MAPPING THE FLASH FLOOD PRONE AREA
Romanian experience
-methods, tools and results-

P4 - Ovidius University of Constanta

Istanbul 2015

Outline

- Research context
- Research objective
- Overview on the flood mapping methodology
- Methodology proposed
- Results
- Recommendations and Conclusions

Research context

Climate change impact → **Flood** → **Effects of flood**

↑ temperature
(2002-2012) >1.3°C (pre-industrial period)
↑ spatial and temporal variability of precipitation
↑ frequency of extreme precipitation

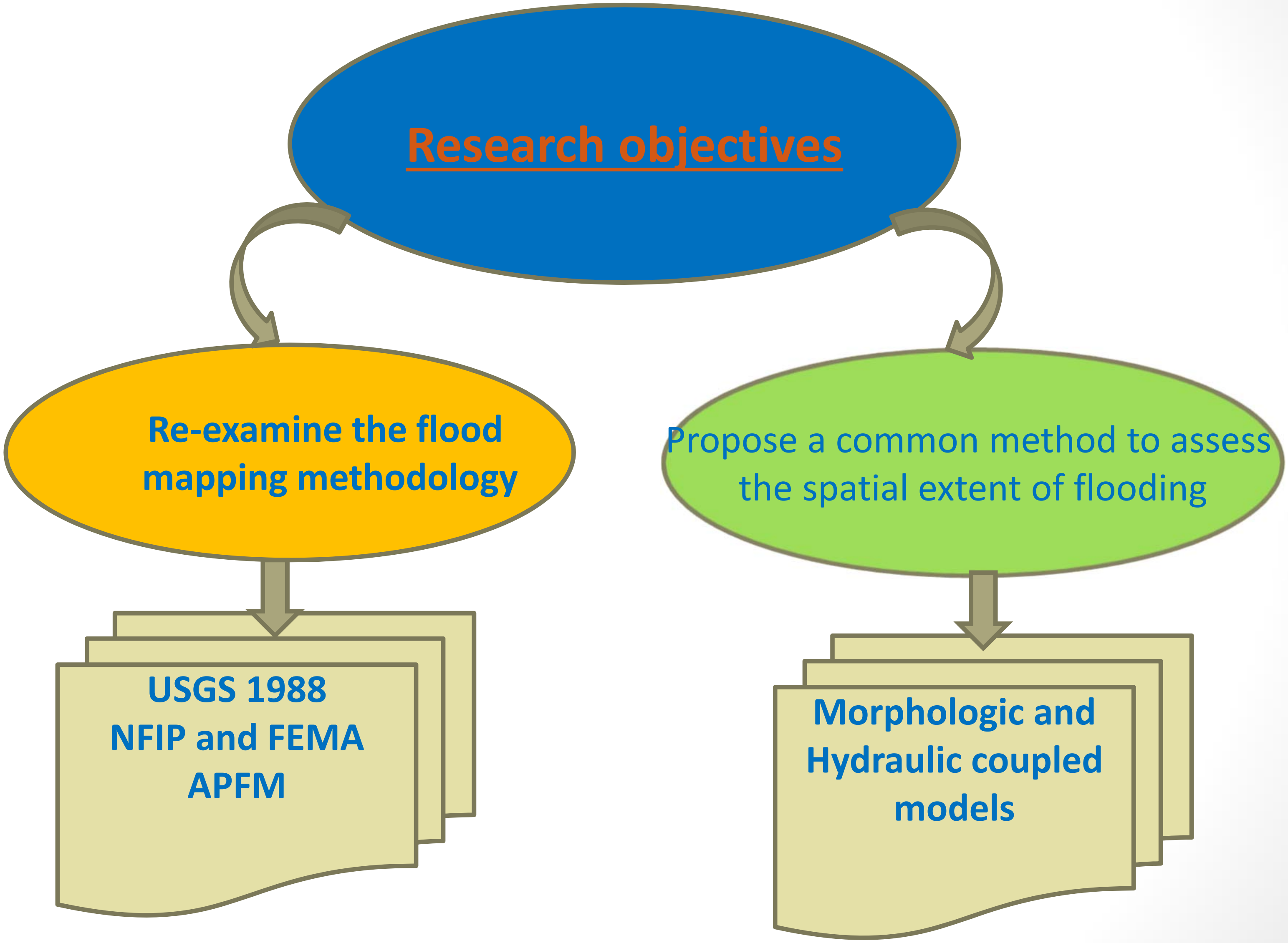
↑intensity and frequency of river floods in winter and spring (in various regions)
N° events (1980-2011) - 3455
N° events in Europe – 325 (200 since 2000)

No of people killed: 195843
Av. people killed per year:6,753
Economic Damage (bill. US$): 397,333,885

Application of Flood Directive

Prepare flood hazard and risk **maps**
Prepare flood risk management plans

scenario considered:
•frequent event (low probability)
•medium event (medium probability - 100 years)
•extreme event (high probability - 1000 years).
Flood parameters provided
•flood extent, WS profile, WS depth, WS velocity


Research objectives
Re-examine the flood mapping methodology
Propose a common method to assess the spatial extent of flooding
USGS 1988
NFIP and FEMA
APFM
Morphologic and Hydraulic coupled models

Flood mapping methodology

- **US Geology Survey (USGS, 1988)**
- **FEMA (Federal Emergency Management Agency) – 2002**
- **WMO – 2013**
- **EXCIMAP (European exchange group on flood mapping)**
- **DANUBE Floodrisk project**

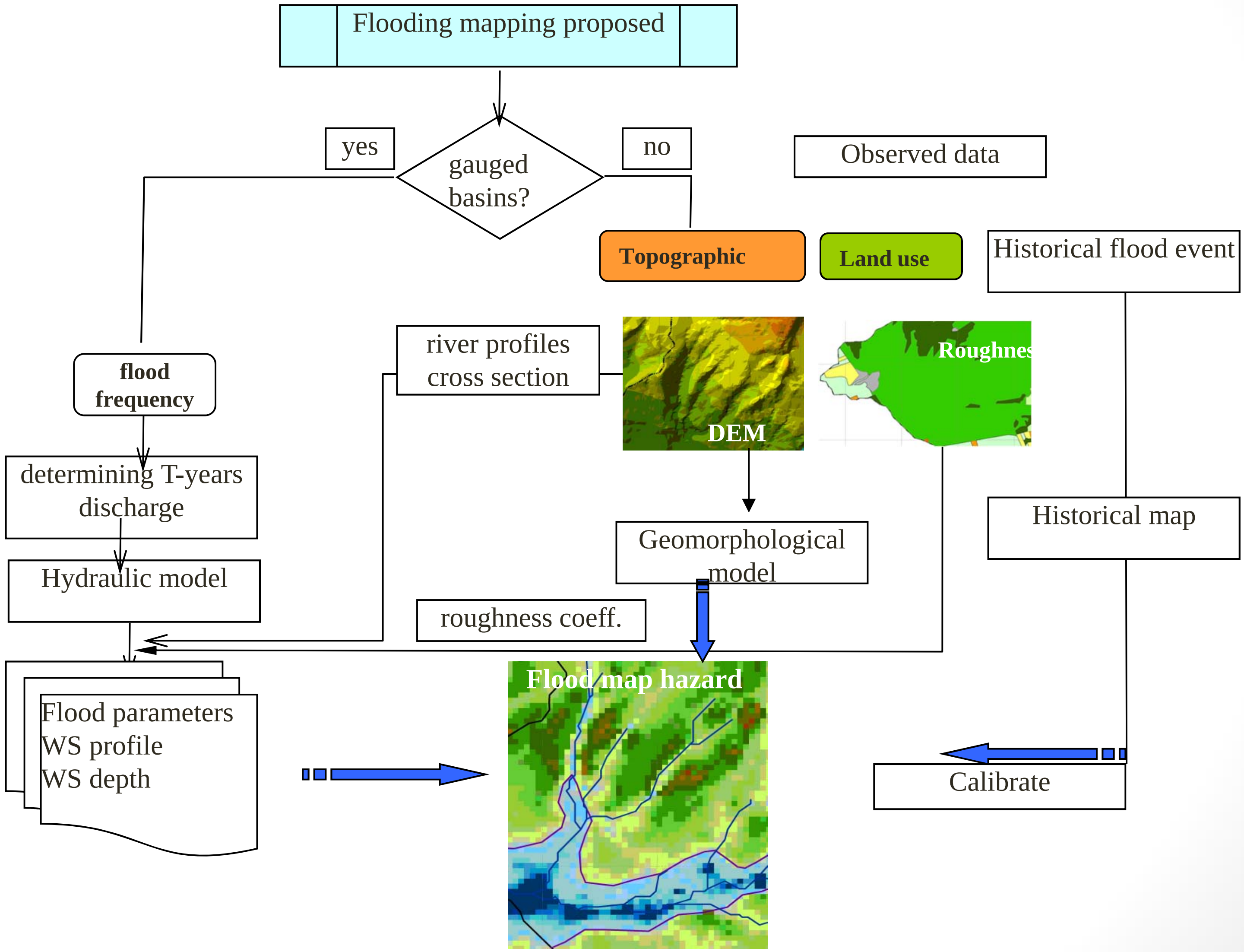
→

- determination of the maximum discharge with a given return period (T-years discharge)
  - For gauged watershed - Statistical analysis of stream-flow records
  - For ungauged watershed:
    - Regional methods
    - Runoff-rainfall model
- determination of a water-surface profile or/and water depth and developing a flood-boundary map (for the T-year discharge calculated).
  - flood routing and the dynamic equation of gradually varied flow .

Recommendation

- FEMA recommended the implementation of a GIS tool to create cross-section and structure data in order to perform water surface elevation
- WMO – 2013 proposed using the geomorphologic approach
- DANUBE Floodrisk project
  - proposed harmonizing the hydraulic modelling
  - reducing differences in the flood plain mapping
  - a common data base

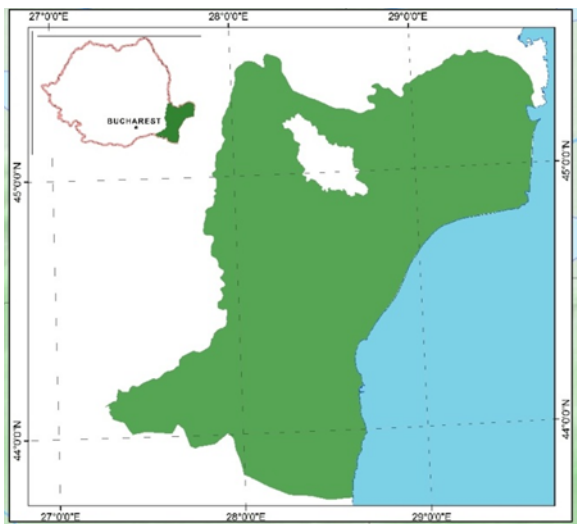
Mapping the flood prone area



Implementation - Results

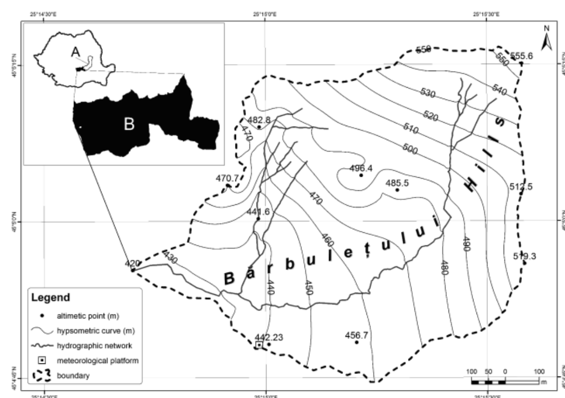
Regional scale

- 30m resolution in Dobrogea region on Taita watersheed



Local scale

- 3 m resolution in South Carpathian montain on Voinesti catchment



Taita catchement

- area 591 km^2
- elevation ranges 261m
- 10 tributaries
- part of North Dobrogea Plateau
- the main source of supply – precipitation 74%

- multi-annual mean temperatures vary in small limits (10-12^{0}C approximately).
- The multi-annual mean precipitation vary in large limits (260–500 mm approximately),
- Vegetation land cover
  - >33% forest
- Average discharge vary between 9.84 and 1.02mc/s

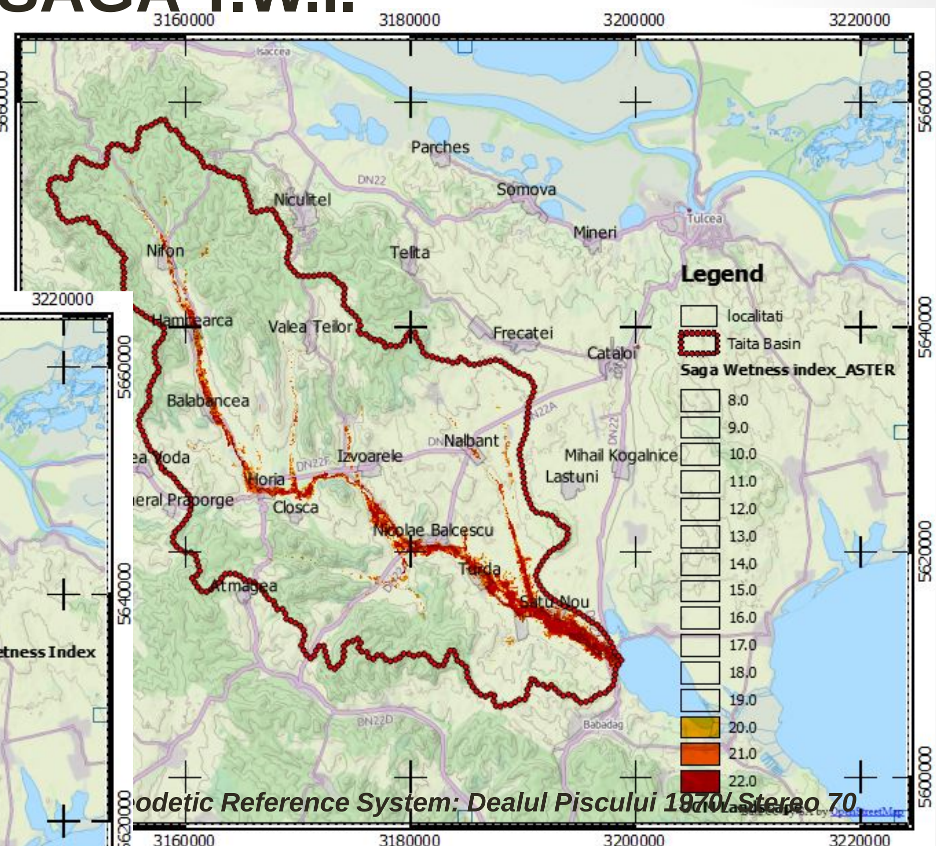
Voinesti catchement

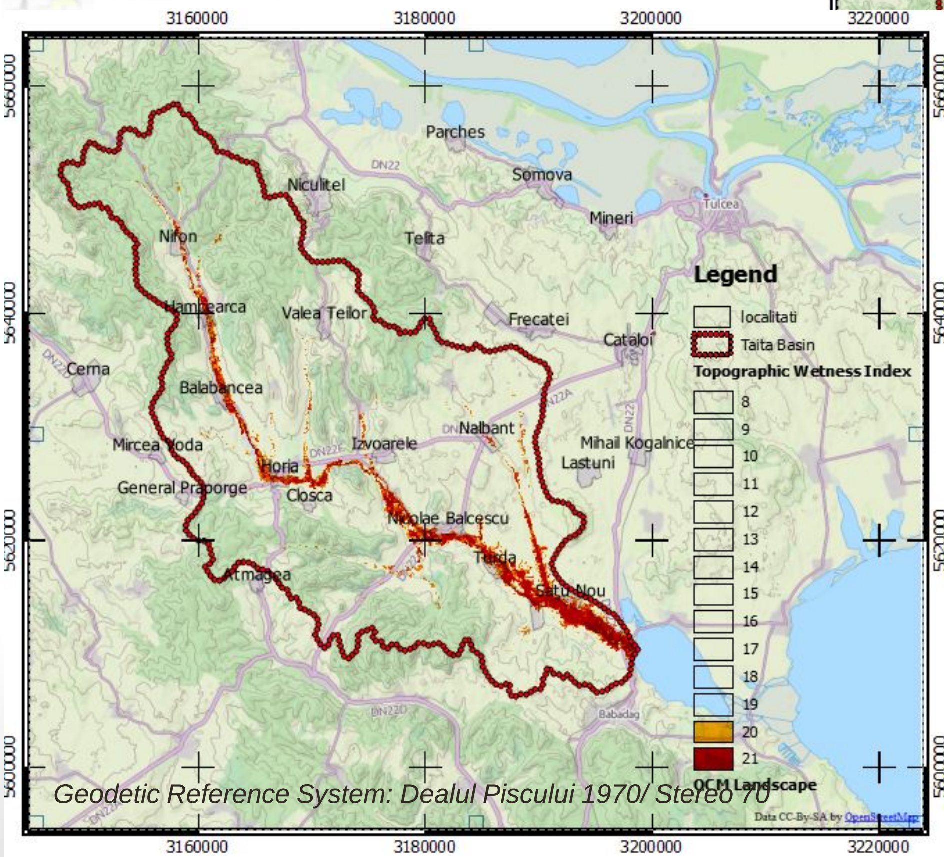
- is located in the Dambovita watershed in the extreme western part of the Ialomiţa Sub Carpathians
- surface of 0.76km^2,
- main channel, the Muret River Valley, located in the Eastern part of the basin.
- The greater slopes are in the upper half (15% or more).
- Sandy clay loam – soil texture
- vegetation land cover: grassland area 59,10% (46,09 ha); forest area 33,10 % (25,82 ha); (c) natural meadow area 3,79 % (2,96 ha); other land cover 4,01 % (3.13 ha)
- The analysis of the rainfall data leads to the following observations:
  - The existence of a large temporal variability of the rainfall amount and of the rainfall intensity at a daily and at a monthly time step;
  - The presence of rather significant surface flow (on average, 51% of the total precipitation);
- The average discharge at the catchment outlet vary between 3.81m^3/s and 1.59m^3/s.

Geomorphological Model - Results

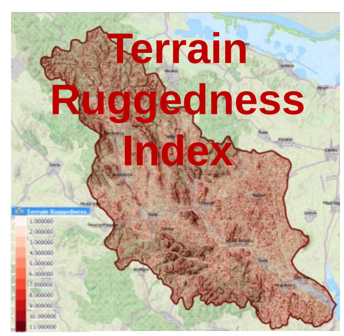
Software Used

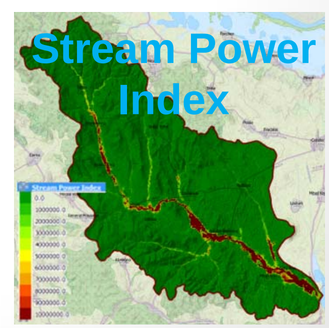
SAGA T.W.I.



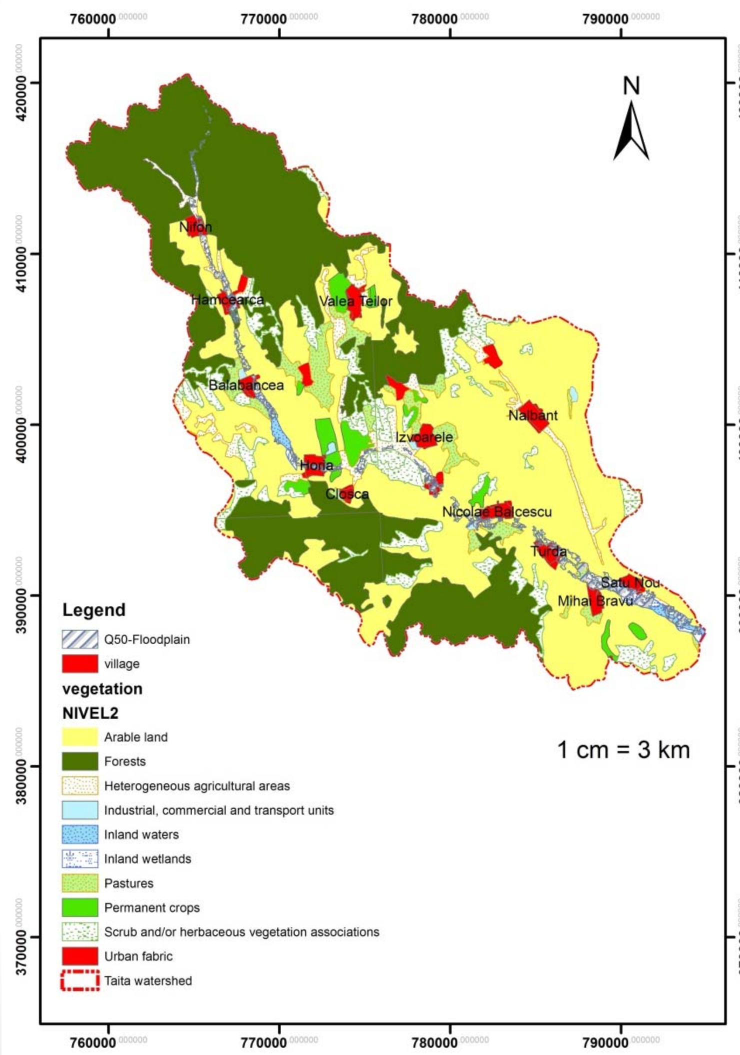


Topographic Wetness Index (TWI)

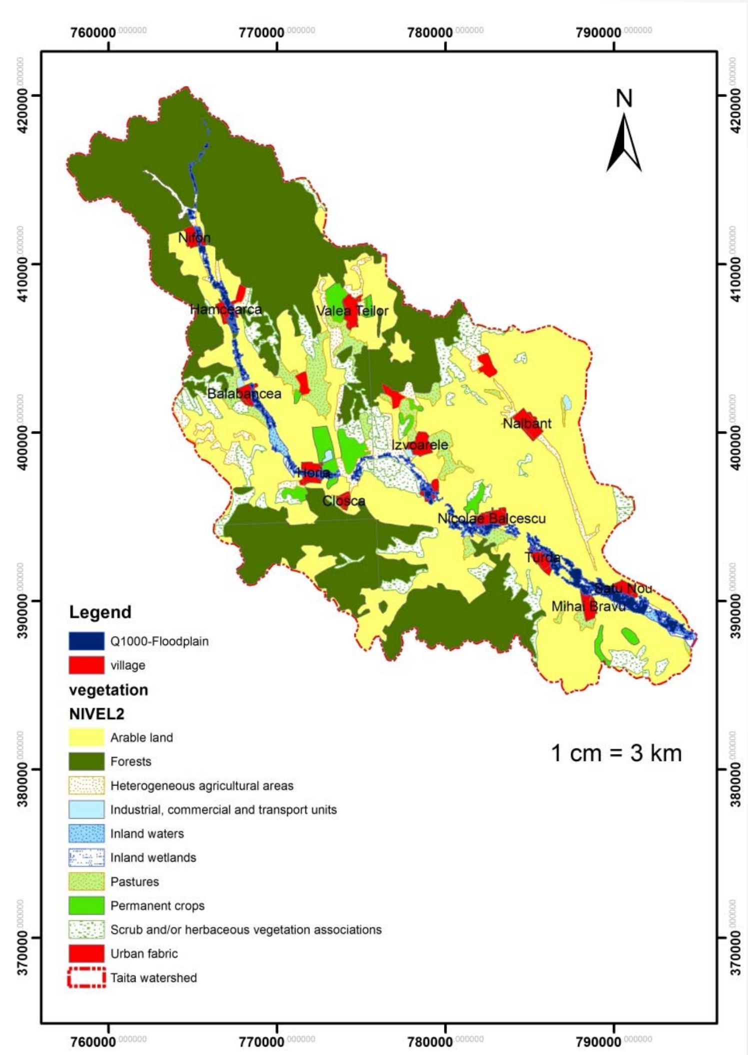




Results hydraulic model

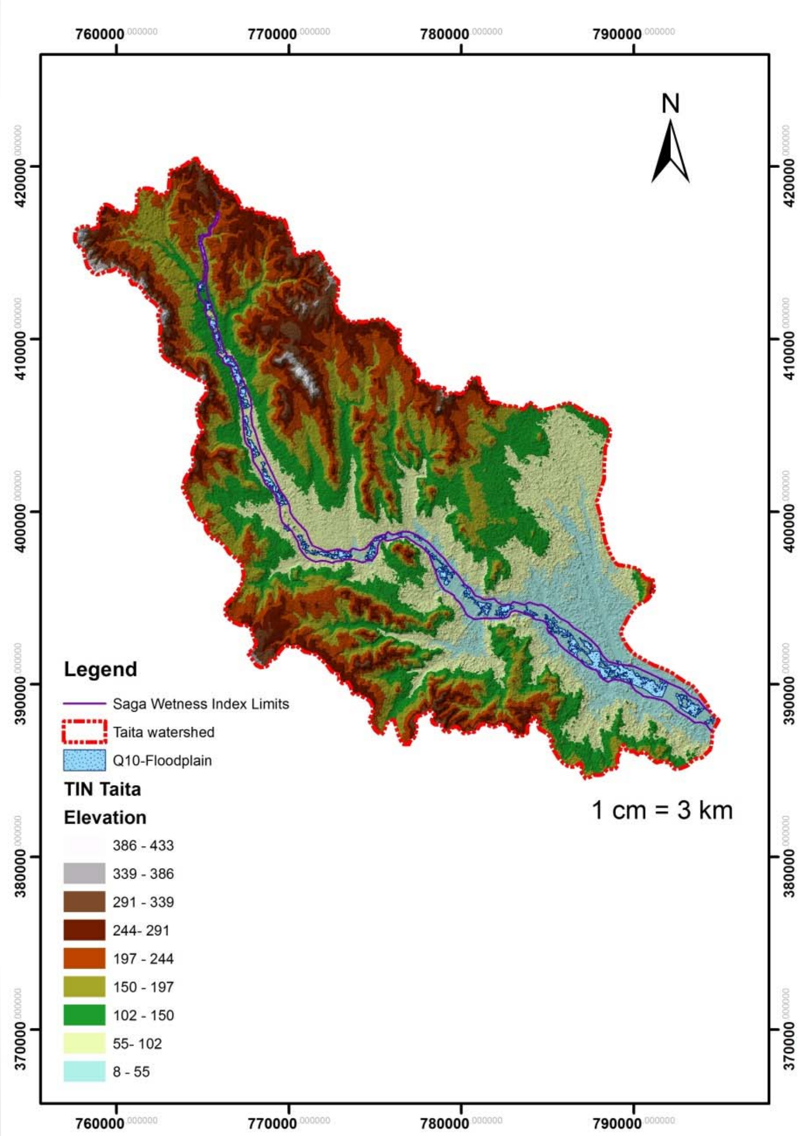


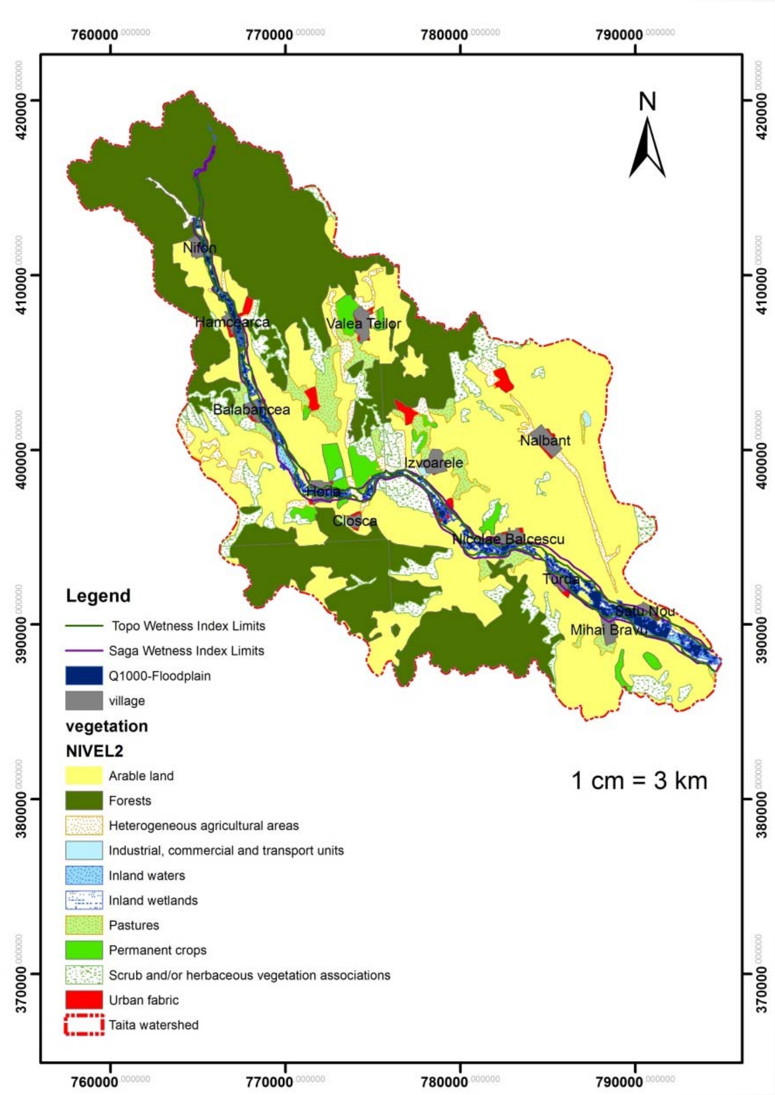
50 years return period



1000 years return period

Comparison of Results





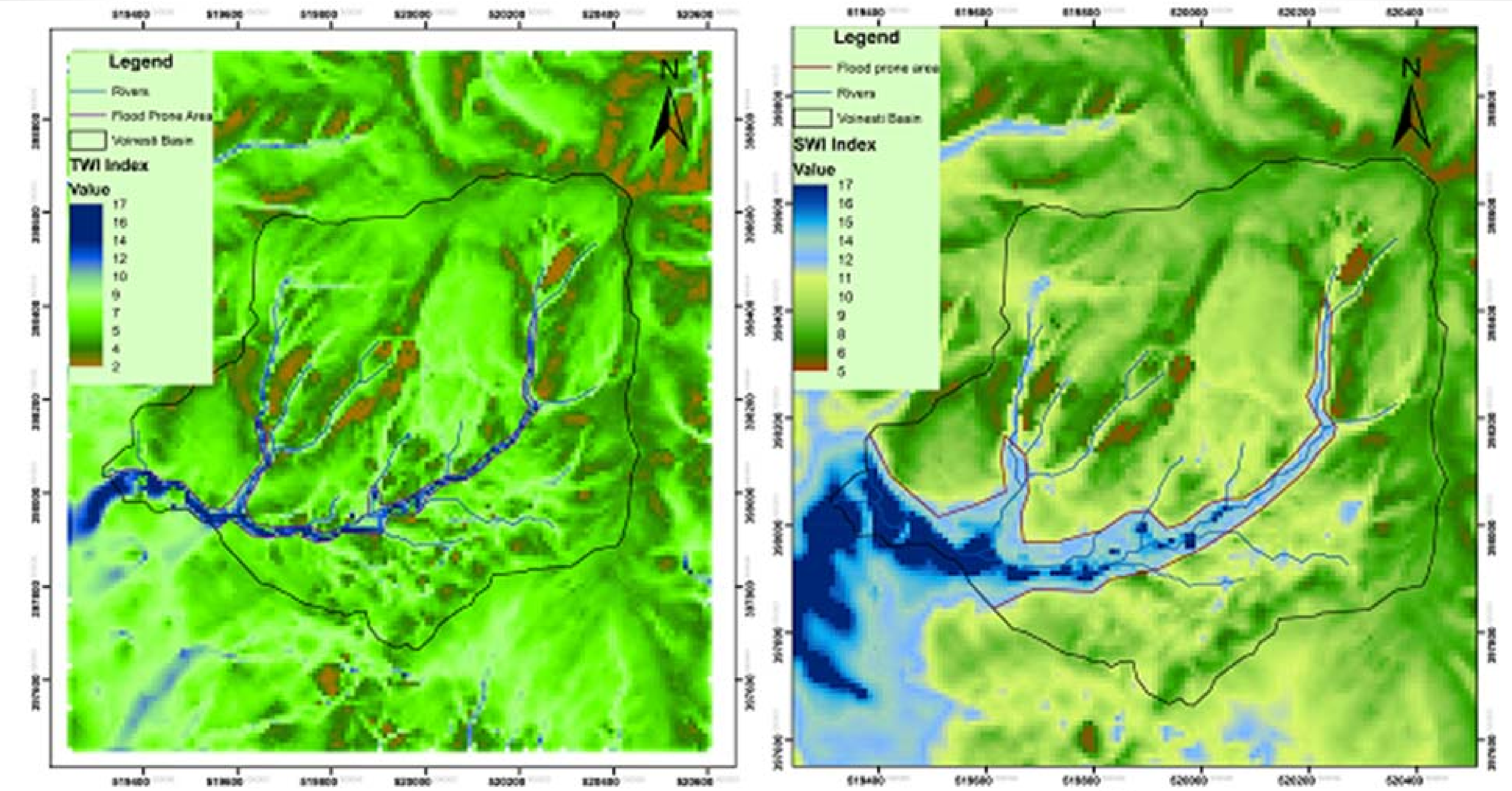
Geodetic Reference System:
Dealul Piscului 1970/ Stereo 70

For the Voinesti catchemnt the models used include

- TOPOG which have it own module to develop spatial data, physical-based distributed model
- ANSWERS through GRASS GIS - physical-based distributed model
- UH models through the MIKE model – conceptual model

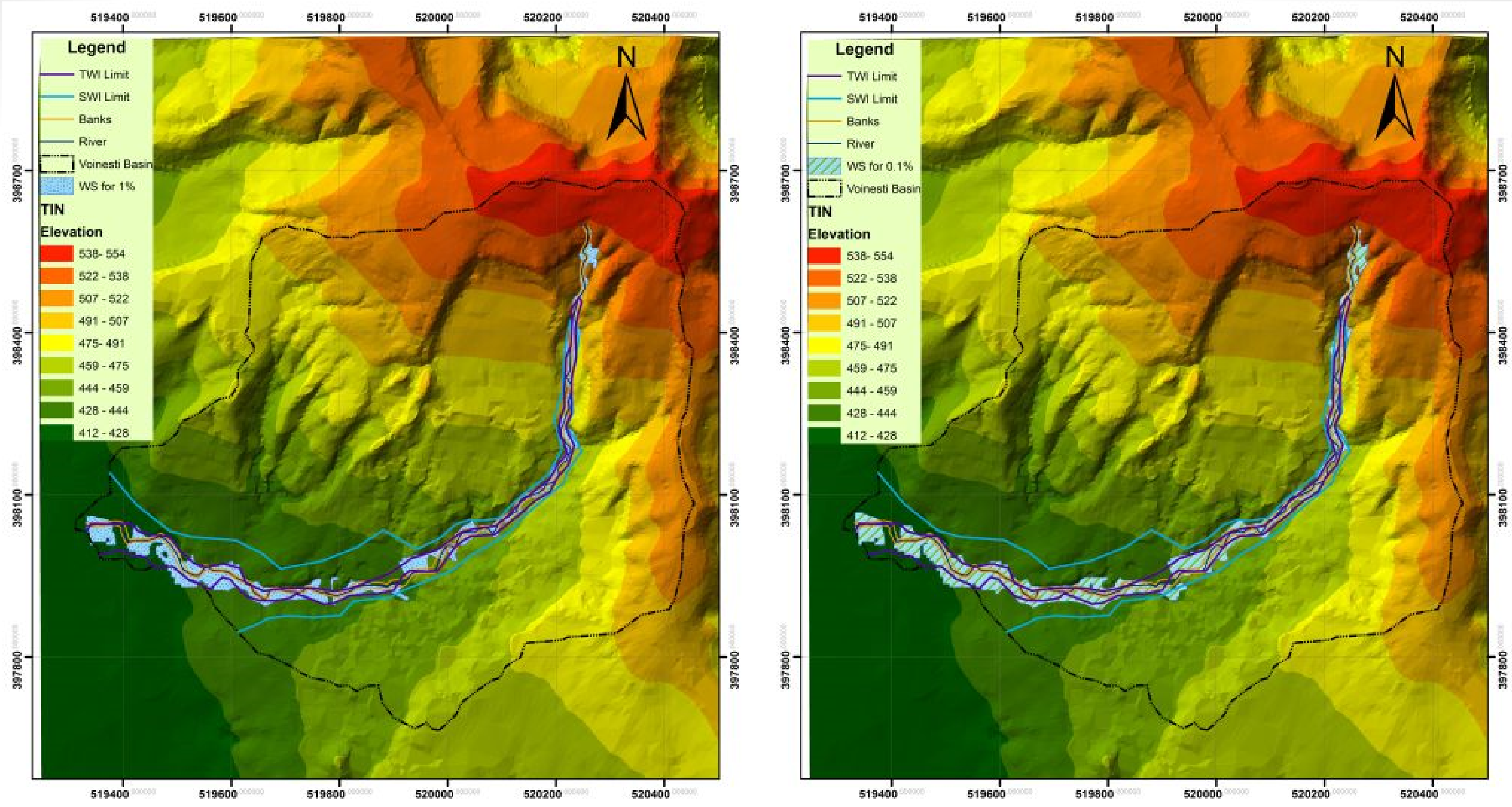
Rainfall –runoff models

- HEC-RAS through ARCGIS → Hydraulic models
- TWI and SWI through SAGA GIS, → Geomorphologic models



a) b)

- TWI index values vary between 2 and 17. As expected, most exposed areas are situated along the river valley and correspond to the higher value (12, 17). For the other flat area this index varies between 2 and 7.
- SAGA wetness index (SWI) values vary between 5 and 17.



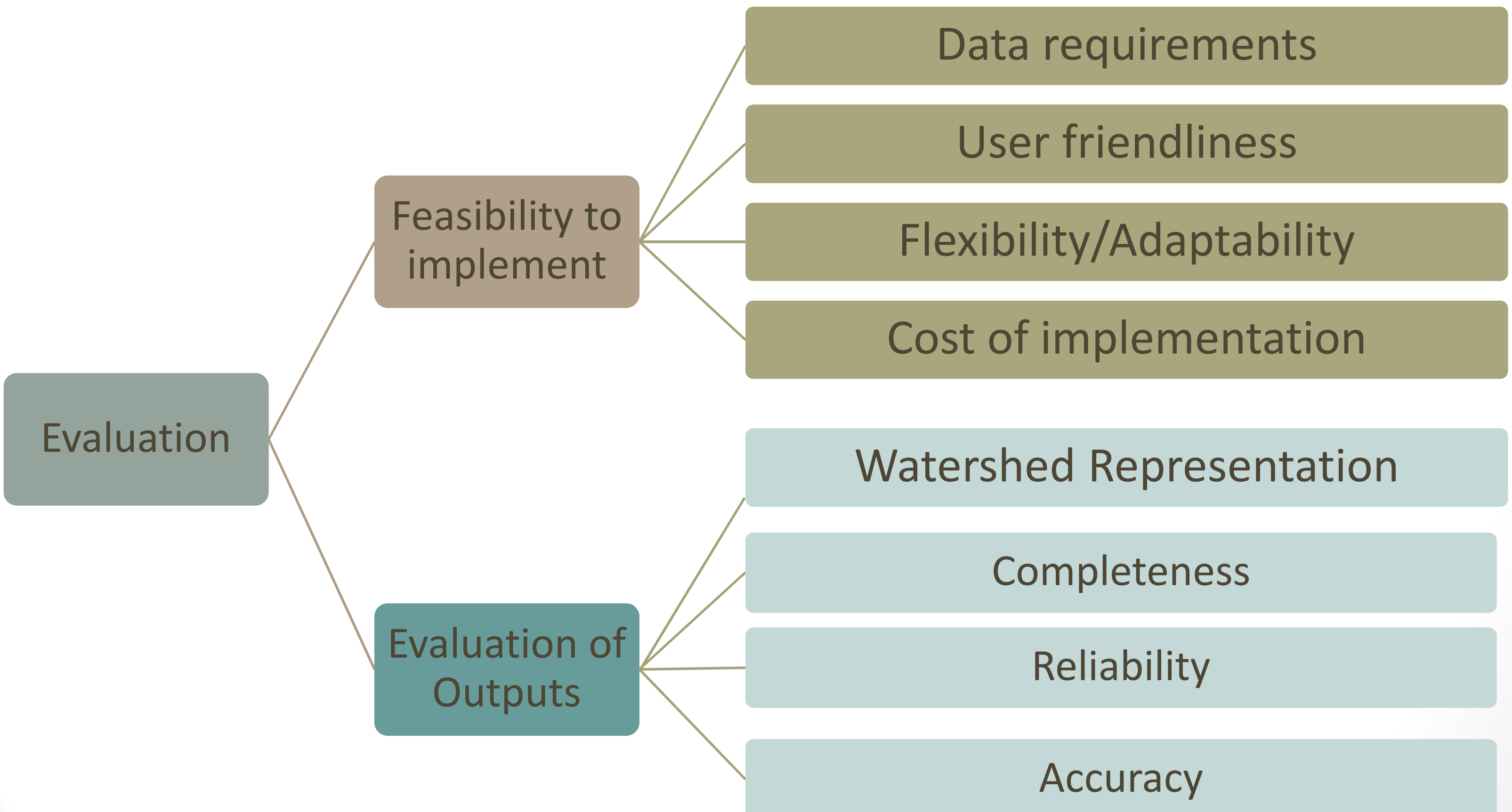
- the flood prone areas derived from the TWI index model are in close agreement to the inundation area derived from the HEC-RAS model. Exceptions occur in the flat areas of the catchment, especially on the outlet section area and this fact can be attributed to the different way those models approach the flood issue in terms of detailed analysis.
- The comparison of the flood prone areas derived by SWI and HEC-RAS, shows that SWI overestimates flood prone zones, especially in the lower third of the catchment where there is a smooth, low relief.

RR model

- TOPOG, ANSWER and UH model

- all model take into account the spatial variability of the watershed through its main morphological characteristics.
- the majority of the models tested, offers good results in terms of *simulated and measured hydrographs*
- the models tested predict only the runoff and stream flow but can not predict hydraulic flow variables such as depth, velocity, etc.; but
- the rainfall-runoff models can provide the data input necessary to calibrate models able to predict the flood extent
- a good representation of topography is necessary in order to improve the distribution and flux of water into the watershed; DEMs (Digital Elevation model) are often used to derive topographic data for distributed hydrological models, and the quality of a DEM depends highly on the data sources and on the interpolation techniques;

Evaluation criteria



Score

Data requirements

1. Heavy (a lot of detailed data (systematic measurements),
2. Medium (Some detailed data needed)
3. Light (Most of the data are readily available)

User friendliness

1. Low (Very difficult to adapt),
2. Medium (Needs some effort to adapt),
3. High (Easily adaptable to local conditions)

Completeness

1. Low (Covers only a few aspects. Additional Software needed),
2. Medium (Covers most aspects of the problem),
3. High (Covers every aspect of the problem)

Flexibility/Adaptability

1. Low (Very difficult to adapt),
2. Medium (Needs some effort to adapt)
3. High (Easily adaptable to local conditions)

Ease of Use					Evaluation of the Output				Score	Remarks
MODEL	Data Requirements*1	Complexity (User Friendlyness)*2	Flexibility (adaptation to local conditions)*3	Cost of Use*4	watersed representation *9	Completeness*5	Reliability*6	Accuracy*7		
TWI/SWI	4	3	3	3	2	1	2	1	19	Regional Scale ONLY
HEC-RAS	1	1	3	3	2	3	3	3	19	Site Specific scale
TOPOG	1	1	1	3	3	2	1	3	15	adapted to small catchemt 1-10sqm requires knowledge of LINUX OS
ANSWERS	2	1	1	3	3	2	2	2	16	requires knowledge of GRASS GISS
UHM (MIKE)	3	2	3	1	2	2	3	2	18	some initial calibration are neded

Recommendation (1/2)

- the hydrological research activities are often interested in several issues relating to:
  - generating flowing mechanisms,
  - validation of certain software or tools which overcomes the empirical approach and achieve a scientific approach to the water cycle and related flows;
  - modeling long-term parameters that control the hydrological processes and identify any developments related to the anthropogenic/or climatic variability.
  - In all this case, a deterministic physic-based hydrological model may be use.
- In engineering practice, to design a hydraulic work, the peak discharge with different return period might be enough and the results of black-box model are acceptable (self-assured). These models can be used successfully to compute the peak flow for small ungauged basin. Their results can be used as input in other models, such HEC-RAS, to perform the floodplain delineation.

Recommendation (2/2)

- When is necessary to design/operate outlet structures, storm drain systems, culverts, small drainage ditches, open channels and energy dissipaters the hydrograph knowledge is necessary. In this case a very useful model is UHM (Unit Hydrograph Model). The most known models which have incorporated UH model used a set of parameters already standardized for different area.
- When considering the watershed plan management and especially the flood plan management, the Flood Directive recommends the use of "the best practice" and "the best available technologies" which do not involve excessive costs. In respect with these recommendations HEC-RAS may be a solution. This program is free and friendly to use. The software performs not only flood modeling in terms on depth, velocity, or discharge, but also the impact of hydraulics works. The model results may be improved using different solutions (as open source GIS tools) that lead to a spatial distribution of parameters which control the runoff, as Manning's coefficient.

Conclusions (1/3)

- This overview on the main methodologies used worldwide provide a scientific base necessary to improve the understanding of the flood hazard mapping

- Two completely different approaches to locate and delineate flood prone areas were applied in different river basin.

  - **Topographic Wetness Index** (based on TOPMODEL) and the **SAGA WI geomorphological models**.

  - **HEC-RAS hydraulic model** by taking into consideration 10, 50, 100 and 1000 years return periods.

Conclusions (2/3)

- **Comparison of the results** of the models used, shows that **there is a remarkable convergence** in the delineation of the inundation (flooded) area despite the fact that these models have very different input data requirements.

- The geomorphological model can be used to provide a reliable location of flood prone zones at a preliminary stage in order to help assess the flood risk in stream catchments. Taking into consideration that **the geomorfological models** have minimal data requirements as the required data are readily available (ASTER DEMs, topographical data), these models **can be used to** reliably **delineate flood prone areas on a regional scale** in order to proceed with Risk assessment.

- At a next stage, **hydraulic models can be used** especially **on site-specific (local) scales** in order to accurately estimate the flooding parameters (inunndation area, depth, flood water velocity etc), thus helping make decisions about designing effective preventive measures.

Conclusions (3/3)

- ✓ To demonstrate the broad applicability of the selected methodologies, open source software was used to store, process data and create maps.

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Maftei C., Papatheodorou K., *Mapping the flash flood prone area in the Taita watershed (Romania) using topographic indexes and hydraulic model*, Second International Conference on NATURAL AND ANTHROPIC RISKS ICNAR2014 04-07 June 2014,

Thank you!

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