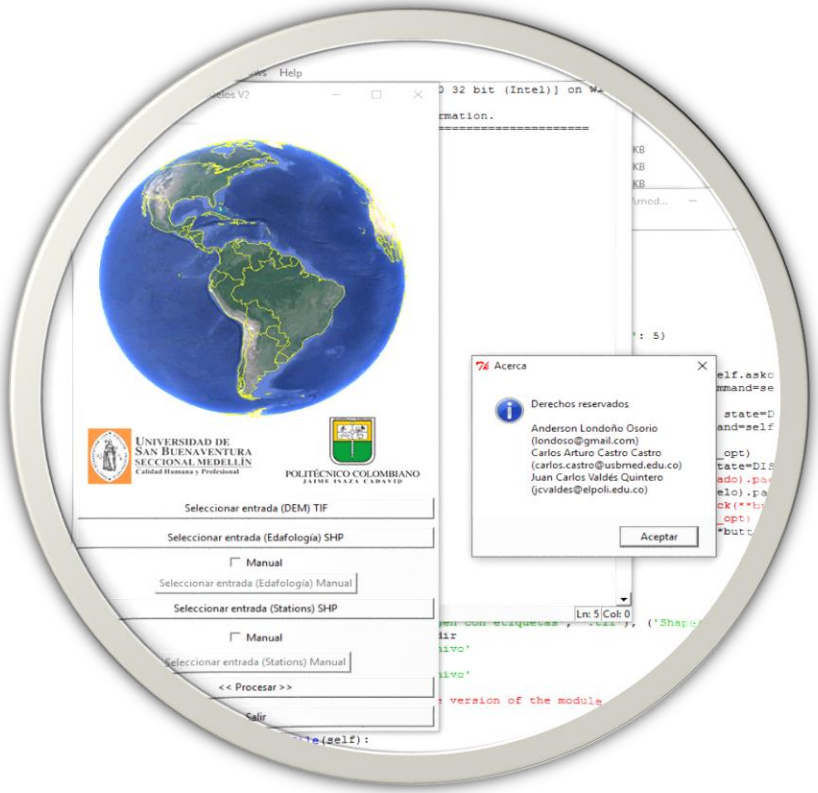
CONCLUSIONS

- A set of criteria and tools for the establishment of a methodology to map ecosystem functions and services is presented.
- This research try to broad the alternatives heading to a subsequent assessment of vulnerability.
- A more reliable risk management is expected to reach, as the territorial planners have more robust elements to support their decisions.
- Enhancing public policies in permanent construction is also a need.

CONCLUSIONS

- More Technical tools for modelling ecological processes and flows of ecosystem functions and services are needed.
- These new tools should filter the relationship between ecosystem services and risk management in the geographic plane.
- They also will help to build solid frames to support decisions about territorial planning.
- Part of this research is driving to the development of a geoinformatic interactive software.
- The software allows the manager/planner to take decisions about processes in different scenarios, even where data are scarce.

CONCLUSIONS



Geoinformatics Python-GIS Tool For Simulating And Analyzing Soil Erosion With Focus On Ecosystems

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