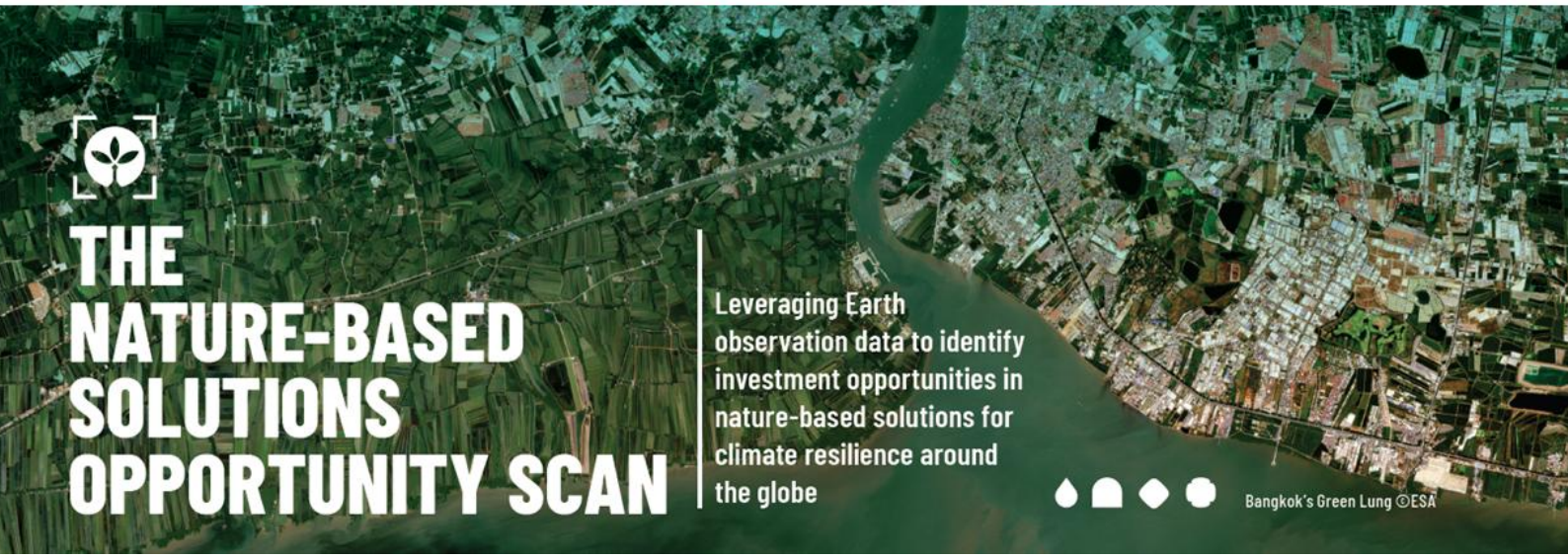


I. INTRODUCTION:

THE TOOL

The Nature-Based Solutions Opportunity Scan for Climate Resilience (NBSOS) is a tool designed for World Bank operations by the Global Program on Nature-Based Solutions (GPNBS) of the Global Facility for Disaster Reduction and Recovery (GFDRR). **NBSOS supports the World Bank, its clients, and development partners in identifying nature-based solutions (NBS) investment opportunities and understanding their benefits for communities and the environment.** It supports the integration into investment project financing, addressing the demand from project teams and government decision-makers lacking essential information on NBS typologies, priority areas, costs, and benefits. Primarily used in the investment identification phase, NBSOS provides NBS opportunities and their resilience-building benefits in urban or coastal areas. It also supports strategic diagnostics, such as in Country Climate and Development Reports and climate change adaptation planning, for cross-sectoral investment prioritization.

See more details about the NBSOS tool at https://naturebasedsolutions.org/opportunity-scan.

FIGURE 1: TYPES OF NATURE-BASED SOLUTIONS IN URBAN AND COASTAL AREAS

Source: A Catalogue of Nature-Based Solutions for Urban Resilience, World Bank, 2021

APPLICATION

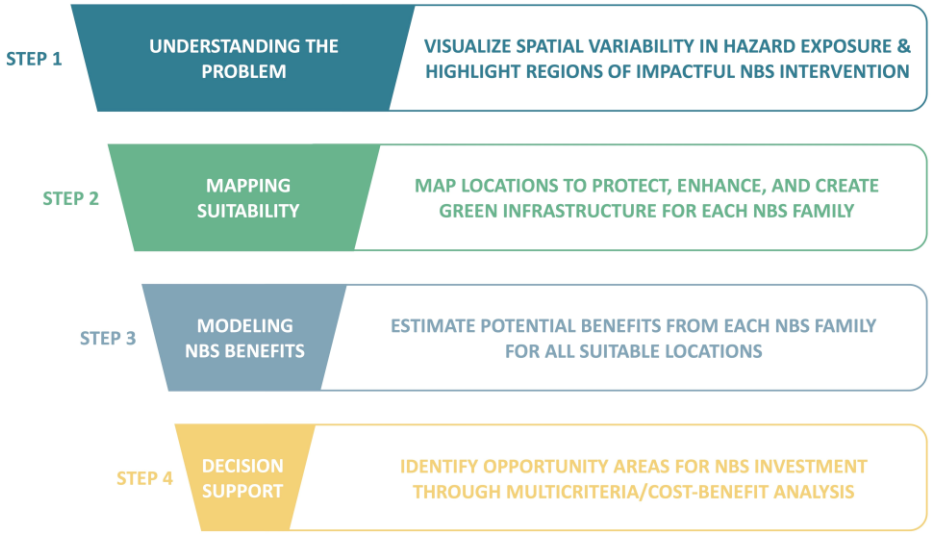
NBSOS is a geospatial analysis and participatory process offered by GFDRR as an on-demand service in World Bank engagements worldwide. NBSOS is applied at the request of and in collaboration with World Bank operations teams and their clients. It is tailored to each case to offer the most pertinent guidance.

In about 6 weeks, NBSOS provides a comprehensive package including geospatial data, hazard maps, NBS opportunities, benefit analyses, prioritization, scenarios, cost-benefit assessments, interpretations, and investment recommendations. As the starting point for an investment plan, NBSOS results help the World Bank engage governments and stakeholders and to inform feasibility studies, design, and implementation.

APPROACH

NBSOS uses 10-to-30-meter resolution global geospatial data and a sophisticated methodology to map the potential benefits of NBS and identify investment opportunities in cities and along coastlines anywhere in the world. NBSOS follows a hierarchical approach to NBS interventions, prioritizing the protection of existing ecosystems over enhanced management, rehabilitation, and restoration, and finally the creation of new NBS.

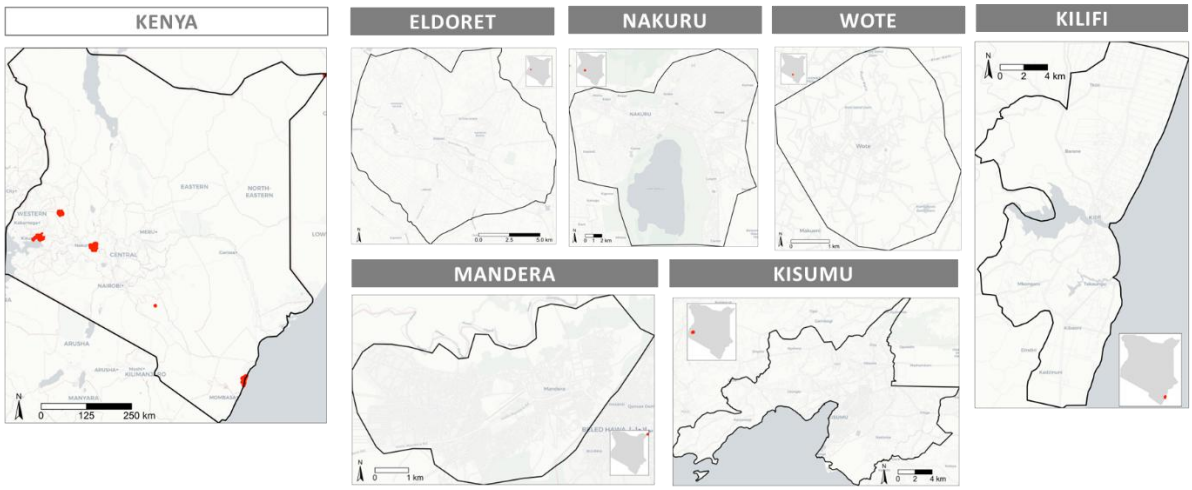
FIGURE 2: METHODOLOGY. NBSOS analysis involves four steps.



II. SUMMARY OF THE NBSOS APPLICATION IN KENYA

The NBSOS was implemented in six regions of Kenya: Eldoret, Kilifi, Kisumu, Mandera, Nakuru, and Wote (Figure 3). This document provides a concise summary of the key findings from the assessment, with a focus on opportunities for the protection and creation of NBS, as well as their potential benefits. **A comprehensive report detailing the full results of the NBSOS application in these areas is available upon request from the authors of this report.**

FIGURE 3: AREAS OF INTEREST

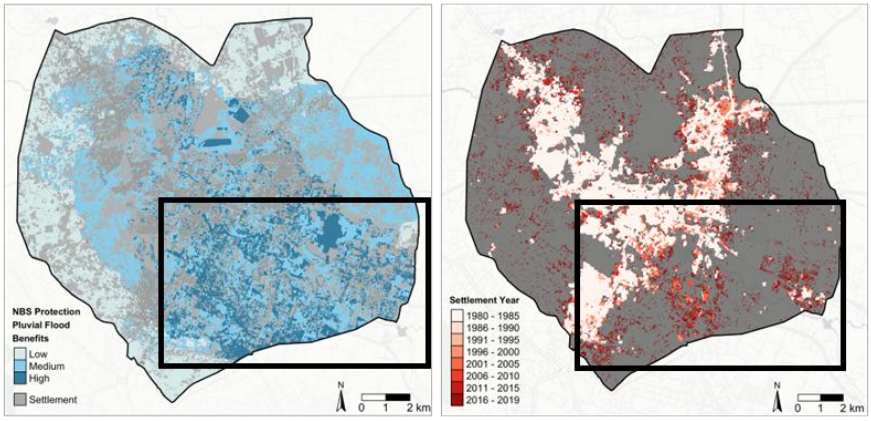


1. ELDORET:

OPPORTUNITIES FOR PROTECTION

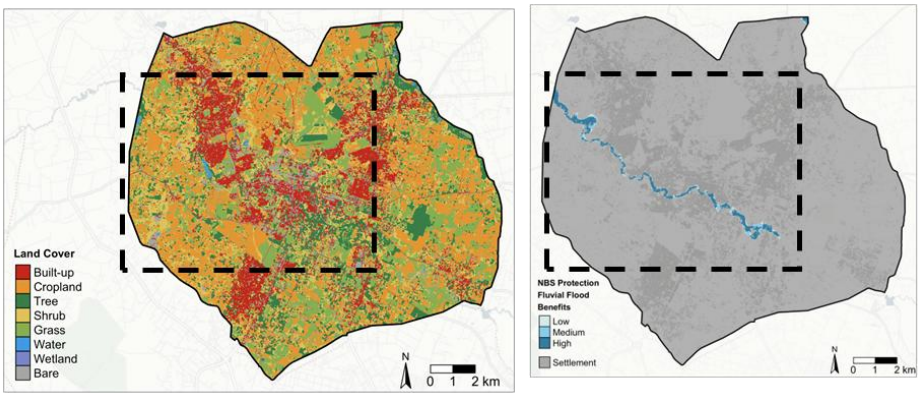
Several areas showing high urbanization trend are observed towards main protection areas for pluvial flood management (highlighted by solid box in Figure 4). Protection of existing green spaces in this area can help to control future urban expansion, helping to avoid higher flood risk in the future.

FIGURE 4: Map left: NBS Protection Benefits – Pluvial Flood mitigation. *Where are the main areas to protect to avoid higher pluvial flood risk?* **Map right:** Urbanization trend in Eldoret.



Areas marked for high benefits against fluvial flood risk is also noted to be within the existing development (highlighted with dashed line in figure 5). Protection against further encroachment into fluvial floodplains should be prioritized in future development and housing regulations.

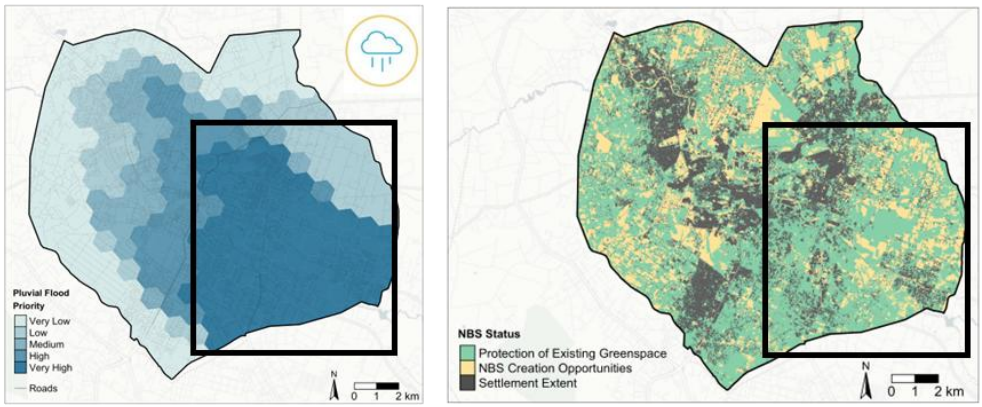
FIGURE 5: Map left: land cover for the area of interest. **Map right:** NBS Protection Benefits for Fluvial Flood mitigation- *Where are the main areas to protect to avoid higher fluvial flood risk?*



OPPORTUNITIES FOR CREATION

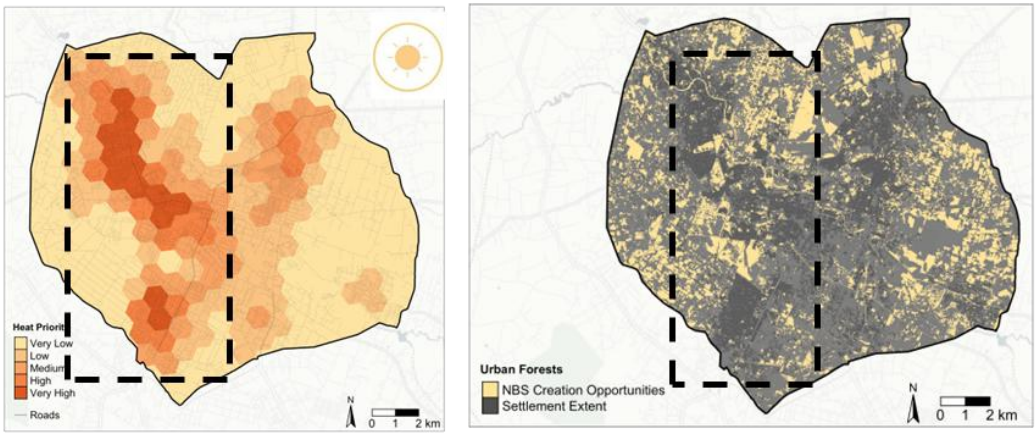
For Eldoret, there is overlap between areas of high priority for pluvial flood risk, NBS creation opportunities, and areas showing recent urbanization trend (highlighted by solid box in figures 4 and 6). Creation of NBS in this area can help to reduce flooding downstream and control future urbanization avoiding higher flood risk in the future.

FIGURE 6: Map left: Priority Areas for NBS Investment - *Where to apply NBS to best reduce pluvial flooding?* **Map right:** *opportunities for protection of existing green space and NBS creation*.



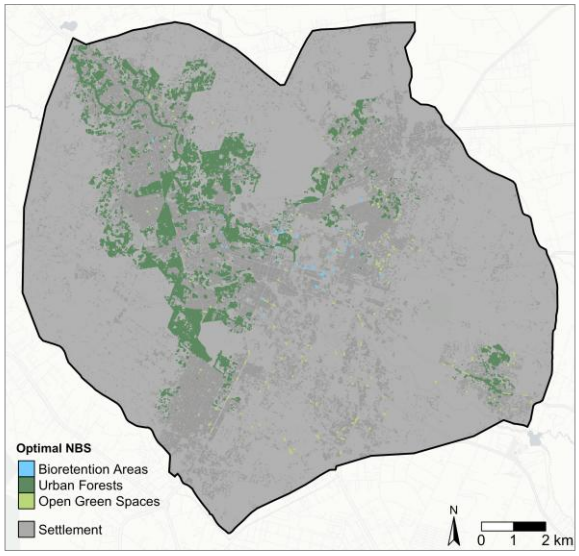
There is also overlap between areas of high heat stress mitigation priority and opportunities for creating urban forests (highlighted by dashed box in figure 7). Benefits can be maximized by multifunctional design of NBS in this areas, to provide both heat reduction and recreation areas for improving social cohesion.

FIGURE 7: Map left: Levels of exposure to heat stress - *Where do people get highest heat stress?* **Map right:** Creation Opportunities for Urban Forests.



Under equal weighting scenario, the NBSOS identified three solutions providing the highest 20% benefits (figure 8) with 8 hectares of bioretention areas, **835 hectares of urban forests** and 21 hectares of open green spaces. However, if a higher weight is assigned to other benefits such as flood risk reduction or social cohesion, open green spaces would be the NBS maximizing benefits.

FIGURE 8: NBS with Highest 20% of Benefits for maximizing targeted benefits. *The distribution shown here corresponds to an equal weights case in which flood benefits, heat benefits, and social cohesion benefits share an equal weight of 33%.*



BENEFITS RECAP TABLE FOR ELDORET:

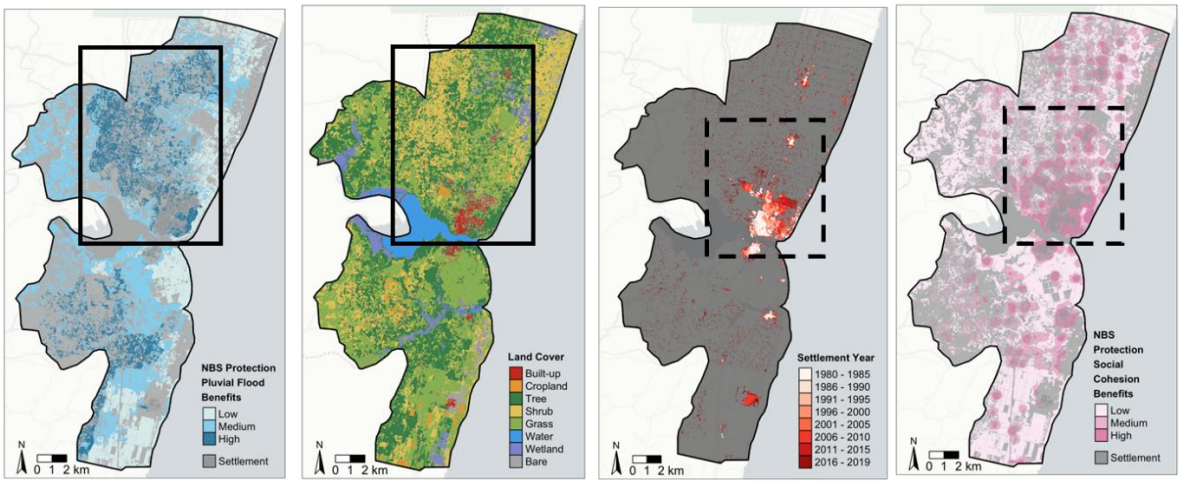
Flood reduction benefits	Heat reduction benefits	Social cohesion benefits
Open green spaces (including storage facilities) and bioretention areas show potential to reduce flooding.	Urban forests show high potential to reduce heat stress in this case, mainly in areas to the northwest of the city.	People in Eldoret have good access to green spaces and none of the NBS analyzed show potential for improving this, although there may be opportunities to enhance spaces for better social cohesion benefits.

2. KILIFI:

OPPORTUNITIES FOR PROTECTION

Several areas showing high pluvial flood benefits from protection are within existing tree or grassland areas (highlighted by solid box in figure 9). Protection of areas immediately around existing development can control future urban expansion, limiting flood risk increase and also improving social cohesion (highlighted by dashed box in figure 9).

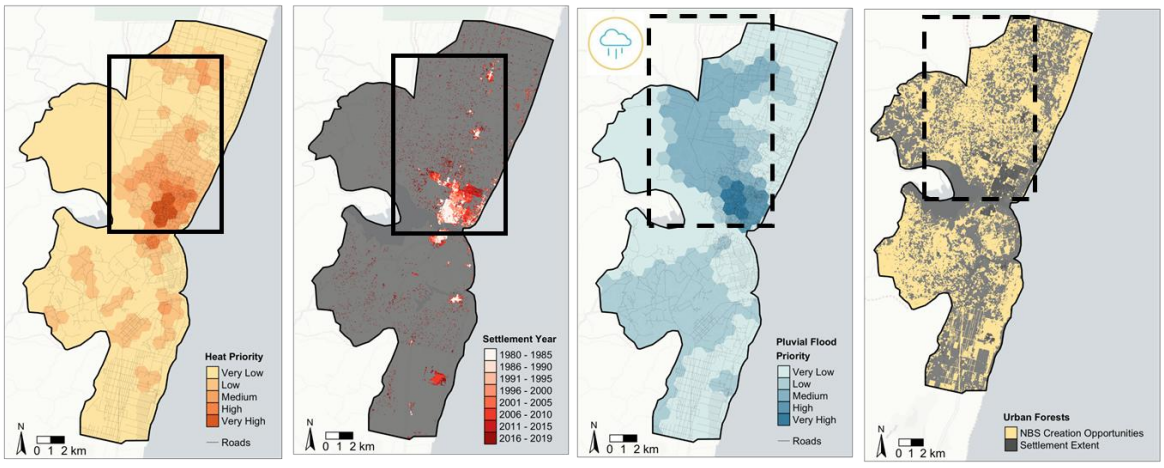
FIGURE 9: Map left: NBS Protection Benefits for Pluvial Flood mitigation - *Where are the main areas to protect to avoid higher pluvial flood risk?* **Map center left:** land cover for the area of interest. **Map center right:** Urbanization trend in Kilifi. **Map right:** NBS Protection Benefits for Social Cohesion - *Where are the main areas to protect to avoid social cohesion deterioration?*



OPPORTUNITIES FOR CREATION

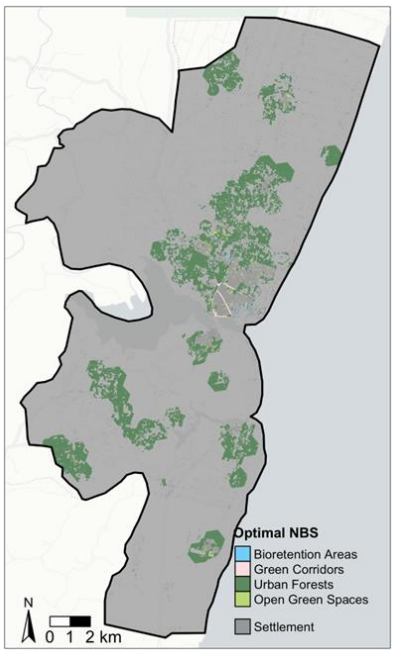
For Kilifi, there is overlap between areas of high heat reduction priority, areas showing recent urbanization trend (highlighted by solid box in figure 10). There are also overlapping areas for high pluvial flood reduction priority and urban forests creation opportunities. Creation of NBS in this area can help to reduce flooding downstream and control future urbanization avoiding higher flood risk in the future.

FIGURE 10: Map left: Levels of exposure to heat stress - *Where do people get highest heat stress?* **Map center left:** Urbanization trend in Kilifi. **Map center right:** Priority Areas for NBS Investment - *Where to apply NBS to best reduce pluvial flooding?* **Map right:** Creation Opportunities for Urban Forests.



Under equal weighting scenario, the NBSOS identified four solutions providing the highest 20% benefits (figure 11) with 5 hectares of bioretention areas, 14 hectares of green corridors, **1937 hectares of urban forests**, and 7 hectares of open green spaces. However, if a higher weight is assigned to other benefits such as flood risk reduction, open green spaces and bioretention areas would also maximize benefits.

FIGURE 11: NBS with Highest 20% of Benefits for maximizing targeted benefits. *The distribution shown here corresponds to an equal weights case in which flood benefits, heat benefits, and social cohesion benefits share an equal weight of 33%.*



BENEFITS RECAP TABLE FOR KILIFI:

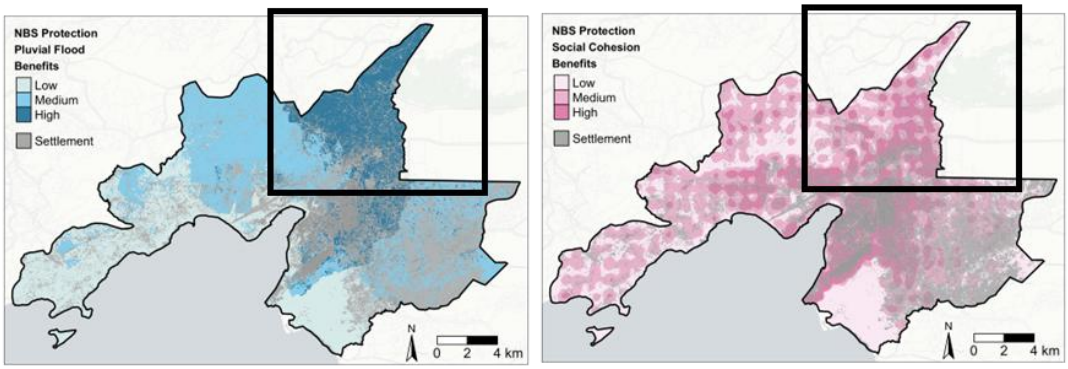
Flood reduction benefits	Heat reduction benefits	Social cohesion benefits
Urban forest, bioretention areas and open green spaces (including storage facilities) show high potential to provide flood reduction benefits.	Urban forests show very high potential to reduce heat stress in this case.	Open green spaces show some potential to provide social benefits in this case, mainly in coastal areas to the north and south of the urban space.

3. KISUMU

OPPORTUNITIES FOR PROTECTION

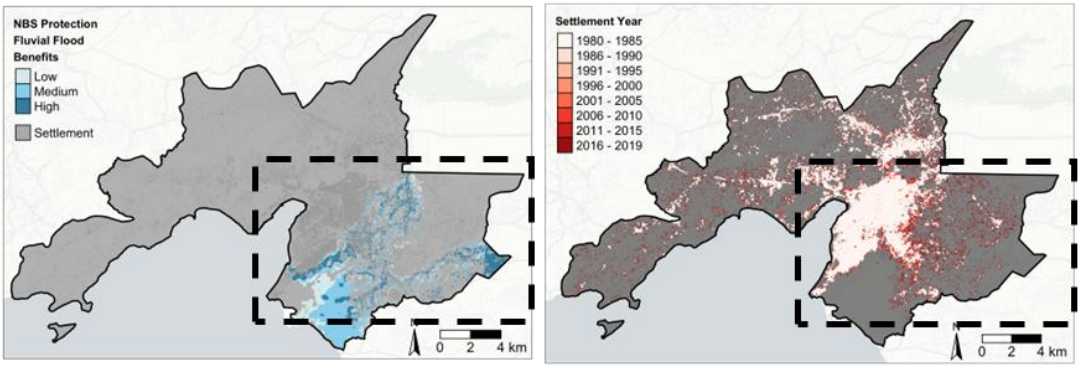
To the North of the city, areas with high pluvial flood protection benefits coincide with areas for high social cohesion benefits from greenspace protection (figure 12). These synergies present opportunities to design existing green spaces protection strategies that would help to maximize benefits.

FIGURE 12: Map left: NBS Protection Benefits for Pluvial Flood mitigation - *Where are the main areas to protect to avoid higher pluvial flood risk?* **Map right:** NBS Protection Benefits for Social Cohesion - *Where are the main areas to protect to avoid social cohesion deterioration?*



Though much of the city is already established, there is sporadic sprawl and informal settlements cropping up into the East of the city, which coincide with areas showing high fluvial flood protection benefits (highlighted by dashed box in figure 13). This area also shows existent wetlands and high biodiversity protection benefits. Protection strategies can help to limit urban development towards this area in the future as the city continues to expand.

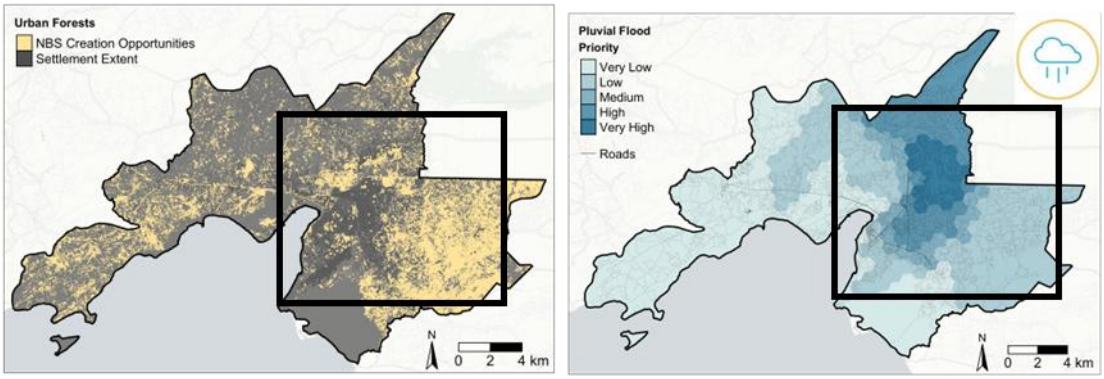
FIGURE 13: Map left: land cover for the area of interest. **Map right:** NBS Protection Benefits for Fluvial Flood mitigation- *Where are the main areas to protect to avoid higher fluvial flood risk?*



OPPORTUNITIES FOR CREATION

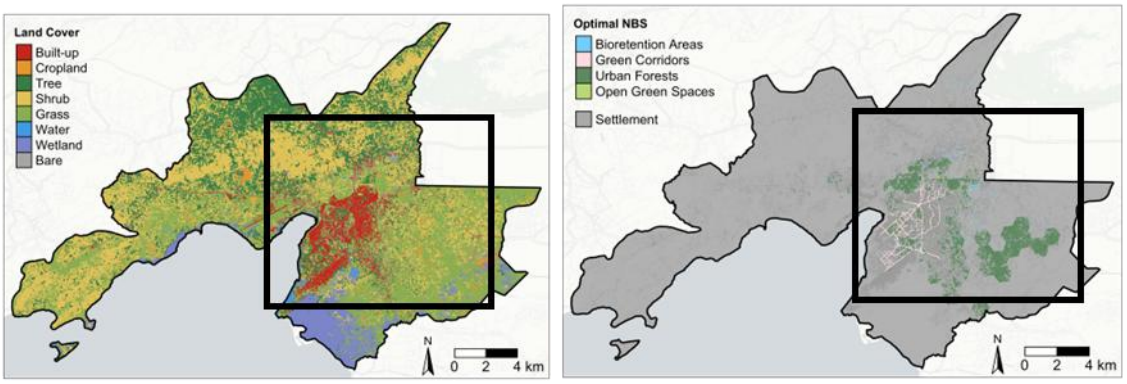
Kisumu shows an overlap between areas for NBS creation to the North and East of the city and priority areas for flood risk reduction (highlighted by solid box in figure 14). The creation of NBS in this area can help to reduce flood risk downstream and at the same time control future urbanization to avoid higher flood risk.

FIGURE 14: Map left: Creation opportunities for urban forests. **Map right:** Priority Areas for NBS Investment - *Where to apply NBS to best reduce pluvial flooding?*



The areas showing high potential for NBS creation are areas mainly covered by existing grasslands, trees and shrubs (figure 15 - left). By concentrating investments in areas identified as of high priority and designing multifunctional NBS, the benefits can be maximized (figure 15 - rigth).

FIGURE 15: Map left: Land cover of the area of interest. **Map right:** NBS with Highest 20% of Benefits for maximizing targeted benefits (equal weight).



Under equal weighting scenario, the NBSOS identified four solutions providing the highest 20% benefits (figure 15 - right) with 5 hectares of bioretention areas, 14 hectares of green corridors, **1937 hectares of urban forests**, and 7 hectares of open green spaces. However, if a higher weight is assigned to other benefits such as flood risk reduction, open green spaces and bioretention areas would also be NBS maximizing benefits.

BENEFITS RECAP TABLE FOR KISUMU:

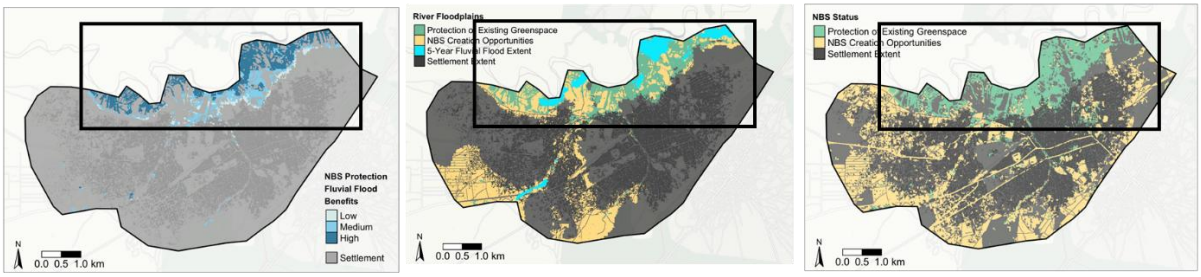
Flood reduction benefits	Heat reduction benefits	Social cohesion benefits
Bioretention areas and open green spaces (including storage facilities) present high potential to reduce flooding. Green corridors and urban forest also show some lower potential to provide this benefit.	Urban forest and green corridors show high potential to provide heat reduction benefits, mainly to the east and in the central area of the city respectively.	Green corridors show some potential to improve social cohesion by providing recreation spaces in the central and most dense area of the city.

4. MANDERA:

OPPORTUNITIES FOR PROTECTION

North of the city shows high fluvial flood benefits from green spaces protection, which coincides with floodplains that are flooded even for low return periods such as 5 and 10 years (highlighted by solid box in figure 16). Protection of existing green spaces can help to avoid future developments in highly risky areas. Existing green spaces protection could be integrated into city development plans and policies to limit urban expansion. Protection and enhancement of these spaces could also provide other benefits such as spaces for recreation and social cohesion through, for instance, the development of public parks.

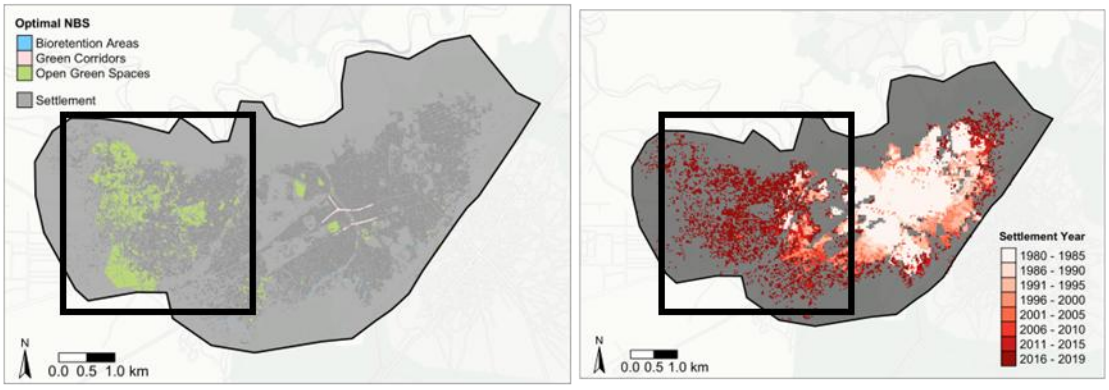
FIGURE 16: Map left: NBS Protection Benefits for Fluvial Flood mitigation - *Where are the main areas to protect to avoid higher fluvial flood risk?* **Map center:** Extents of Fluvial Flood Events (5 years). **Map right:** Existing green spaces & opportunities for NBS creation.



OPPORTUNITIES FOR CREATION

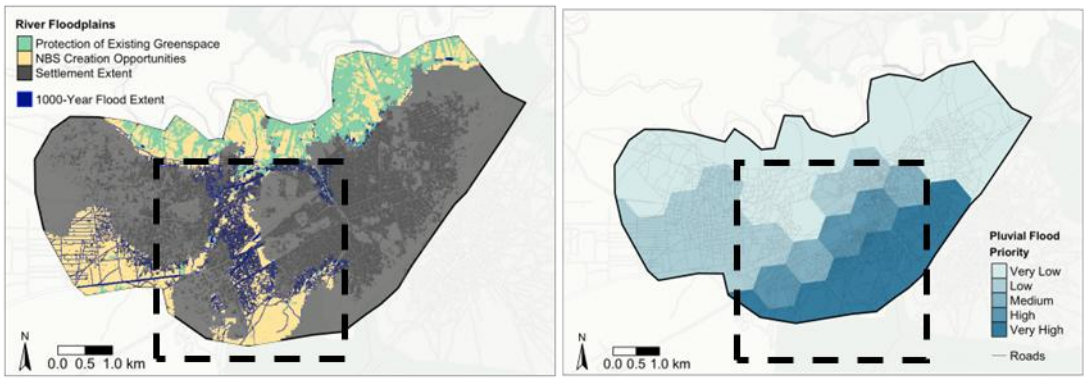
For Mandera, there is overlap between recent urbanization expansion to the West and optimal NBS investments for open green space (highlighted by solid box in figure 17). Designed spaces can be strategically weaved into the existing fabric to enhance recreation and social cohesion, limit further urban sprawl, and reduce heat stress since the area is also a priority area for heat reduction.

FIGURE 17: Map left: NBS with Highest 20% of Benefits *for maximizing targeted benefits (equal weight)*. **Map right:** Urbanization trend in Mandera.



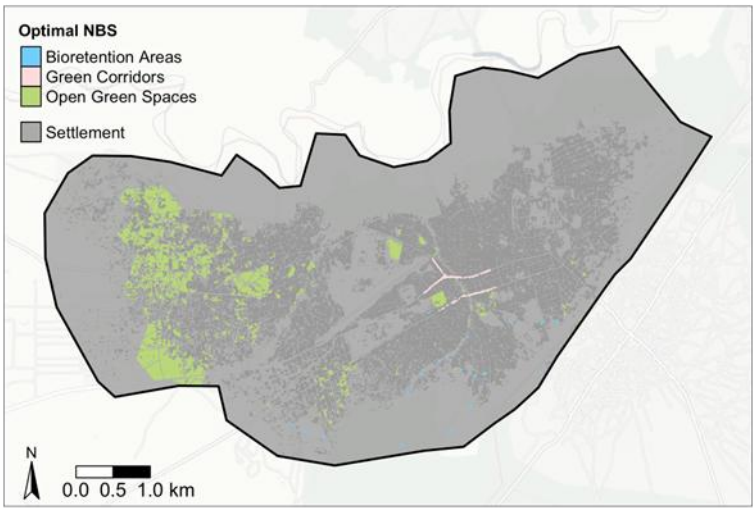
There is also overlap between areas of NBS creation opportunities for river floodplains, and pluvial flood priority to the South of the city (figure 18). Benefits can be maximized by multifunctional design of NBS in these areas, providing both pluvial and fluvial flood reduction, while also providing spaces for social cohesion since the area is a priority area for this.

FIGURE 18: Map left: Protection & Creation Opportunities for River Floodplains. **Map right:** Priority Areas for NBS Investment - *Where to apply NBS to best reduce pluvial flooding?*



Under equal weighting scenario, the NBSOS identified three solutions providing the highest 20% benefits (figure 19) with 3 hectares of bioretention areas, 8 hectares of green corridors, and **136 hectares of open green spaces**. However, river floodplains creation and enhancement (not included in the MCA) is also a main NBS for this case.

FIGURE 19: NBS with Highest 20% of Benefits for maximizing targeted benefits. *The distribution shown here corresponds to an equal weights case in which flood benefits, heat benefits, and social cohesion benefits share an equal weight of 33%.*



BENEFITS RECAP TABLE FOR MANDERA:

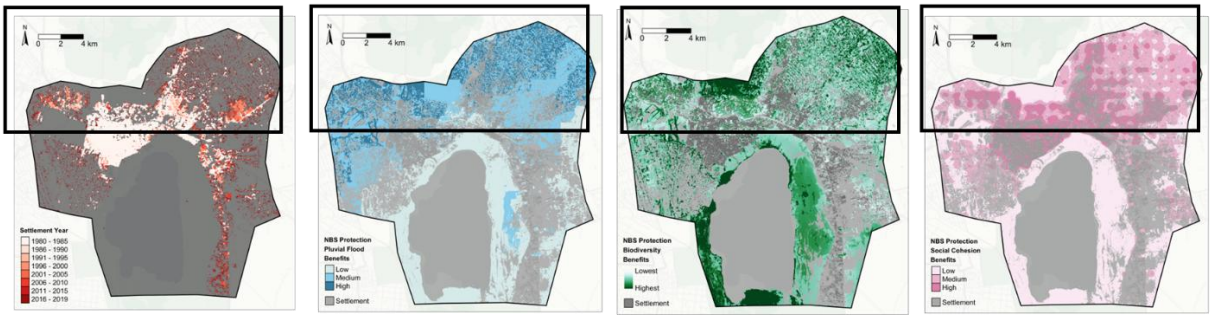
Flood reduction benefits	Heat reduction benefits	Social cohesion benefits
Bioretention areas and open green spaces (including storage facilities) show some potential for flood reduction in this area.	Open green spaces show good potential for heat reduction while green corridors show also some lower potential for this benefit.	Open green spaces show good potential for providing social benefits while green corridors show also some lower potential for this benefit.

5. NAKURU:

OPPORTUNITIES FOR PROTECTION

Considering the high urbanization trend observed towards the North of the area of interest (highlighted by solid box in figure 20), and the high level of flood benefits obtained from existing green spaces protection, the protection of this area to limit further urbanization should be prioritized to avoid higher flood risk downstream in the future. This could be done while also protecting areas of high biodiversity value, and by developing recreational green spaces to enhance social cohesion which is also a priority in the area.

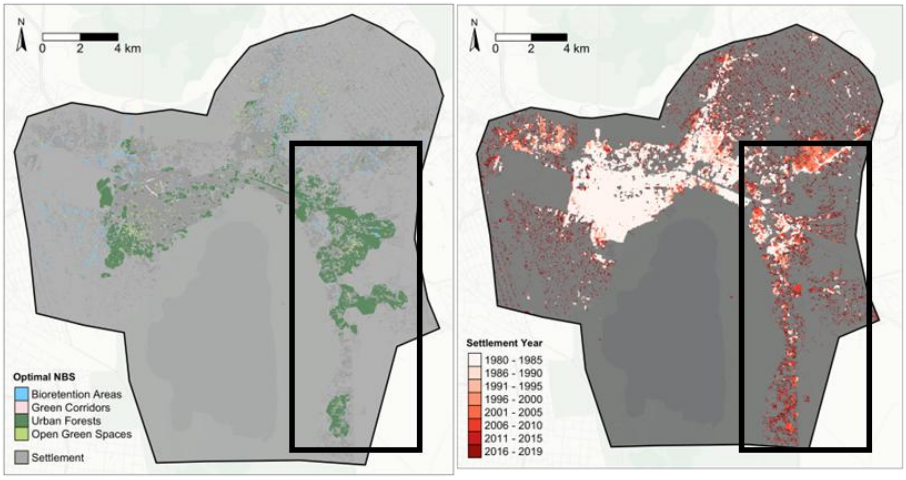
FIGURE 20: Map left: Urbanization trend in Nakuru. **Map center left:** NBS Protection Benefits for Pluvial Flood mitigation - Where are the main areas to protect to avoid higher pluvial flood risk? **Map center right:** Potential biodiversity benefits of green spaces protection**. Map right:** NBS Protection Benefits for Social Cohesion - *Where are the main areas to protect to avoid social cohesion deterioration?*



OPPORTUNITIES FOR CREATION

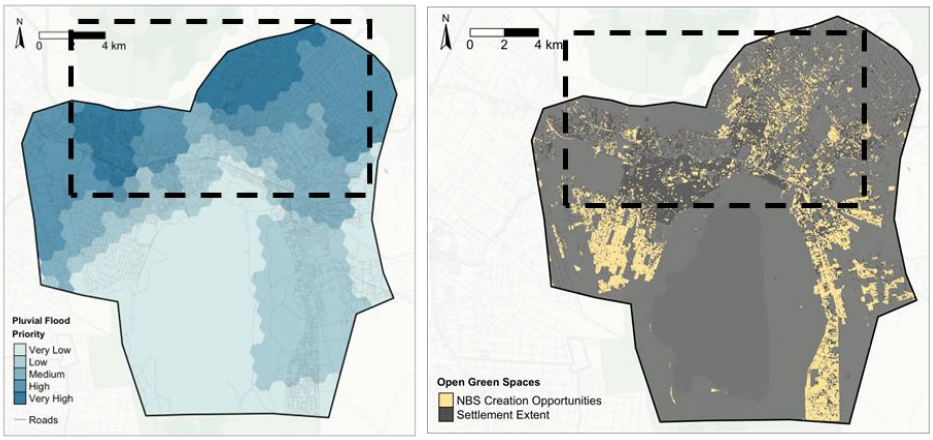
For Nakuru, considering its high population density and urban expansion to the East of the area of interest (highlighted by solid box in figure 21), creation of recommended optimal NBS such as urban forests should be prioritized to limit sprawl.

FIGURE 21: Map left: NBS with Highest 20% of Benefits *for maximizing targeted benefits (equal weight)***. Map right:** Urbanization trend in Nakuru.



There is also overlap between open green space creation, and pluvial flood priority areas (highlighted by dashed box in figure 22). Benefits can be maximized by multifunctional design of NBS in these areas, to provide flood risk reduction, social cohesion and heat stress.

FIGURE 22: Map left: Priority Areas for NBS Investment - *Where to apply NBS to best reduce pluvial flooding?* **Map right:** Creation Opportunities for Open Green Spaces.



Under equal weighting scenario, the NBSOS identified three solutions providing the highest 20% benefits (figure 21 left) with 113 hectares of bioretention areas, 7 hectares of green corridors, **1268 hectares of urban forests**, and 50 hectares of open green spaces.

BENEFITS RECAP TABLE FOR NAKURU:

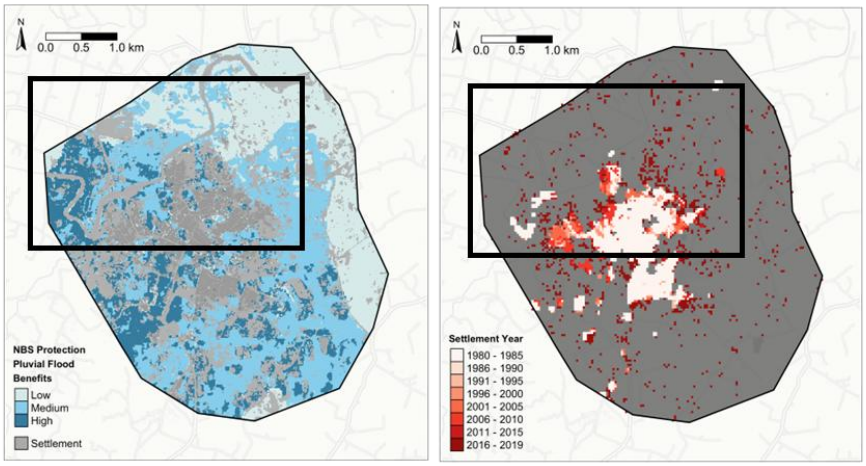
Flood reduction benefits	Heat reduction benefits	Social cohesion benefits
Bioretention areas and open green spaces (including storage facilities) present high potential to reduce flooding. Green corridors also show some lower potential to provide this benefit.	Urban forests show very high potential to reduce heat stress in this case, while green corridors show also some lower potential for this benefit.	Open green spaces and urban forest show good potential to provide social benefits in this case, mainly in areas to the east of the lake.

6. WOTE:

OPPORTUNITIES FOR PROTECTION

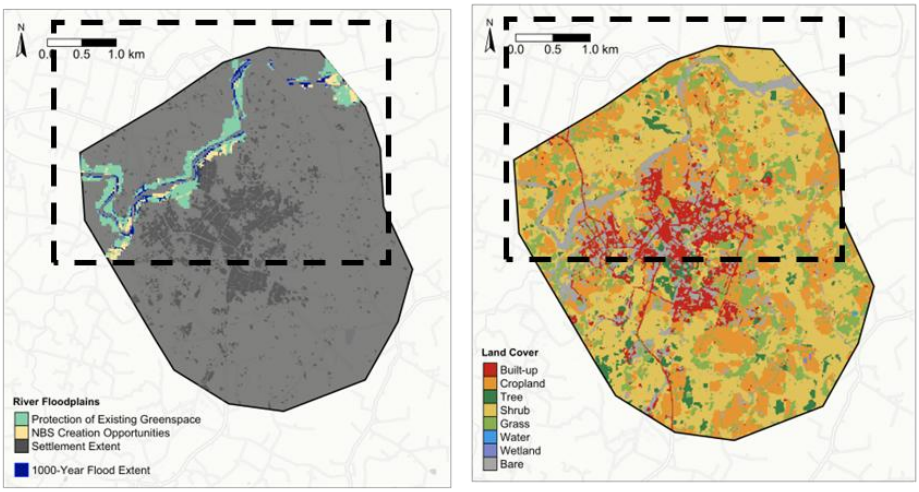
Several areas showing high urbanization trend are observed towards main protection areas for pluvial flood management (highlighted by solid box in figure 23). Protection of existing green spaces in this area can help to control future urban expansion, helping to avoid higher flood risk in the future.

FIGURE 23: **Map left:** NBS Protection Benefits for Pluvial Flood mitigation. *Where are the main areas to protect to avoid higher pluvial flood risk?* **Map right:** Urbanization trend in Wote.



Given that much of the area of interest is located in a river front, floodplain protection areas, which coincides with existing croplands and shrublands, should be prioritized (highlighted with dashed line in figure 24) in future development and regulatory plans.

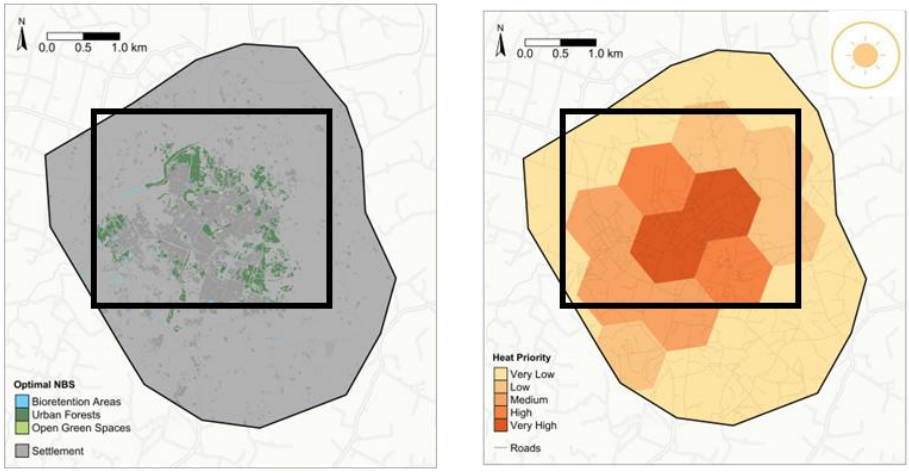
FIGURE 24: **Map left:** Protection & Creation Opportunities for River Floodplains. **Map right:** Land cover for the area of interest.



OPPORTUNITIES FOR CREATION

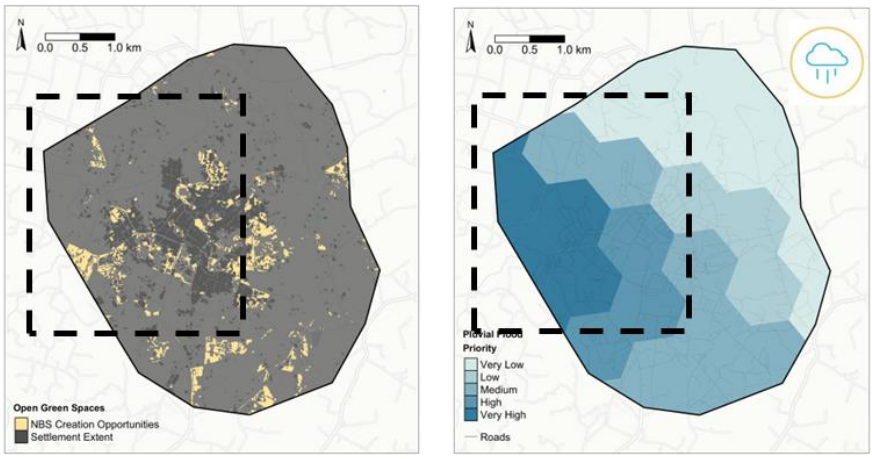
For Wote, there is an overlap between areas of high priority for heat stress reduction, and areas of optimal NBS interventions (highlighted by solid box in figure 25). Creation of NBS can help mitigate heat stress while providing areas for recreation.

FIGURE 25: Map left: NBS with Highest 20% of Benefits for maximizing targeted benefits (equal weight). **Map right:** Levels of exposure to heat stress - Where do people get highest heat stress?



There is also overlap between priority areas for pluvial flood risk reduction and open green spaces creation (highlighted by dashed box in figure 26). Benefits can be maximized by multifunctional design of NBS in these areas, to provide both flood risk reduction and spaces for social cohesion.

FIGURE 26: Map left: Creation Opportunities for Open Green Spaces. **Map right:** Priority Areas for NBS Investment - *Where to apply NBS to best reduce pluvial flooding?*



Under equal weighting scenario, the NBSOS identified three solutions providing the highest 20% benefits (figure 24 left) with 3 hectares of bioretention areas, **74 hectares of urban forests**, and 1 hectares of open green spaces. However, if a higher weight is assigned to other benefits such as flood risk reduction, open green spaces and bioretention areas would also maximize benefits.

BENEFITS RECAP TABLE FOR WOTE:

Flood reduction benefits	Heat reduction benefits	Social cohesion benefits
Bioretention areas and open green spaces (including storage facilities) show potential to reduce flooding in this case.	Urban forests show potential to reduce heat stress in this case.	People in Wote have good access to green spaces and none of the NBS analyzed show potential for improving this.