# Long term simulation of a nature-based solution scenario in enhancing the urban resilience to climate change in Genoa

## Simulation à long terme d'un scénario de solution fondée sur la nature visant à renforcer la résilience urbaine au changement climatique à Gênes

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## RÉSUMÉ

L'activité de recherche vise à évaluer le rôle des solutions naturelles pour la gestion des eaux pluviales (NBS-Sw) dans la résilience urbaine face au changement climatique. La simulation continue de la réponse hydrologique et hydraulique d'un bassin versant urbain est réalisée à l'aide du modèle EPA SWMM avec une résolution temporelle inférieure à une heure. À cette fin, l'étude de cas du quartier de Sampierdarena à Gênes, dans le nord de l'Italie, a été sélectionnée ; la zone d'étude (143 ha) et le système de drainage correspondant sont schématisés à l'aide de 90 sous-bassins versants et 137 conduites de raccordement où aucune NBS-Sws n'est mise en œuvre (scénario de référence), tandis que le déploiement généralisé de NBS-Sw représente le scénario NBS-Sw. Le climat passé et futur a été simulé sur le domaine ALP3 et la correction des biais a été effectuée à la fois sur les températures minimales et maximales quotidiennes et sur les précipitations horaires, ces dernières ayant en outre été réduites statistiquement à une résolution de 5 minutes. Les résultats hydrologiques à long terme (série de 5 ans) confirment que le scénario NBS-Sw contribue à restaurer partiellement les processus d'évapotranspiration et d'infiltration et à réduire de manière significative le volume des inondations, respectivement de 90 % et 56 % dans le climat actuel et futur.

## ABSTRACT

The research activity aims at evaluating the role of Stormwater Nature Based Solutions (NBS-Sw) in addressing the urban resilience in a changing climate. The continuous simulation of the hydrologic hydraulic response of an urban catchment is undertaken using EPA SWMM at a sub-hourly time resolution. At this aim, the case study of the Sampierdarena district in Genoa, northern Italy has been selected; the case study area (143 ha) and the corresponding drainage system is schematized by means of 90 sub-catchments and 137 conduit links where no NBS-Sws are implemented (reference scenario) while the widespread deployment of NBS-Sw (including bio-retention systems, dry swales and green roofs) represents the NBS-Sw scenario. The past and future climate are simulated over the ALP3 domain, and the bias correction was performed on both daily minimum and maximum temperatures and hourly precipitation, the latter further statistically downscaled to 5-minute resolution. Long-term hydrological results (series of 5 years) confirm that the NBS-Sw scenario contributes to partially restore evapotranspiration and infiltration processes and to significantly reduce the flood volume equal to 90% and 56% in the current and future climate respectively.

## KEYWORDS

climate change, continuous modelling, nature based solution, pluvial flooding, urban drainage

# 1 INTRODUCTION

The long-term simulations of urban catchments with a widespread deployment Stormwater Nature Based Solutions (NBS-Sw) are recently adopted to evaluate the NBS-Sw contribution to partially restore the hydrologic processes (such as evapotranspiration and infiltration) thus supporting the urban resilience in a changing climate. This research is developed in the framework of the GreenStorm project whose aim is to assess the role of NBS-Sw in driving towards liveable and resilient cities.

# 2 MATERIALS AND METHOD

## 2.1 CASE STUDY

The innovative methodology is applied and tested in the case study of the Sampierdarena district in Genoa, northern Italy. The case study area (143 ha) has been selected in agreement with the Municipality of Genoa, focusing on urban areas prone to frequent pluvial flood events and characterized by strategic activities and services (Gnecco et al., 2024). The modelled urban drainage system includes 137 junction nodes, 3 outfall nodes, 137 conduit links and 90 sub-catchments. The NBS-Sw scenario is defined by means of a multi-objective genetic algorithm (Creaco et al., 2026) and includes bio-retention systems, dry swales, extensive green roofs, intensive green roofs. No NBS-Sw systems are implemented in the reference scenario.

## 2.2 CLIMATE MODEL

Genoa is located in a particular location from a climate point of view with a combination of complex orography and the influence of the Ligurian gulf. For those reason, available convection permitting models were considered as a basis for long-term simulations. The output of a climate model simulated over the ALP3 domain is selected based on its ability to reproduce seasonal variation after performing a bias correction. The bias correction is done with CDF transform on both hourly precipitation and daily minimum and maximum temperatures. The precipitations are then further statistically downscaled to 5-minute resolution similarly to Pons et al. (2022).

## 2.3 CONTINUOUS HYDROLOGICAL MODEL

The continuous simulation is undertaken using EPA SWMM at a sub-hourly time resolution. Dimensionless monthly evaporation correction factors calculated after Jabeen et al. (2025) for both the time-series climate records (current and future) are applied to assess the actual ET rates in the simulation of the NBS-Sw scenario.

# 3 RESULTS

Long-term hydrological results (series of 5 years) are analysed for reference and NBS-Sw scenarios according with current and future climate to evaluate the role of NBS-Sw in mitigating the pluvial flooding hazard in a changing climate. Collectively, all the NBS-Sw systems applied to case study area reduce the overall imperviousness from 74% to 67% with 7% area covered by NBS-Sw in total. This effective impervious area reduction of 7% translates into significant hydrologic improvement under current climate as overall flooding volume reduces from 78.19 ML to 7.98ML contributing to the 90% flood volume reduction (Table 1). Under future climate an increased flooding stress is observed while NBS-Sw scenario limits flood volume to 50.01 ML providing the 55% flood volume reduction (Table 1).

Table 1. Total flooding volumes occurred for the for reference and NBS-Sw scenarios according with current and future climate.

| | Imperviousness Degree | NBS-Sw Degree | Flooding Volume | |
|---|---|---|---|---|
| | | | Current | Future |
| Scenario | [%] | [%] | [Ml] | [Ml] |
| Reference | 74 | 0 | 78.19 | 113.32 |
| NBS-Sw | 67 | 7 | 7.98 | 50.01 |

Figure 1 shows the reduction in the maximum node flooding volumes occurred for the NBS-Sw scenarios with respect to the reference one according with current and future climate. Figure 2 illustrates the water balance evaluated for three selected subcatchments (SCAS_2_3, SANG_BELV_1_0 and CANEP 1_4) where green roof, bioretention and dry swale are respectively implemented in the 25%, 10% and 9% of the three catchment areas. Results point out the role of NBS-Sw in limiting the runoff volume and enhancing mainly the infiltration for the bioretention in the SANG_BELV_1_0 subcatchment and for the dry swale in the CANEP 1_4; while the

evapotranspiration is mainly promoted for the extensive green roof in the SCAS_2_3.The hydrologic restoration on an annual basis is directly correlated with the corresponding NBS-Sw scenario deployment.

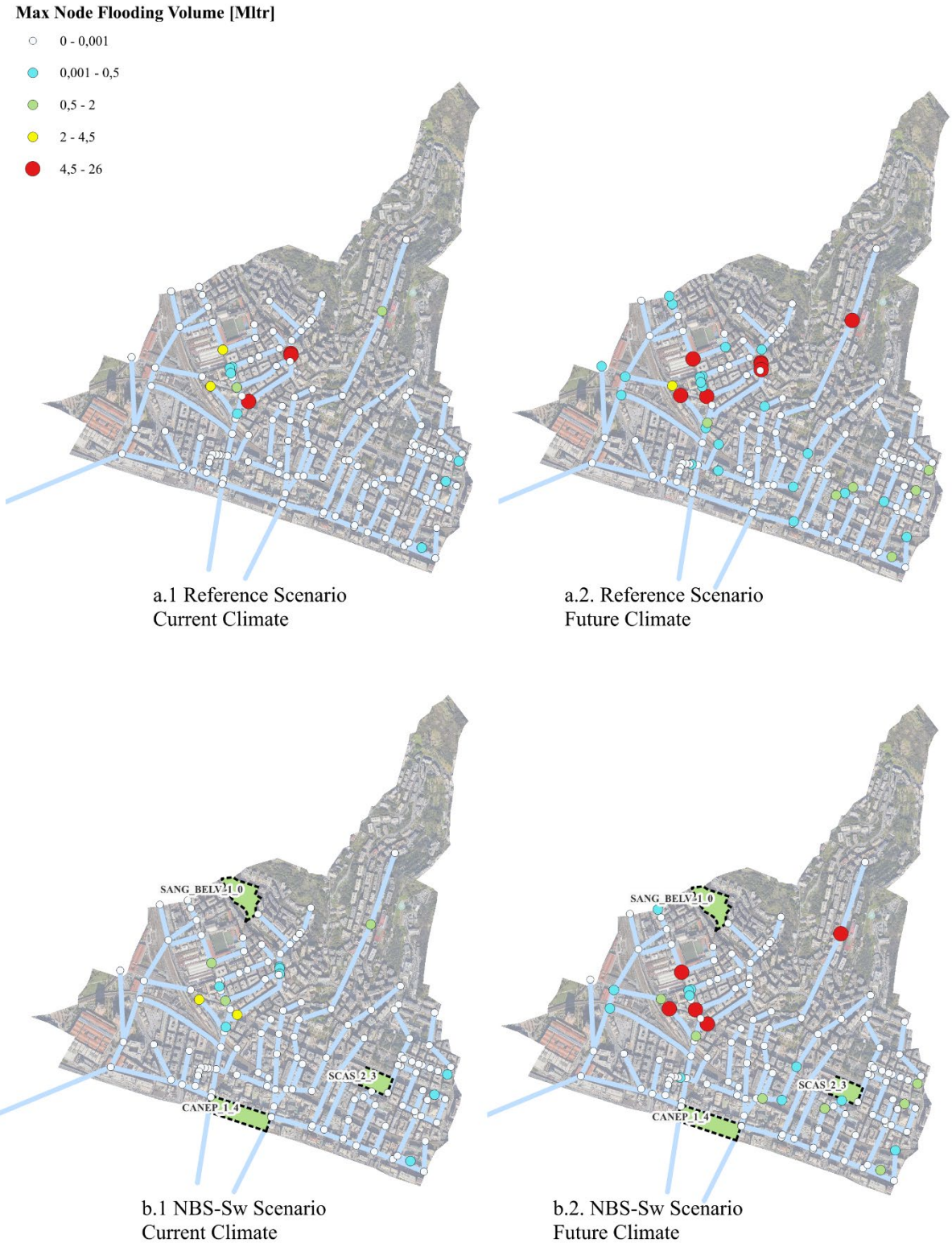


Figure 1. Maximum node flooding volumes occurred for the for reference (a) and NBS-Sw (b) scenarios according with current (1) and future (2) climate. In the NBS-Sw scenario, three selected catchments where green roof, bioretention and dry swale are respectively implemented are highlighted in green, as an example.

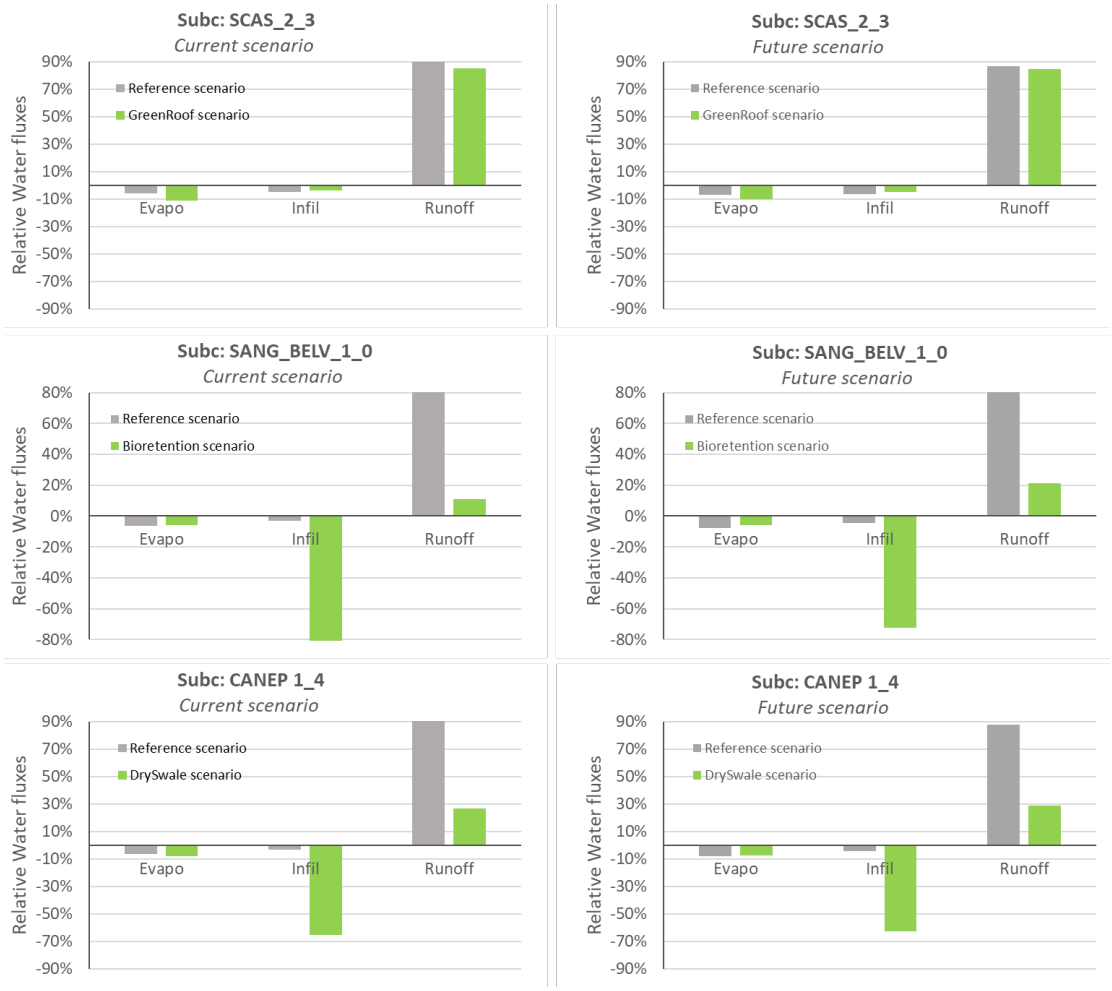


Figure 2. Percentage of evaporation, infiltration and runoff with respect to total precipitation for three selected catchments where green roof, bioretention and dry swale are respectively implemented.

## 4 CONCLUSIONS

Preliminary results (5-years series) confirm that the NBS-Sw scenario is effective in enhancing the urban resilience to climate change in Genoa as confirmed by a 56% reduction of the total pluvial flooding volume for the future climate scenario.

## 5 FUNDING

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