The mineralization of urban soils facing the risk of climate change: case of the flooding phenomenon in the city of Annaba

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Abstract. The city of Annaba, located in the north of Algeria, is among these dense coastal cities, which have experienced rapid and strong urbanization over the past 20 years. This phenomenon, along with the worrying and increasing climate change, has increased the risk of flooding events such as droughts, floods and cyclones, notably in the city of Annaba. Annaba therefore puts it face to face with the direct risk of soil sealing. Indeed, this city has experienced strong periods of heat in recent years, reaching 47°C in summer, during the most recent periods. This increase in heat has been linked to the high concentration of impermeable urban infrastructure. For example, the increase in surface impermeability acts as an aggravating factor for the effects of climate change. This results in the expansion of impermeable infrastructure at the expense of the soil sealing, which affects the natural infiltration of precipitation, increasing the sensitivity of the area to flood events.

1 Introduction

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2 Case study presentation

Fig. 3. Impervious cover of various land uses

Fig. 4. Climate change and urbanization scenarios

3 Objectives

4 Methodology
4.1 Presentation of the climatology of the town of Annaba

Annaba is a coastal town located in the north east of Algeria (at approximately 36°54'N and 7°45'E). Due to its geographical location on the southern shore of the Mediterranean basin (Figure 5), the city of Annaba has a Mediterranean climate. This is defined by hot, dry summers and mild, wet winters with abundant rainfall.

In figures, the average annual temperature in Annaba is 18.2°C and the average annual cumulative rainfall is 741.8 mm, based on climate normals for the period 2010-2021 (Infoclimat, 2022).

This figure illustrates an increase of 1°C in maximum temperatures and a rise of 0.8°C in average temperatures since 2010 in Annaba.

By observing the graph, we notice the variability of the frequencies of climatic phenomena in Annaba. The effect of climate change is obvious: the number of occurrence of thunderstorms and fog has increased in recent years, reaching the threshold of 58 days per year. Thus, extreme heat records are becoming more intense, reaching the record of 47°C in 2021.

4.2 Analysis of rainfall variations in Annaba (Period 2010-2023)

This figure shows the change in annual rainfall in Annaba (1982-2021); Source: Infoclimat (2022).

Fig. 7. Change in annual rainfall in Annaba (1982-2021);
Source: Infoclimat (2022), ICED2023 https://doi.org/10.1051/e3sconf/202343602012
5 Results’ Analysis

5.1 Application of GIS to determine impervious surfaces

5.1.1 Location

Fig. 8. Location of the study area.

5.1.2 Extraction of the NDII

Fig. 9. Map of impermeable surfaces in the study area.

5.1.3 Determining the relationship between NDII, NDBI and NDVI

Fig. 10. The relationship between existing impervious surfaces, built-up areas and vegetation in the study area.

The NDBI and NDVI indices are used to correlate and determine the rate of impervious surfaces in built-up areas. Figure 10 confirms the existence of a strong positive correlation between the NDII and NDBI indices of around 70%, and a strong negative correlation of 80% between NDII and NDVI.

5.1.4 Extraction of the waterproofing index (NDWI)

Fig. 11. Map of flooded areas in the study area, NDWI index.

5.1.5 Determination of the relationship between NDWI, NDBI and NDVI
A correlation analysis was carried out between NDWI, NDBI and NDVI on 22-12-2021. The result of the statistical analysis was a positive trend relationship of 50% between NDWI and NDBI (Figure 12) (weakened by the limitation of NDBI in distinguishing between built-up and bare land). A negative trend of 97% was attached to the relationship between NDWI and NDVI (Figure 12), making vegetation a genuine means of avoiding the risk of flooding. The results established in this analysis clearly demonstrate the impacts of urbanization and soil sealing on the study area through the various correlation relationships derived from the chosen indices. The study area is therefore vulnerable to the risk of flooding.

6 Conclusion

The urbanisation process in this city has continually led to the development of impermeable infrastructures through the removal of permeable vegetation cover. Aggravated by the effects of climate change, the problem of soil sealing in this city has developed a series of negative impacts on the local climatic environment of the region, making it vulnerable to repeated flooding in both winter and early summer. According to the results of the analyses carried out in this study, the impact of soil mineralisation on the climatic environment of the city of Annaba was well established, and vegetation cover constitutes a rapid and effective solution that can mitigate it.

References

4. MedECC, Climate and environmental change in the Mediterranean basin, Current situation and risks for the future (First Mediterranean Assessment Report, Union for the Mediterranean, Plan Bleu, UNEP/MAP, 2020)

Fig. 12. Relationship between flooded areas, built-up areas and existing vegetation in the study area.