

Uses of geographic information systems to analyze the Hydro-Geotechnical hazards and related risks in the Tiflet watershed, Morocco

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Abstract. Geographical information systems have a very important role in visualizing geographical, geological, hydrological and geotechnical data, in the form of layers in thematic maps that are easy to analyse and interpret on a local or regional scale. Based on multi-source and technical data, we have defined all the hydro-geotechnical hazards existing in the Oued Tiflet watershed. The latter is characterized by different lithological formations whose physical-mechanical parameters vary from upstream to downstream. By combining these characteristics with morphological and hydrological data, we can assess the degree of soil erodibility and identify unstable zones in each part of the watershed. And to provide a detailed geotechnical zoning of the Tiflet basin useful for future urbanization projects and the construction of engineering structures.

Keyword: GIS, Geotechnics, Hydrology, Urbanization, Geomorphology.

1. Introduction

The Oued Tiflet watershed is located in the western part of the Sebou watershed (north-west Morocco). It covers an area of 886.44 km². This preliminary study is being carried out as part of a project to develop engineering structures in this watershed. It consists of a general summary of geological, hydrological and hydrogeological data. Accompanied by a qualitative assessment of the degree of erosion [1]. The aim of this work is to combine different approaches: bibliographical data, geoinformatics data and experimental geotechnical data to map the different soil cohesions in the watershed.

2. Methodology

The methodology used to analyze the risks associated with hydro-geotechnical hazards is divided into two stages:

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The first stage is devoted to mapping qualitative soil erosion in the watershed, using the PAP/CAR approach [2]. The result of this method combines three complementary approaches: predictive, descriptive and integrative;

The second stage is devoted to geotechnical mapping of the watershed, using geotechnical data based on LCPC classification and mechanical test results [3], superimposed on the maps obtained by the PAP/CAR approach.

3. Presentation of the study area

The Oued Tiflet watershed (fig.1) lies between the coordinates X = 380000 and X = 400000 and Y= 350000 and Y= 420000. It lies to the west of the Sebou watershed in the Rharb sector. It covers an area of 886.44 km², with a perimeter of 280.60 km.

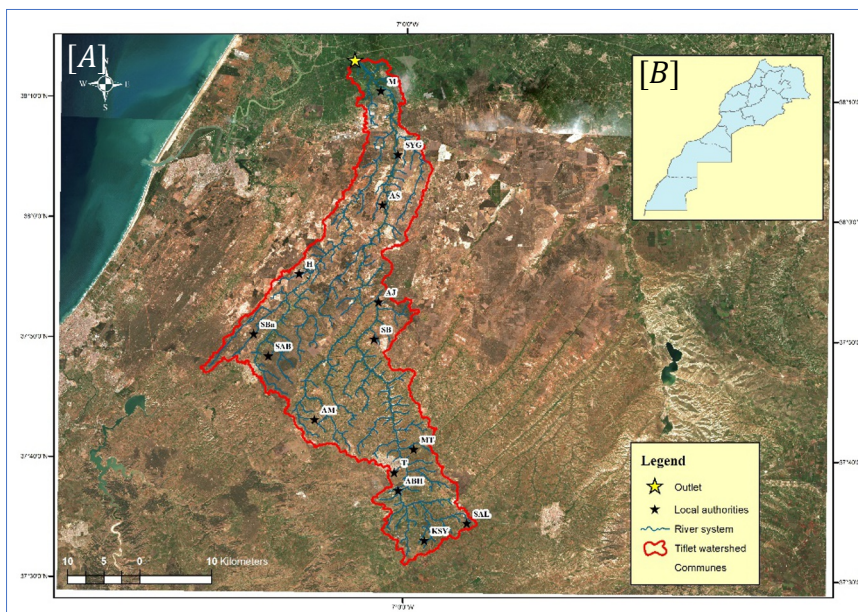


Fig.1. A. Geographical location of the study area, B. Location of the study area within the national framework.

4. Results

4.1. Mapping of qualitative soil erosion in the Oued Tiflet watershed

Erosion is significant when the slope is steep and/or the soil is weak and friable. In the Oued Tiflet watershed, erosion is low upstream and downstream, and moderate at the foot of the watershed, especially in the middle, where alluvial formations (gravels, sands, gravelly calcareous tuffs, etc.) are found.

Soil protection map: The distribution of soil protection classes in the Oued Tiflet catchment shows that over 63% of the catchment area has very low to low soil protection, moving away from the river. High protection zones are located in the downstream part of the basin. This is due to the presence of dense vegetation.

Erosion map: The results of the map of erosive conditions in the Oued Tiflet watershed show that the latter is characterized by a high level of soil protection. This can be explained by the high density of vegetation cover. Areas with very high erosion rates are located in the middle of the basin and on the banks of the Oued, which facilitates the transport of alluvial formations. These areas do not exceed 7.6% of the entire basin.

The map of erosion forms shows the presence of simple forms such as sheet erosion and gully erosion, and combined forms presented by the association of different forms. These combinations are more dominant and visible, the upstream part of the basin is characterized by gully erosion + gullies and the median part is characterized by sheet erosion + rives (fig. 2).

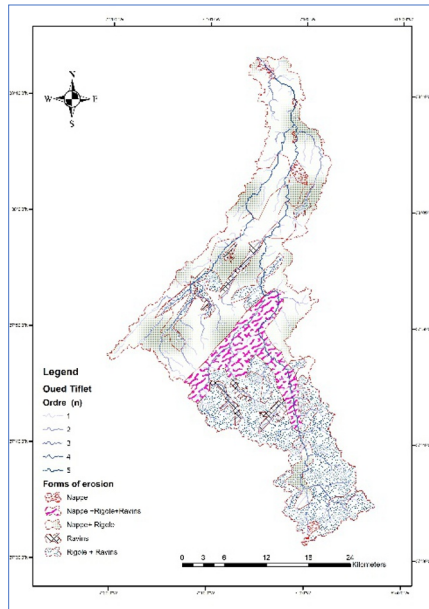


Fig. 2. Map of erosion forms Of Tiflet watershed

4.2. Geotechnical mapping and determination of the physico-mechanical characteristics of soils in the Tiflet watershed.

The LCPC classification of soils in the Oued Tiflet basin indicates that these soils belong to different families depending on the part of the basin, the geological formation and the presence or absence of watercourses. From upstream to downstream, we find successively: silty sands, plastic clays, clayey sands and clayey gravels in the downstream part and at the foot of the slope.

Shear test results show that the watershed is characterized by non-cohesive to moderately cohesive soils. These cohesions range from 0 to 20KPa, confirming the results of the LCPC soil classifications studied. The distribution of these cohesions shows that the upstream part of the watershed is characterized by slightly cohesive soils between the communes of Houderran and Tiflet. Moderately cohesive soils are found in the M'qam Tolba region, while the Ain johra and Sidi Boukhekhal regions are characterized by non-cohesive soils. The middle part of the watershed is marked by poorly cohesive soils, while the downstream part of the study area is characterized by soils with low to very low cohesion.

By overlaying the results of qualitative soil erosion mapping of the Oued Tiflet watershed using the PAP / CAR approach with the mechanical values of soil cohesion deduced from geotechnical tests, we were able to produce a hydro-geotechnical synthesis map of the Oued Tiflet watershed. This map shows areas with low to very low erosion risk, coinciding with areas with zero to medium cohesion. This map enables users to easily define areas that will have significant erosion potential in the event of heavy rainfall, groundwater pressure, slope destabilization resulting from deforestation (figs 3 and 4).

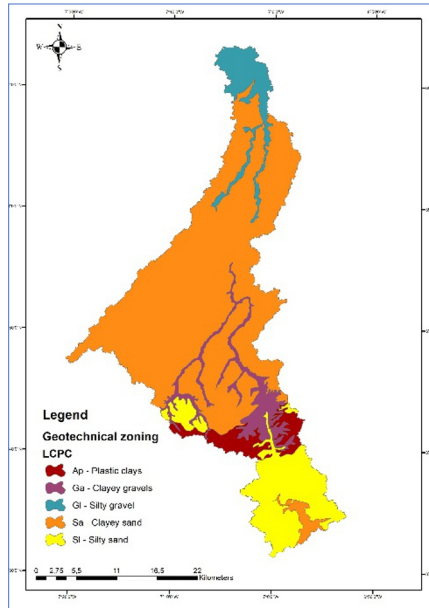


Fig.3. LCPC soil classification Of Tiflet watershed.

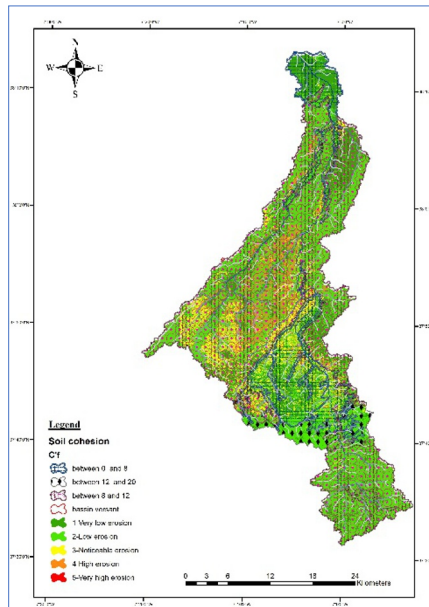


Fig.4. Map presenting the results of hydrological and geotechnical soil erosion in the Oued Tiflet watershed.

5. Conclusion

The hydro-geotechnical synthesis map of the Oued Tiflet watershed defines the priority areas for erosion control, which are essentially located in the middle part of the watershed, in the communes of Ait Malek and Ain johra, and in the downstream part of the watershed. These areas present a high to very high erosion risk and are of medium extent. The map of erosion patterns shows that the basin studied is affected by a variety of erosion types: sheet, gully and channel erosion. These can be combined or simple. Physico-mechanical studies of the existing soils show that they are characterized by cohesions of between 0 and 20 Kpa. This cohesion is weaker upstream and downstream of the basin, which favors soil transport by gravity. This hydro-geotechnical study highlights vulnerable zones characterized by advanced erosion. This state of vulnerability could have an impact on the stability of future civil engineering structures. These risks include dam failure and long-term silting, instability of building foundations close to the river, and retreat of the shoreline due to erosion and soil loss.

And given the hydrogeological conditions at the downstream end of the Oued Tiflet watershed, another geotechnical hazard - soil liquefaction - has been identified, requiring another potential study to assess its significance and limit potential damage.

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Author contribution

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Ethics approval and consent to participate

Not applicable

Consent for publication

All the authors have agreed to publish this article.

Competing interests

The authors declare that they have no competing interests.

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References

1. F. Lakhili, M. Benabdelhadi, N. Bouderkha, A.A. Chaouni, A. Lahrach. cartography of the qualitative erosion of the soils of the Beht watershed Morocco. *ESJ*. **No.11** 132-147 April (2015).
2. A. Hili, Y. Khalki, H. Reddad, J. Gartet, M. Abahrour. Comparaison of the resultats of the PAP/CAR approach and the model in the mapping and qualitative estimation of water erosion in the Oued Amlil Morocco. *PDG*. **No.66** 138-150 February (2020). <https://revistas.um.es/geografia/article/view/415511>
3. H.Tribak, A.Belkacem, A.Elgarouni, A.Lahrach. Geotechnical study of compressible soils characterisation, mechanism and recommendation case of the berrechid and kenitra regions, Morocco. *ESJ*. **No.9** 321-336 March (2020). <https://www.researchgate.net/publication/340351807>