بسمه تعالی

دانشگاه فردوسی مشهد

Land Subsidence in Urban Areas: Environmental Consequences and Management

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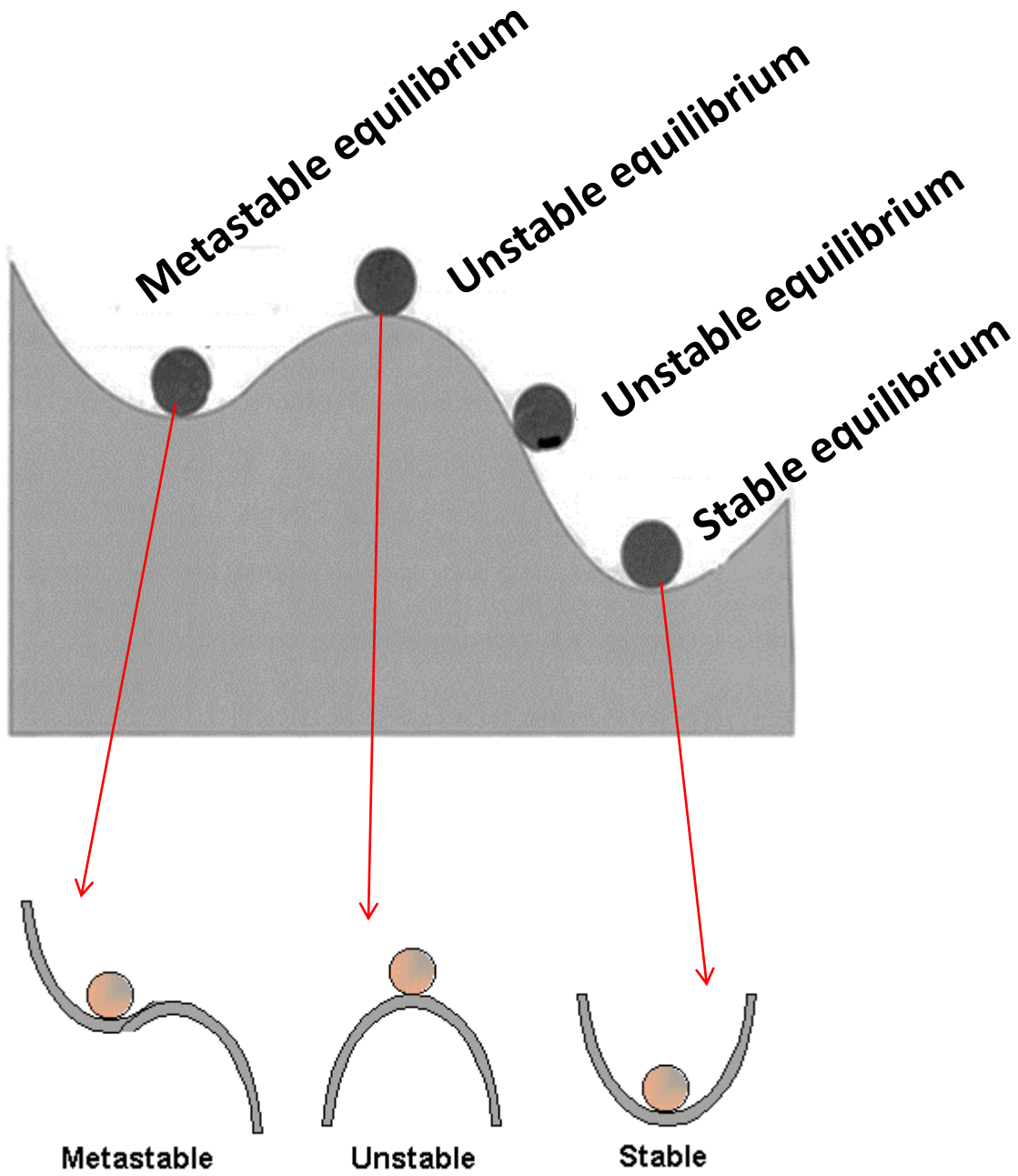
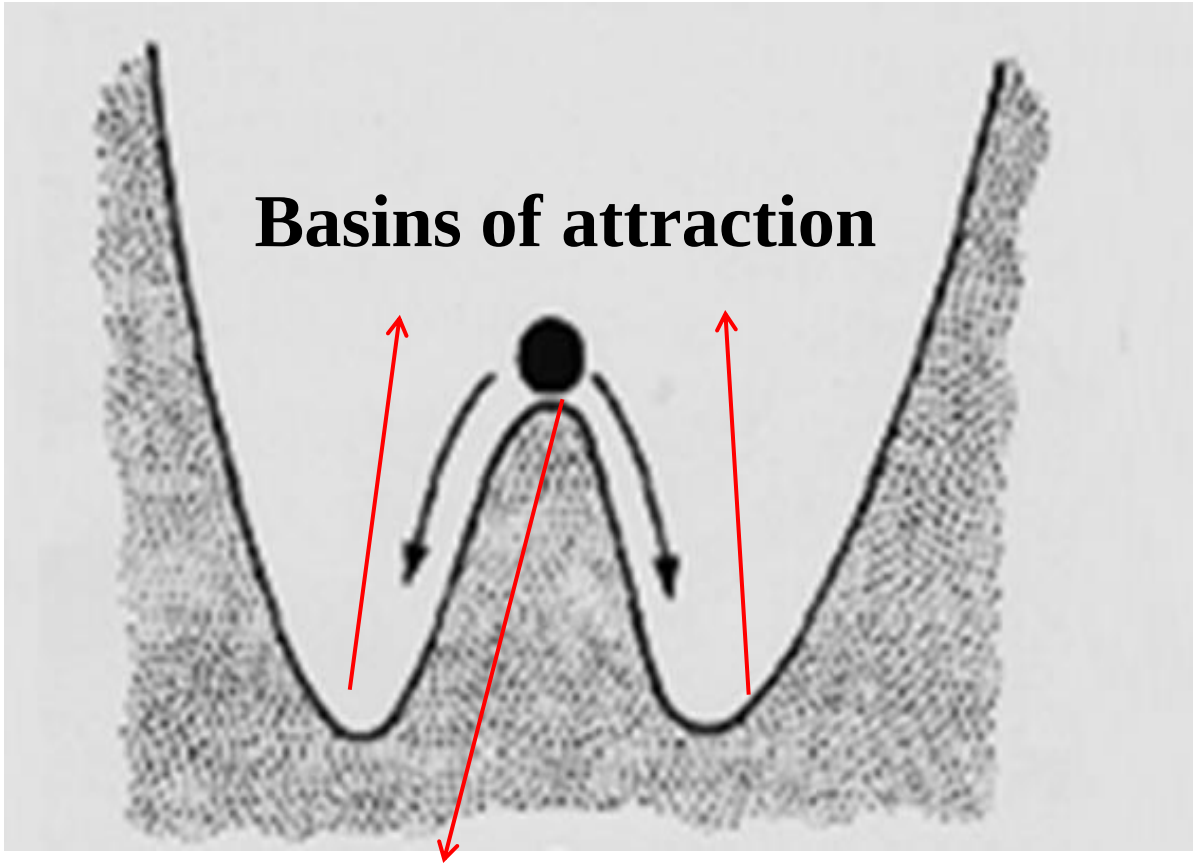
We live in landscapes; we manage landscapes; We often describe the environment around us in terms of landscapes. Yet landscapes have long been a scientific blind spot.
Noble, I.R., 1999

September 2022

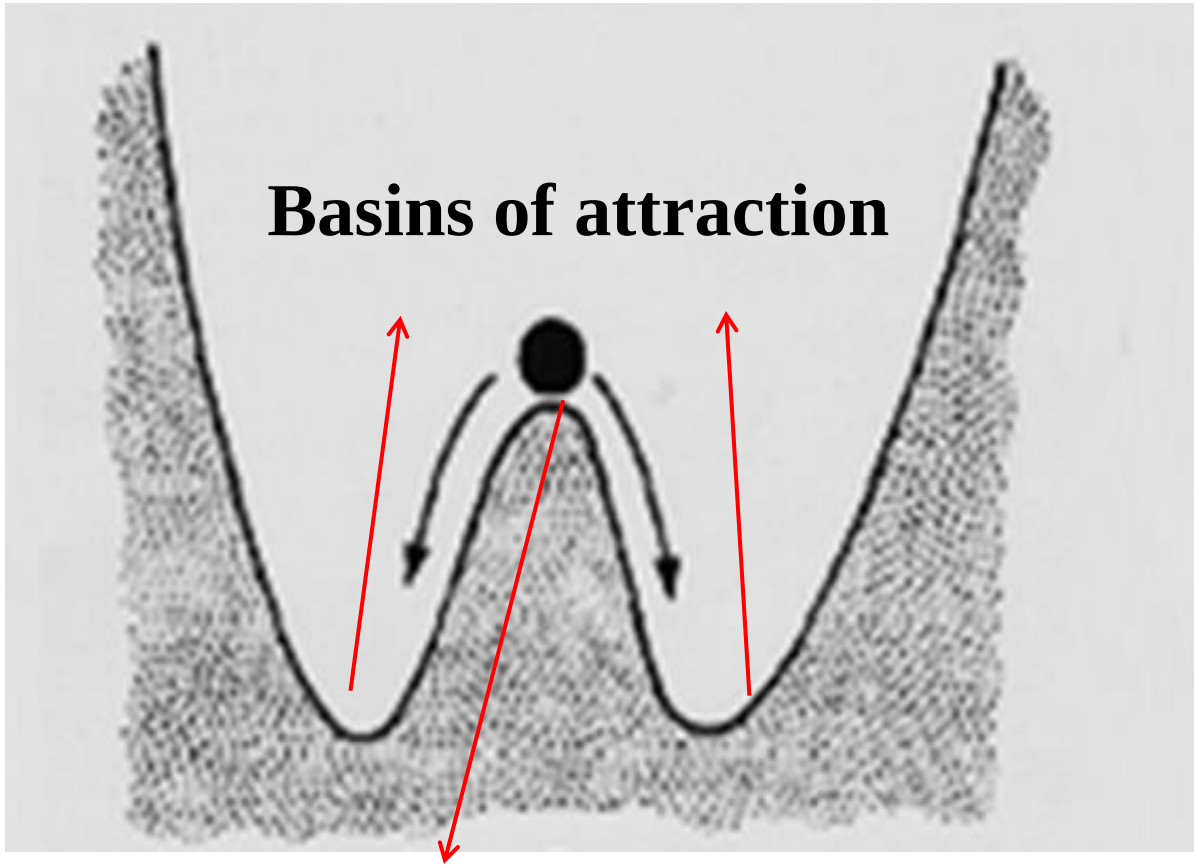
✓ Stable VS. Metastable equilibrium



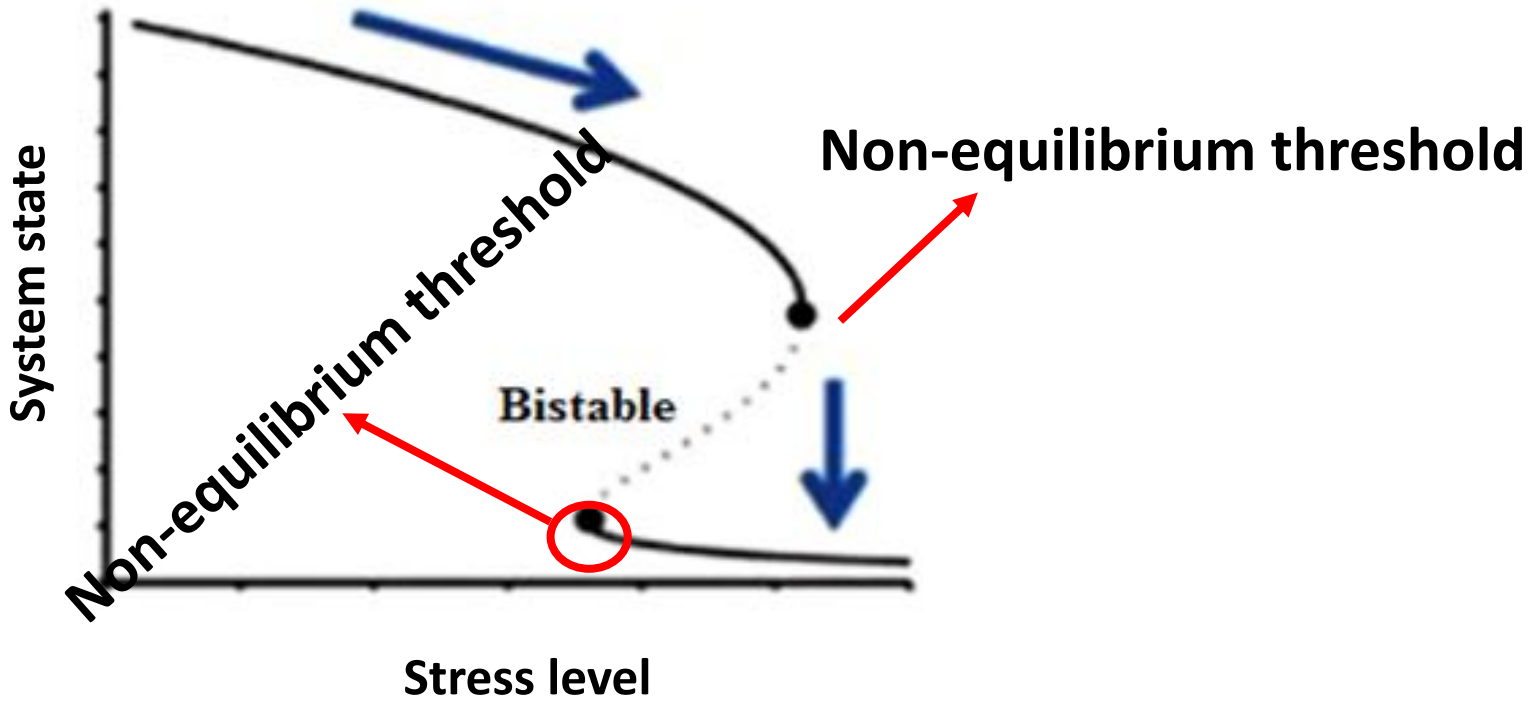
✓ Metastable equilibrium with multiple stable states



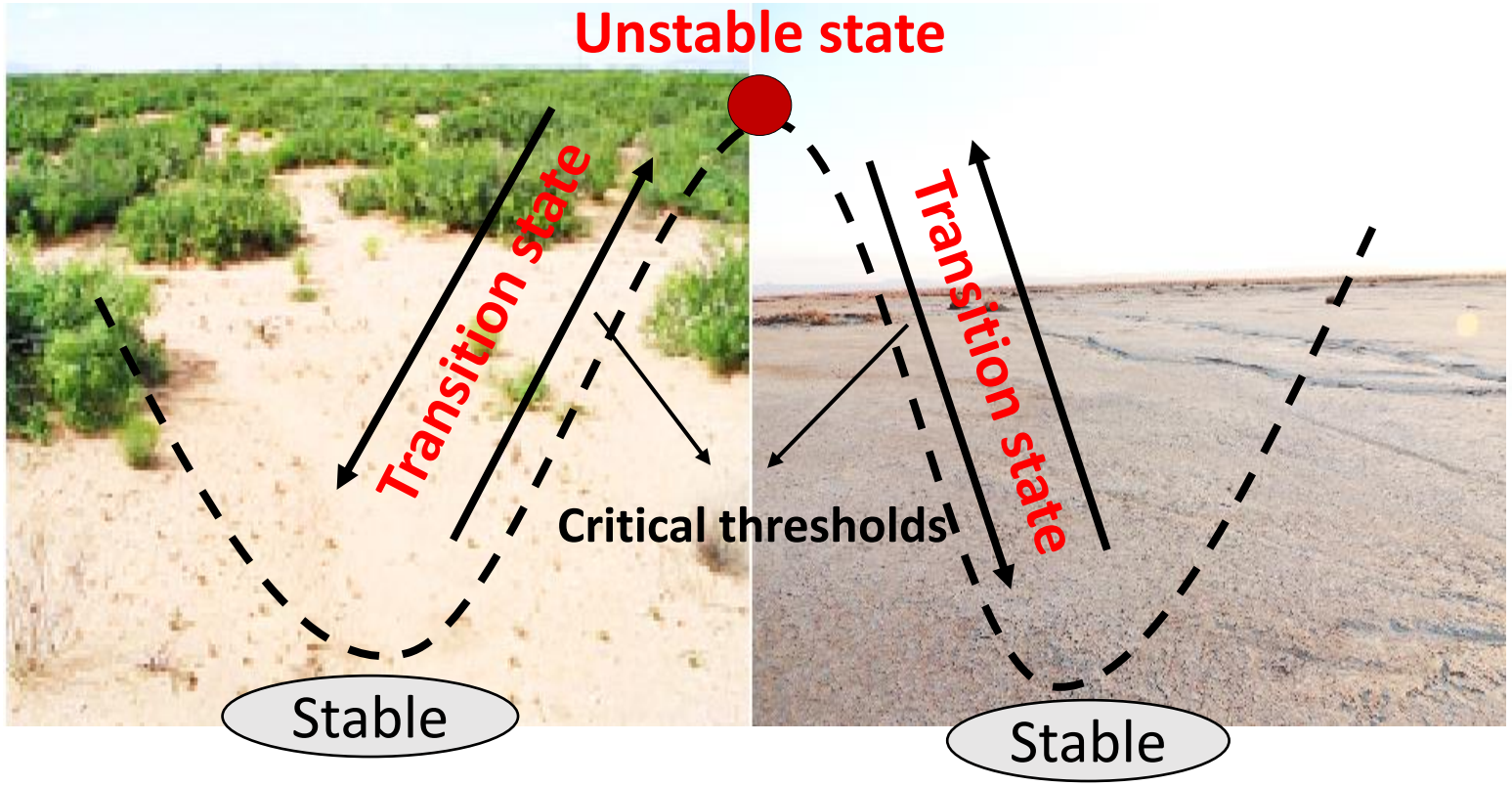
Transitional stable state (Bistable area)

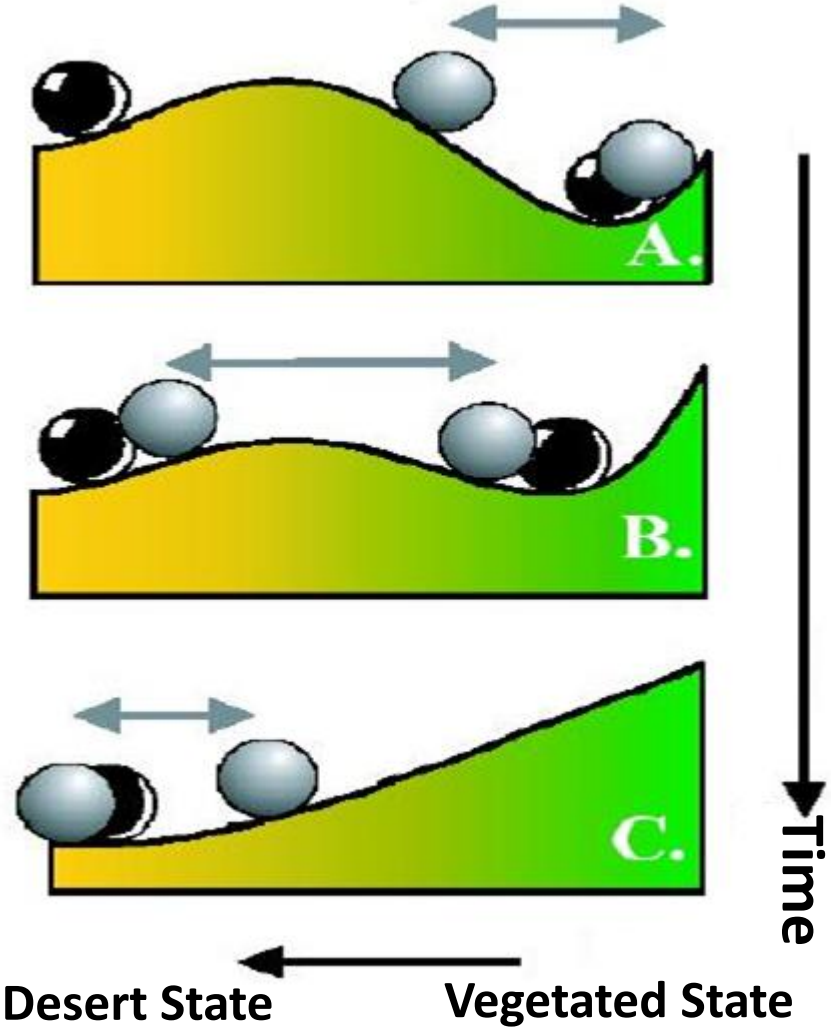


Transitional stable state (Bistable area)


System state
Non-equilibrium threshold
Non-equilibrium threshold
Bistable
Stress level

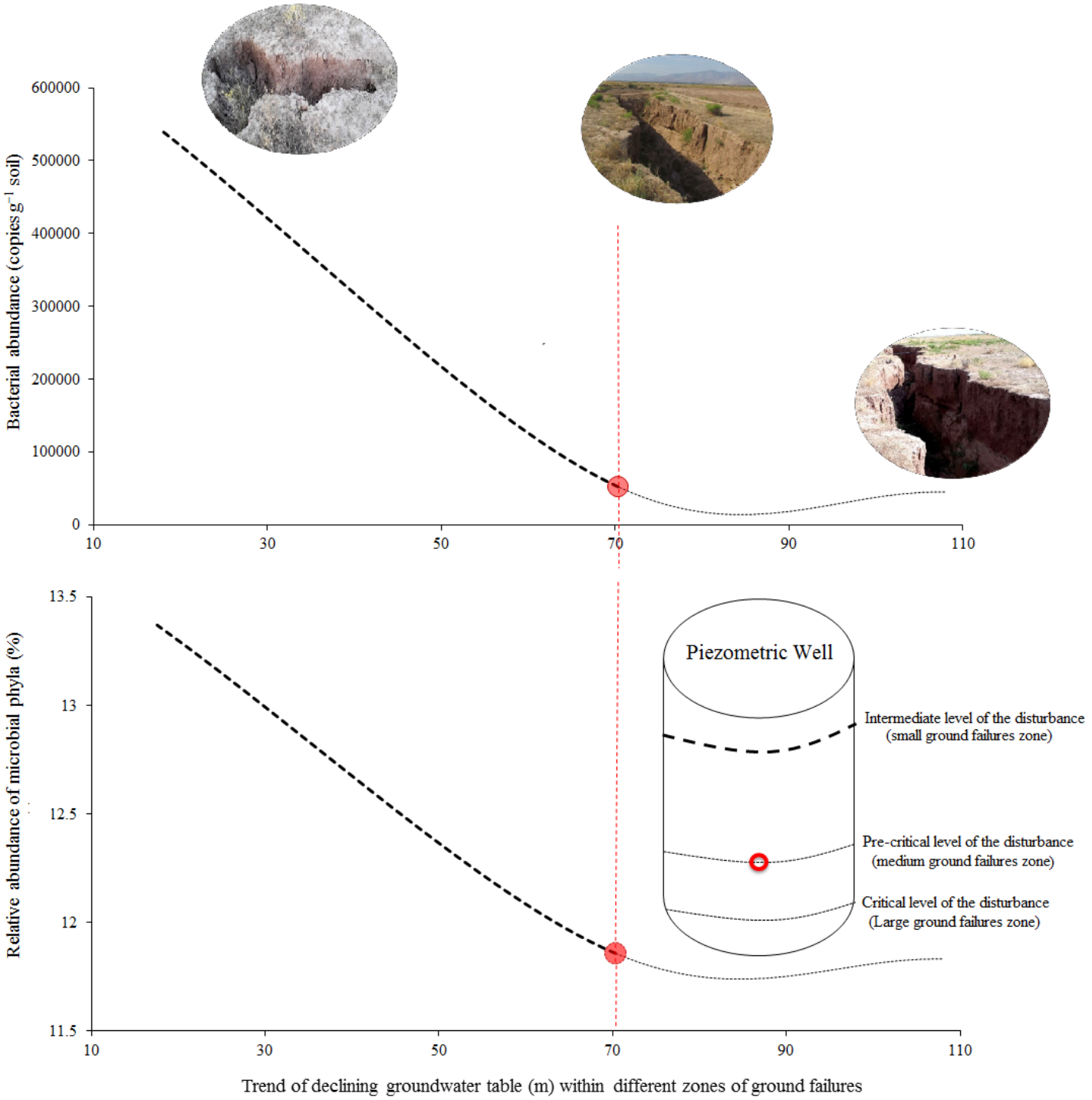
✓ Metastable equilibrium in arid land





Vegetated state

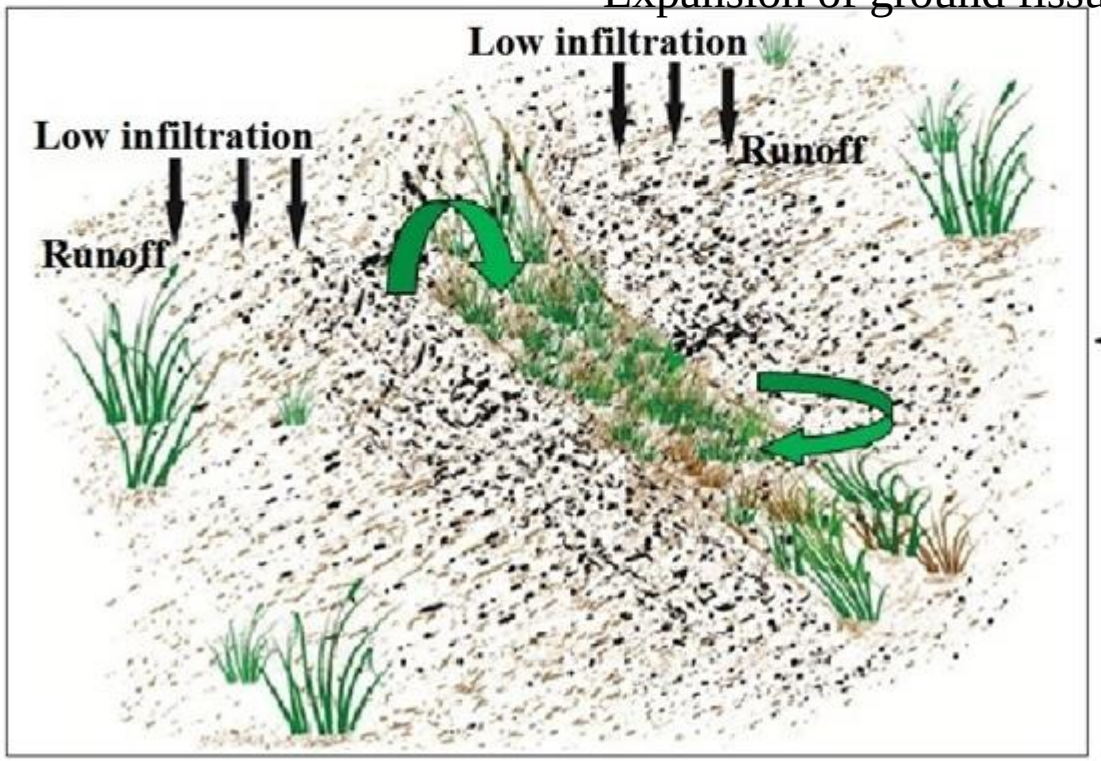
Desert state

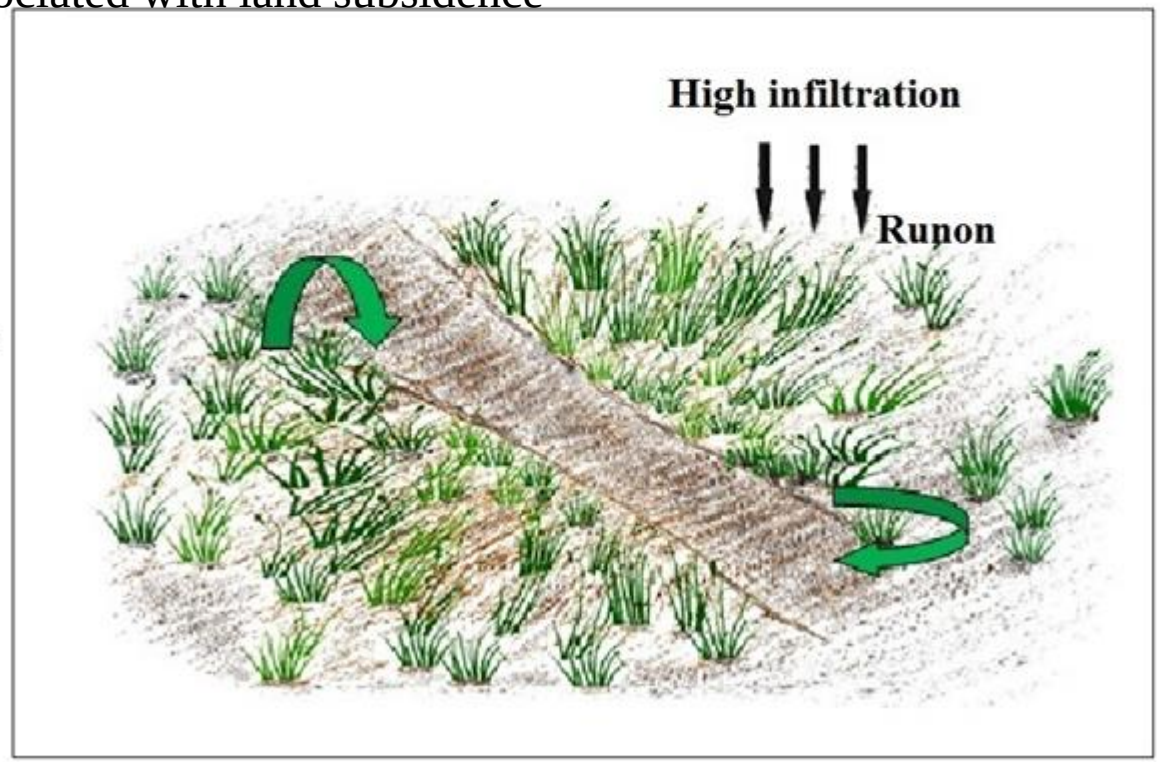


- Land subsidence is recognized as an outcome of the compaction of fine grain sediments within aquifer systems.
- A decrease in the groundwater level leads to a higher effective stress, encouraging the soil skeleton to compact.
- By contrast, a rise in the groundwater table reduces the effective stress, causing an expansion (uplift) of the soil skeleton

✓ Land Subsidence and environmental instability

Expansion of ground fissures associated with land subsidence





Mosaics with sparse vegetation

Post-threshold stable state
Desert state

Pre-threshold stable state
Vegetated state

Bistable state

Increasing land subsidence

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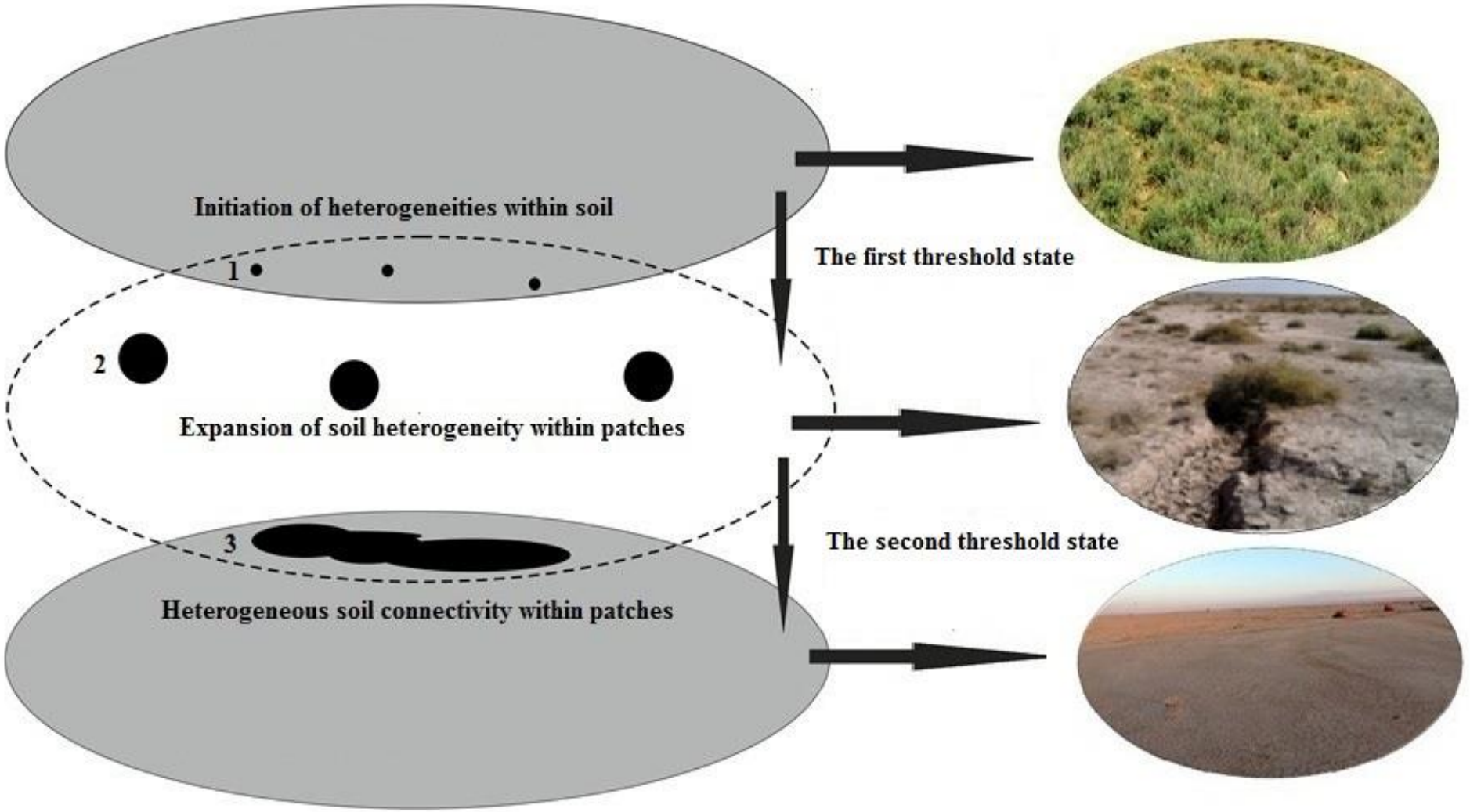
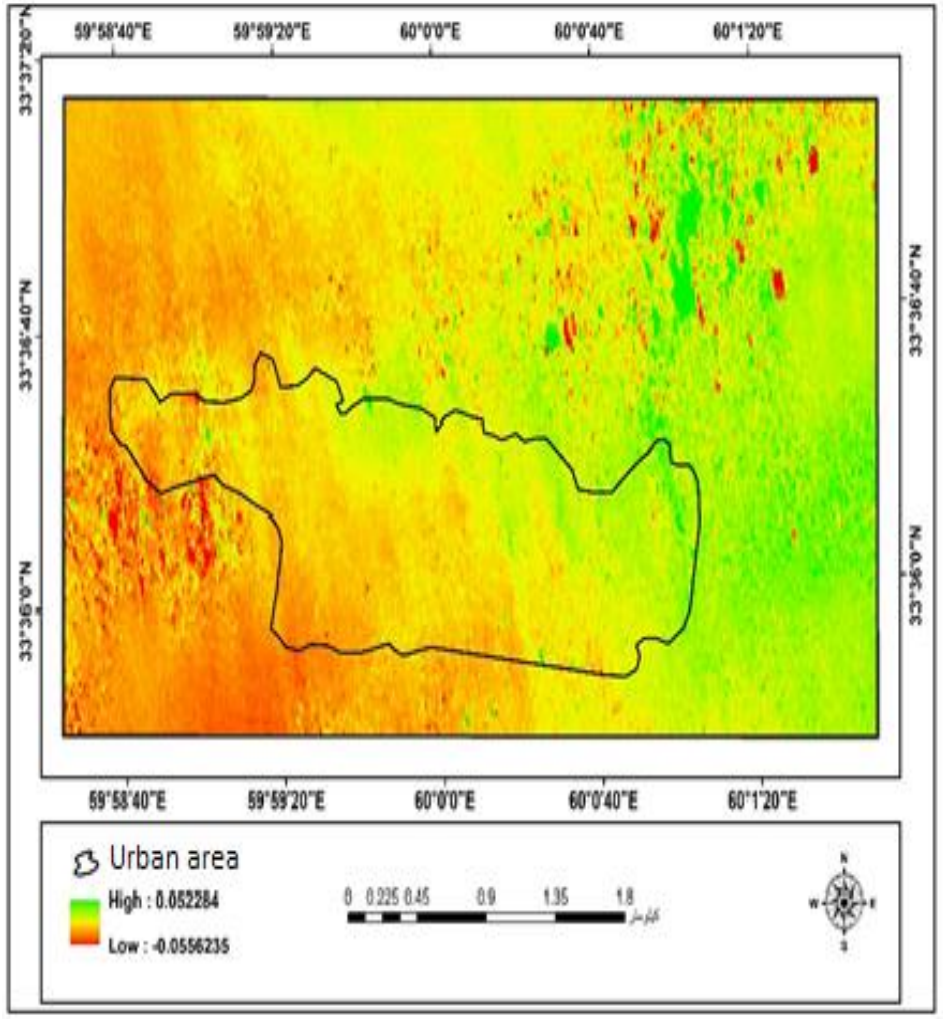
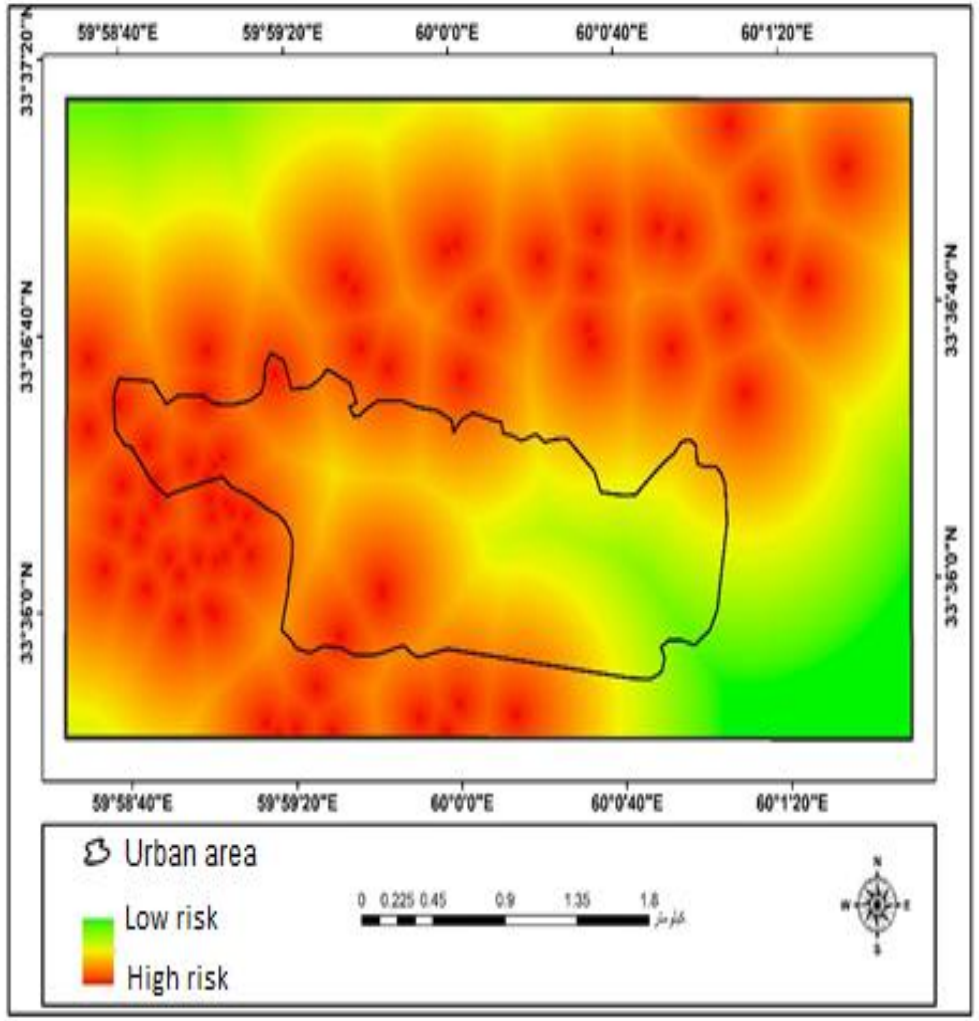


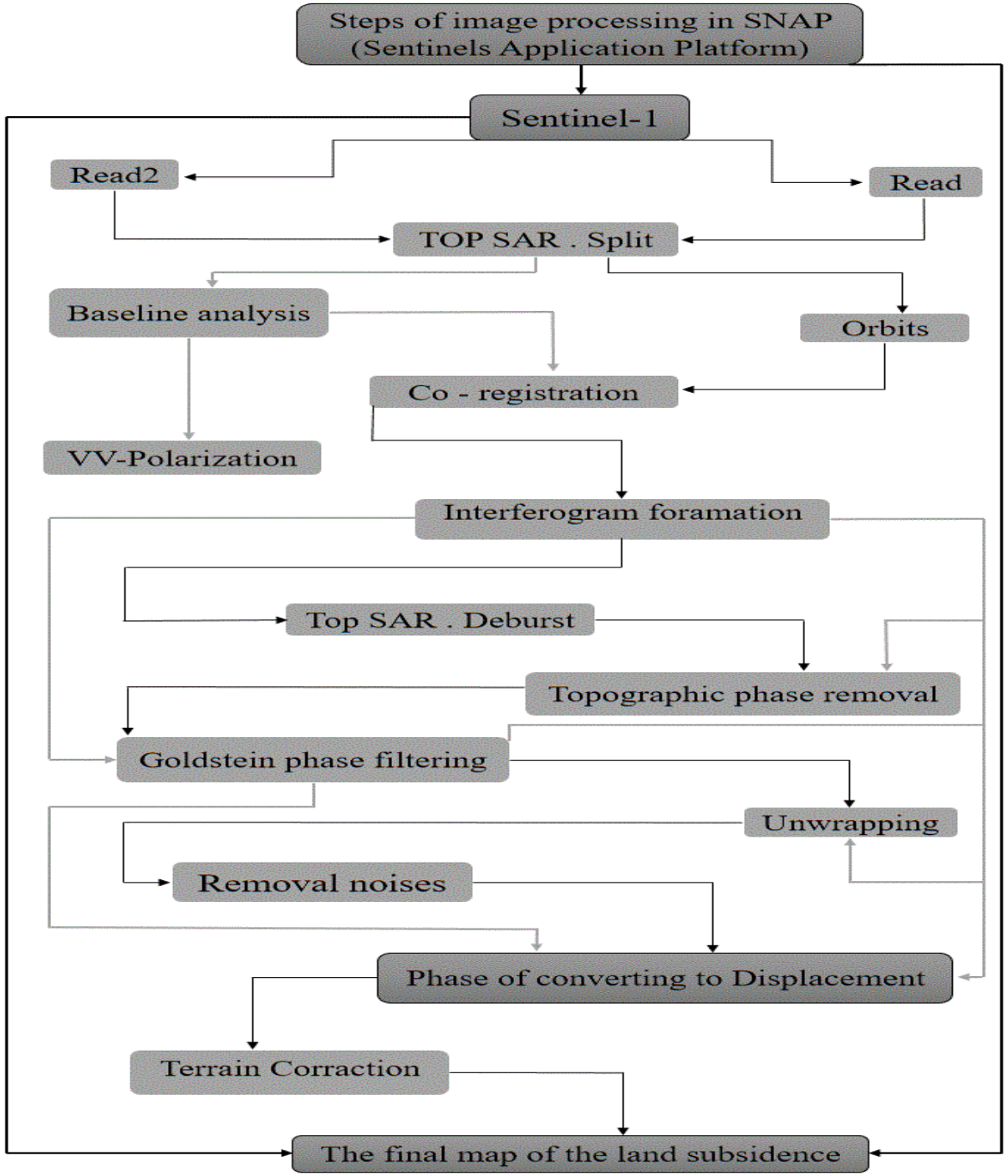
Conceptual framework of landscape dynamic stages due to the expansion of soil heterogeneities related to land subsidence. Gray areas show transformation between alternative equilibrium states together with the expansion of land subsidence. Dashed area illustrates the emergence of a non-equilibrium state between the underexploited and overexploited states along with an increase in heterogeneous soils.

✓ Land subsidence analysis in the urban areas



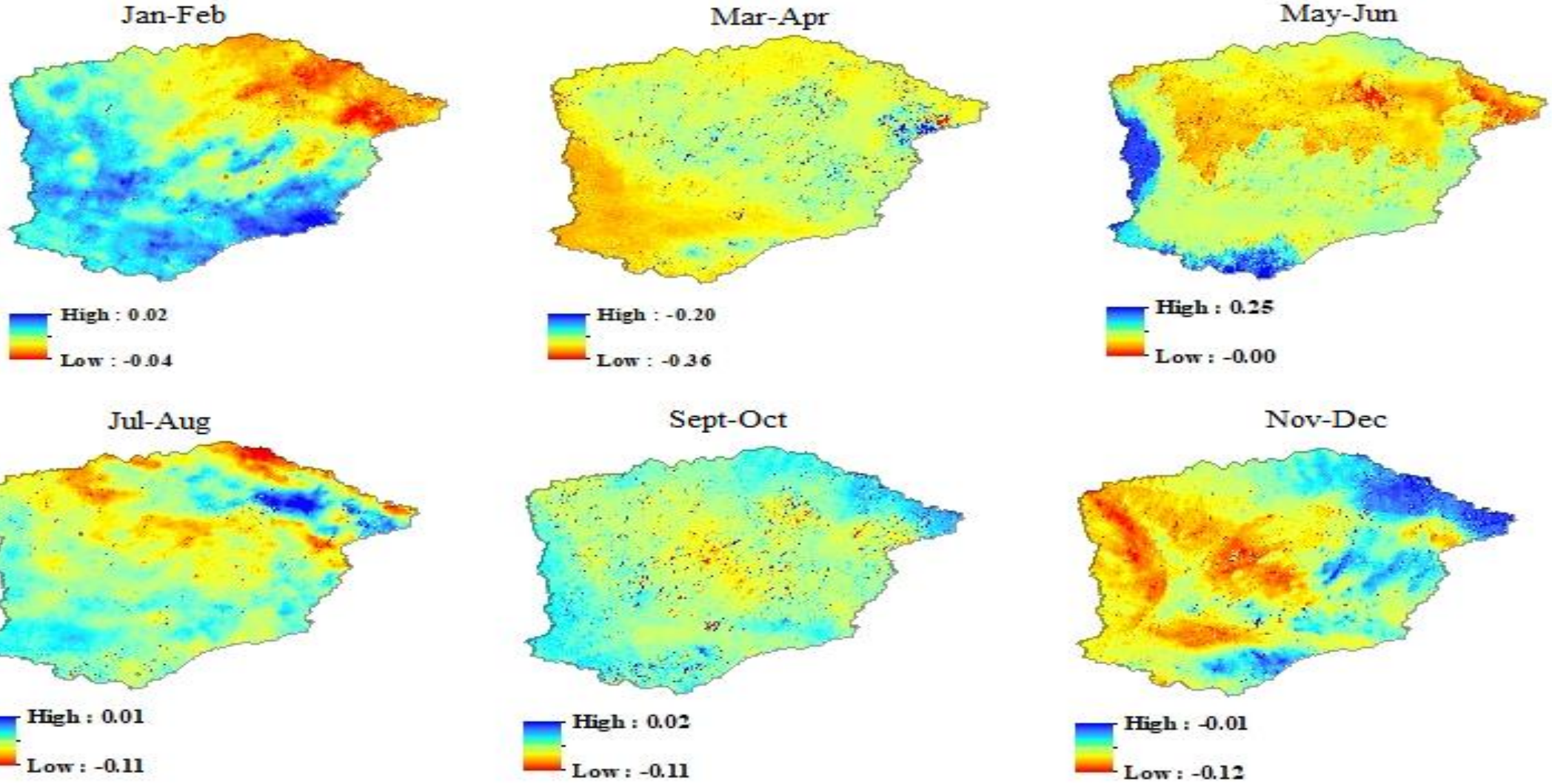


Displacement rate in the study area

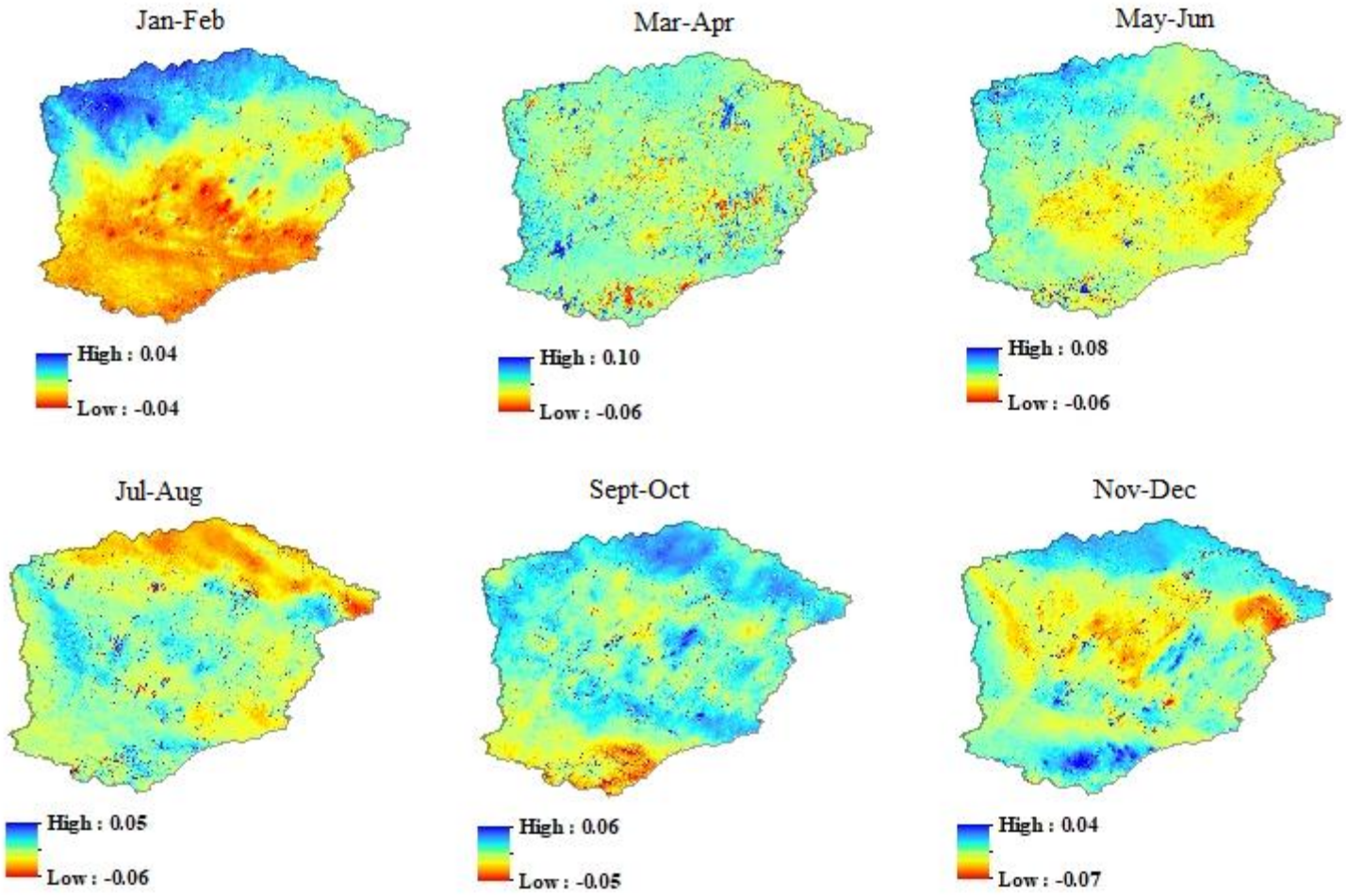


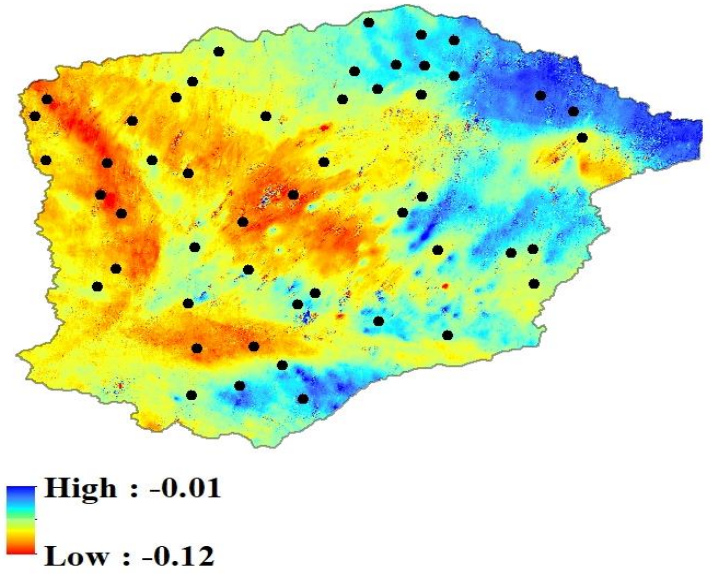
✓ Displacement rate analysis

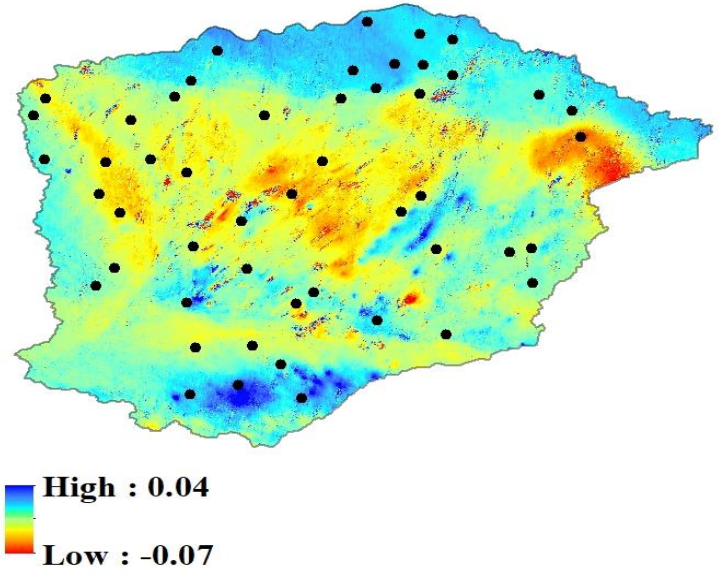
✓ Land subsidence analysis in the urban areas

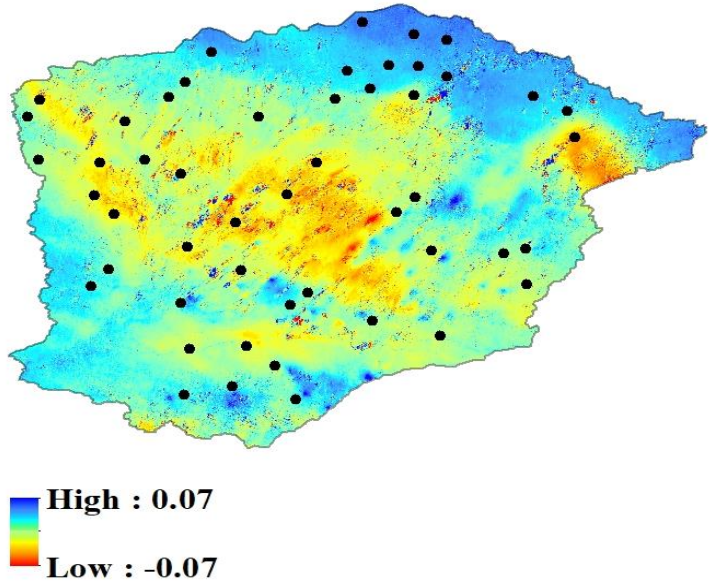


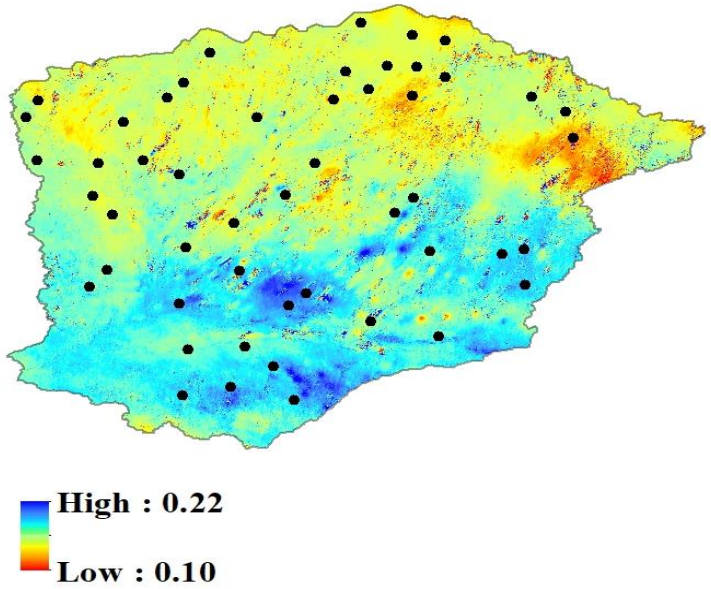
✓ Land subsidence analysis in the urban areas

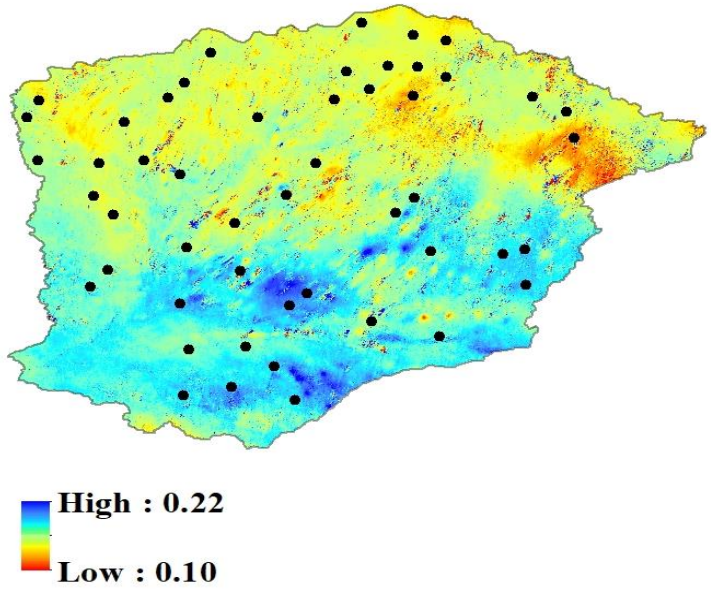






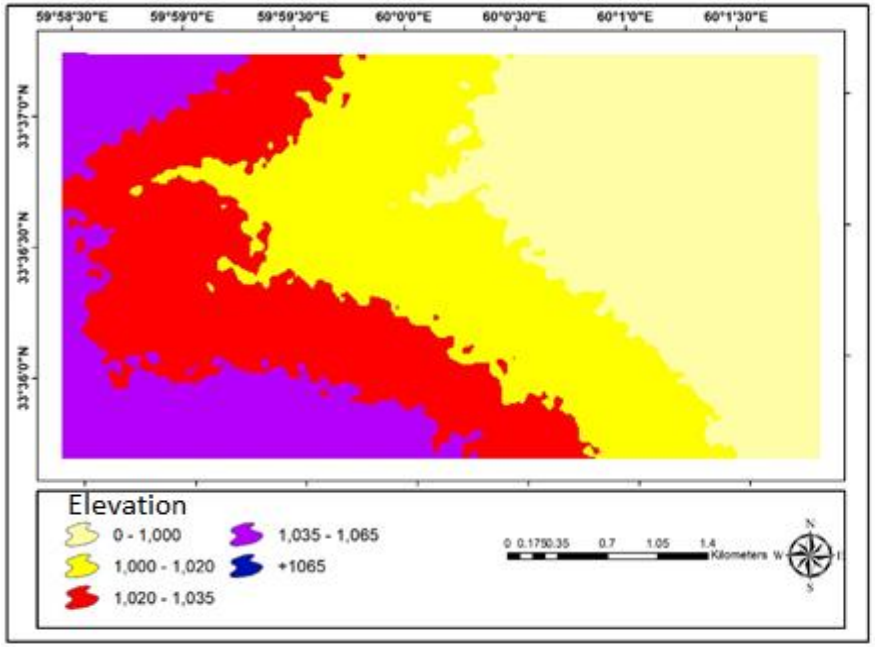


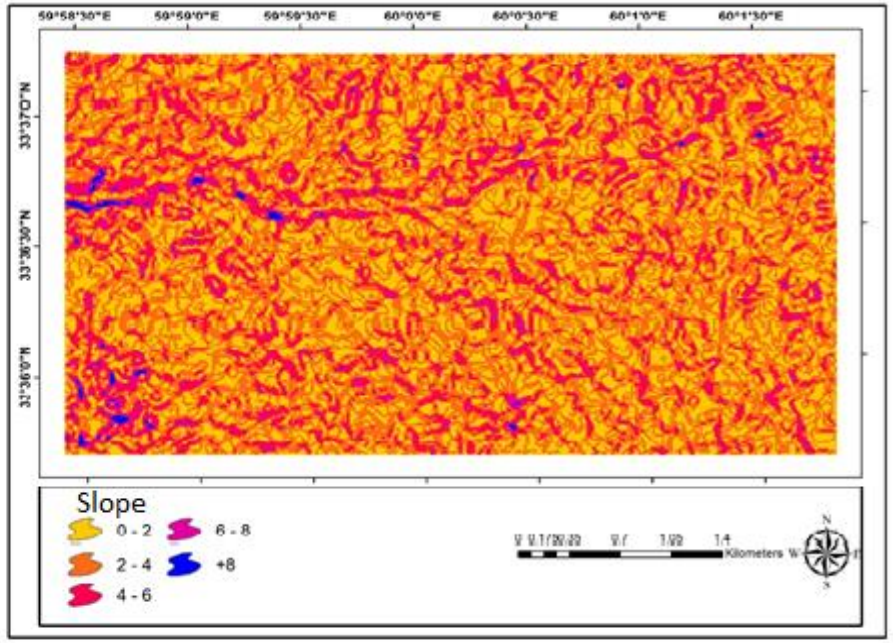


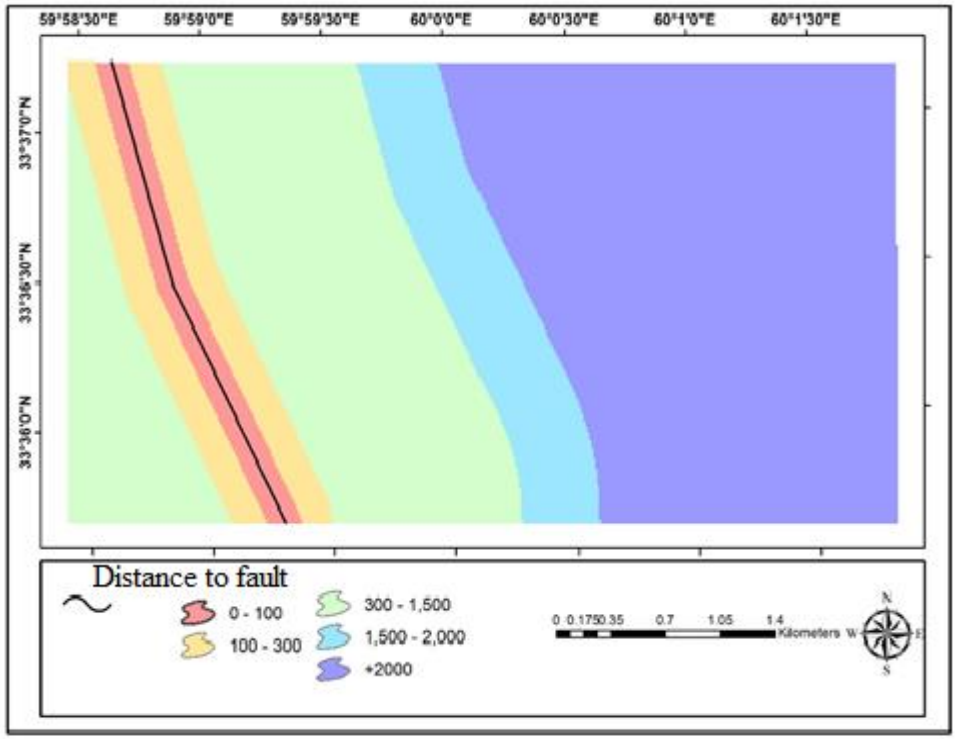


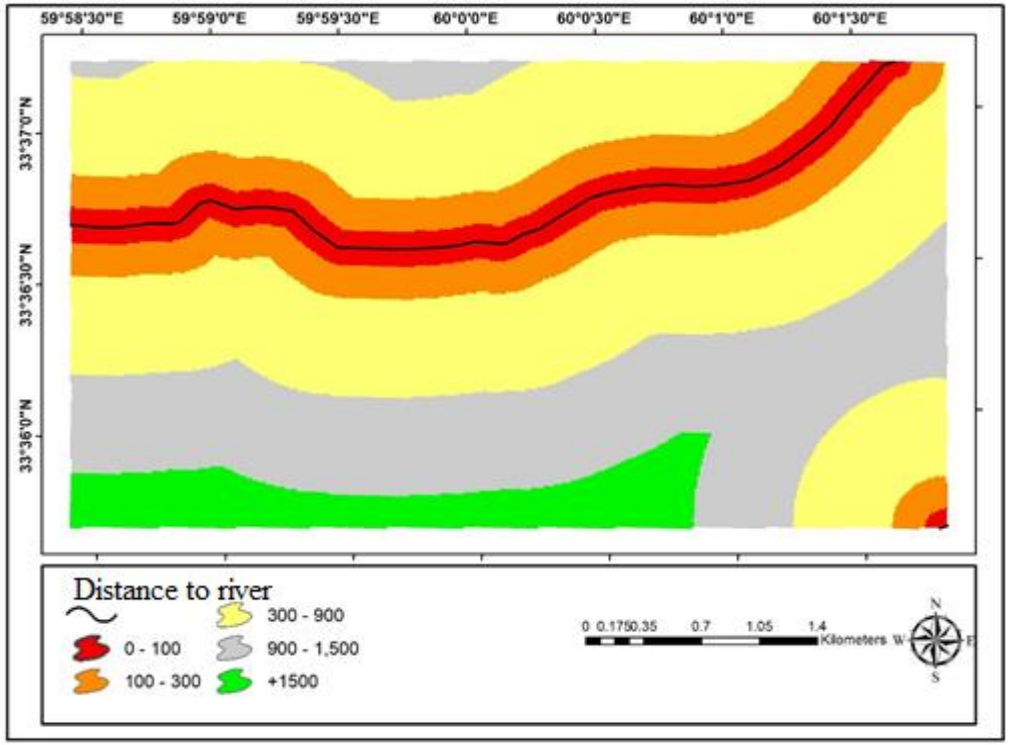
GPS points related to ground fissures in the study area

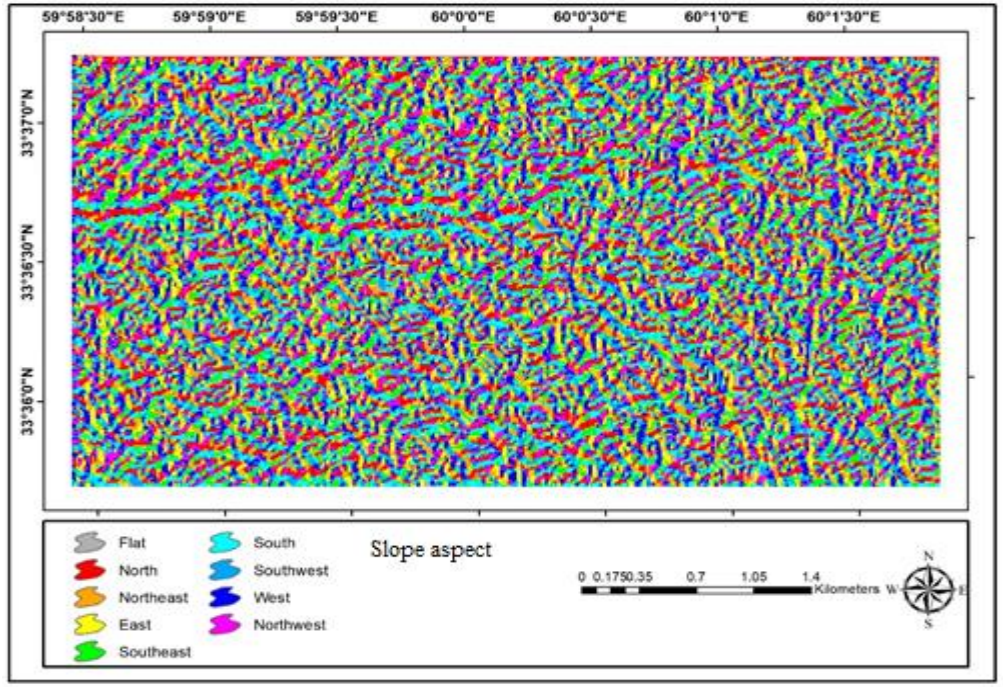
- ✓ Land subsidence and potential criteria in the study area

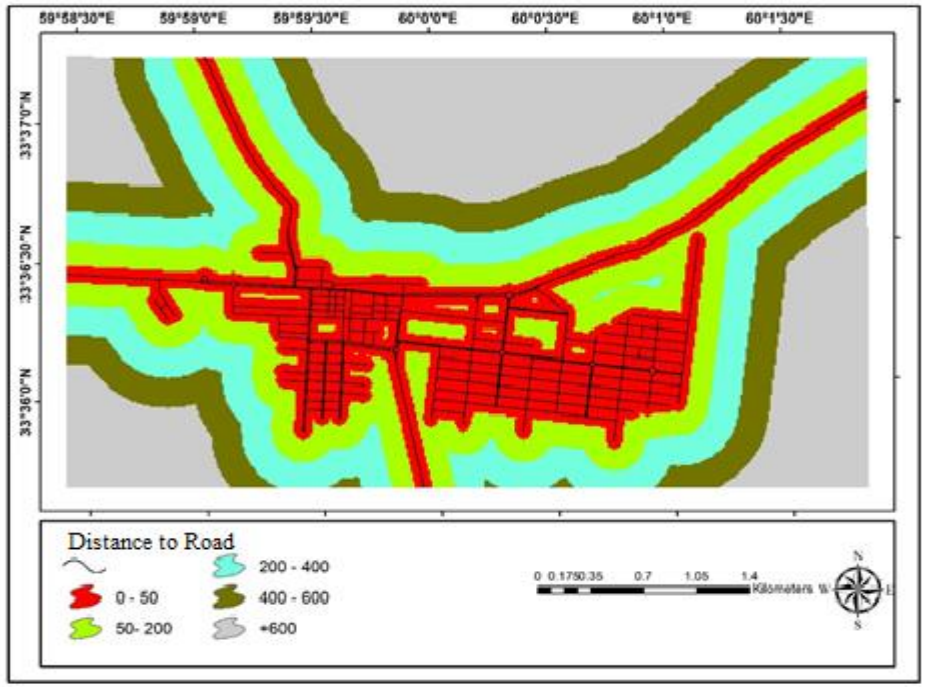


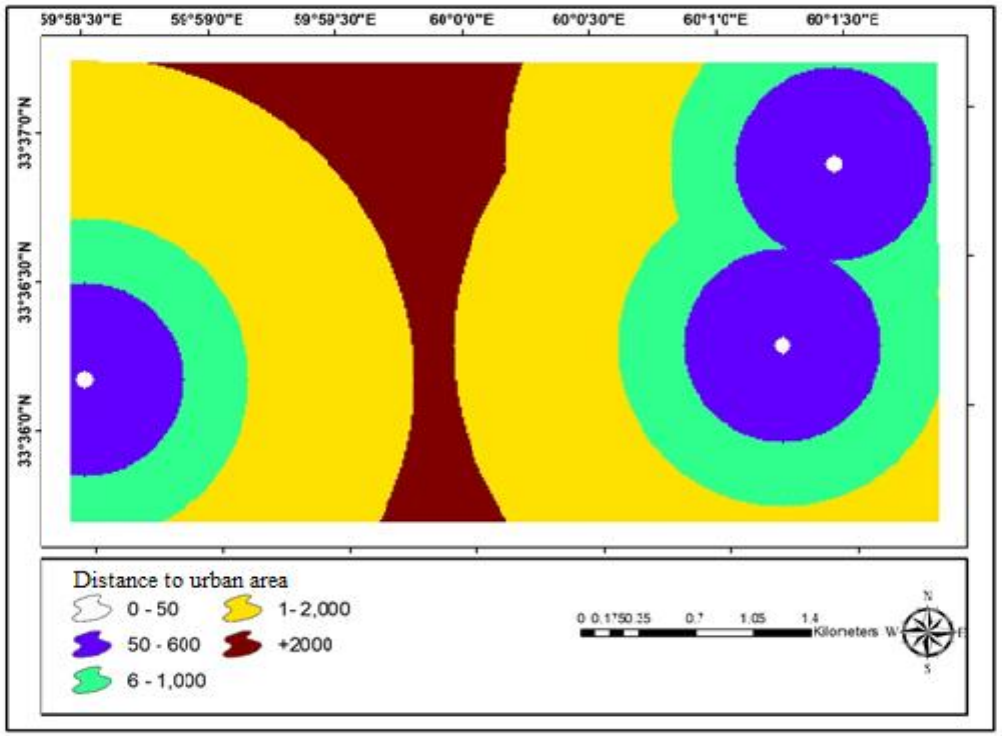












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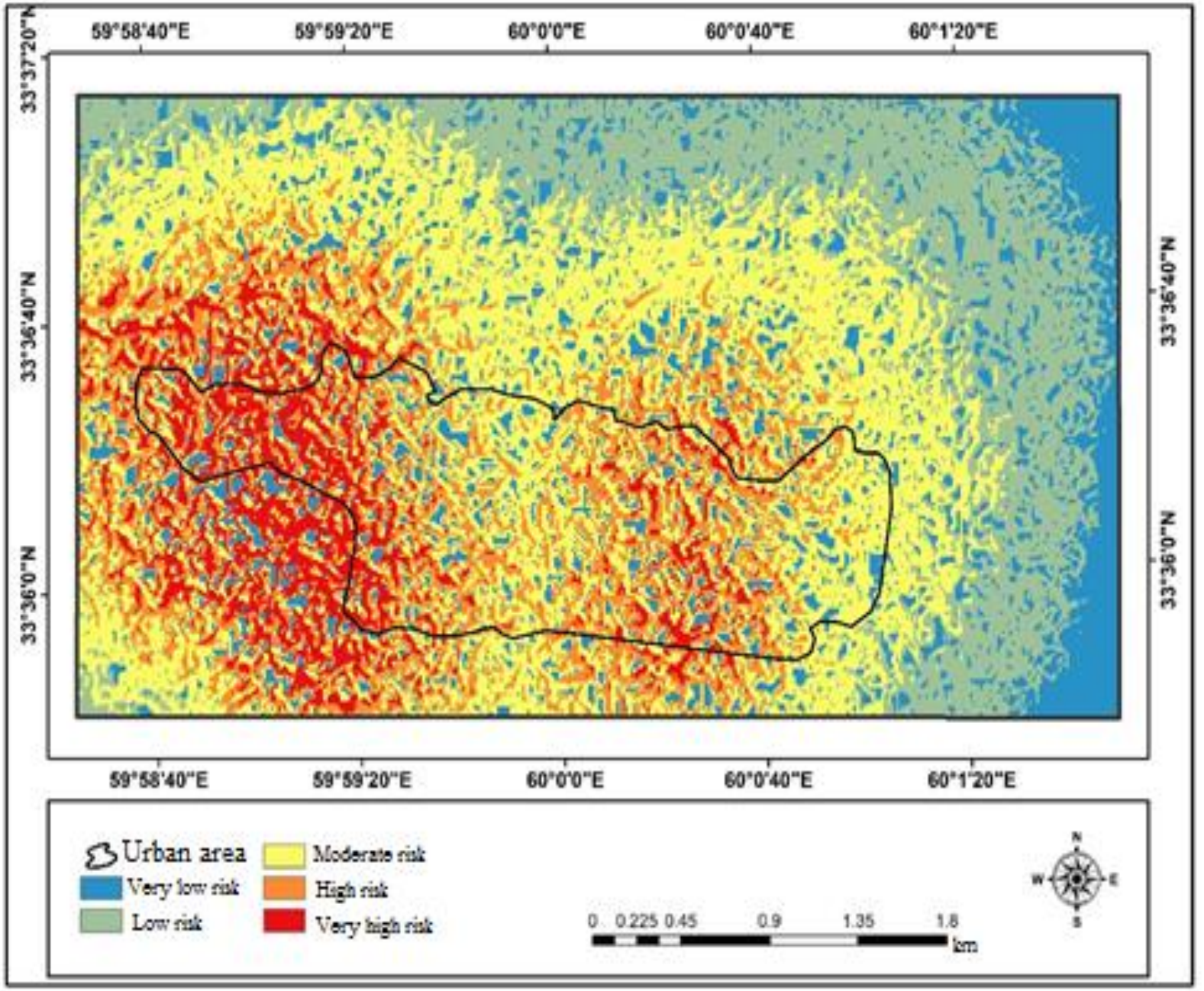
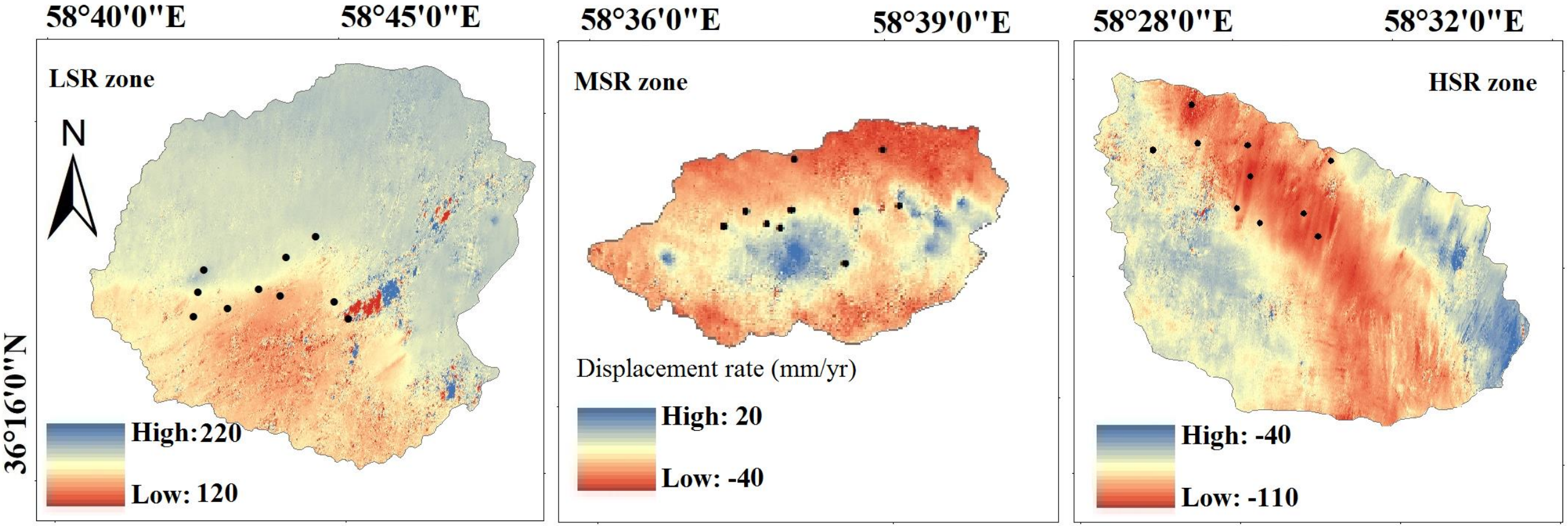
✓ Land subsidence in the urban area: Causes and management



Final map based on the results of the model

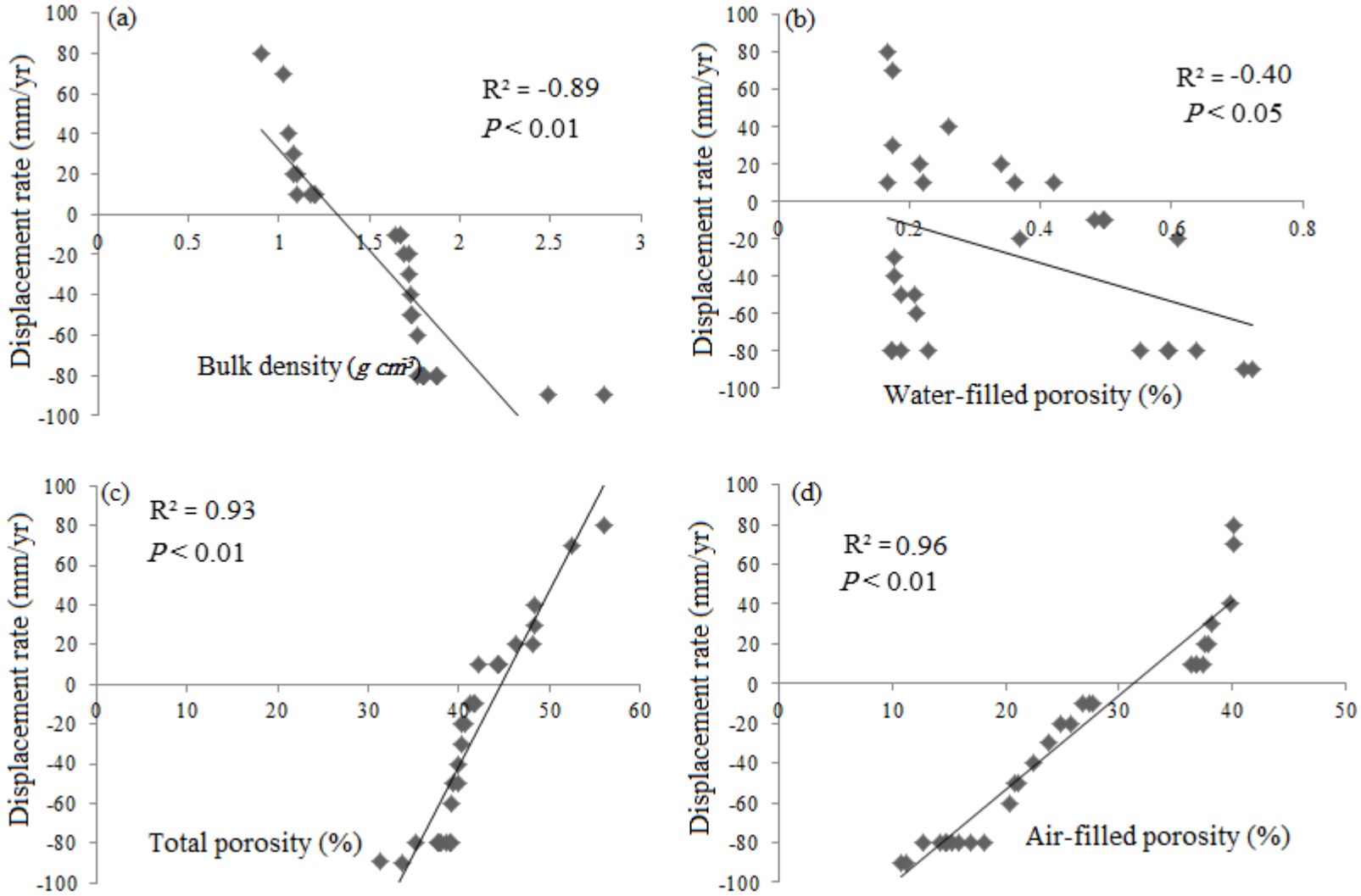
✓ Variations in the displacement rate and the development of associated ground fissures

✓ Environmental consequences of land subsidence



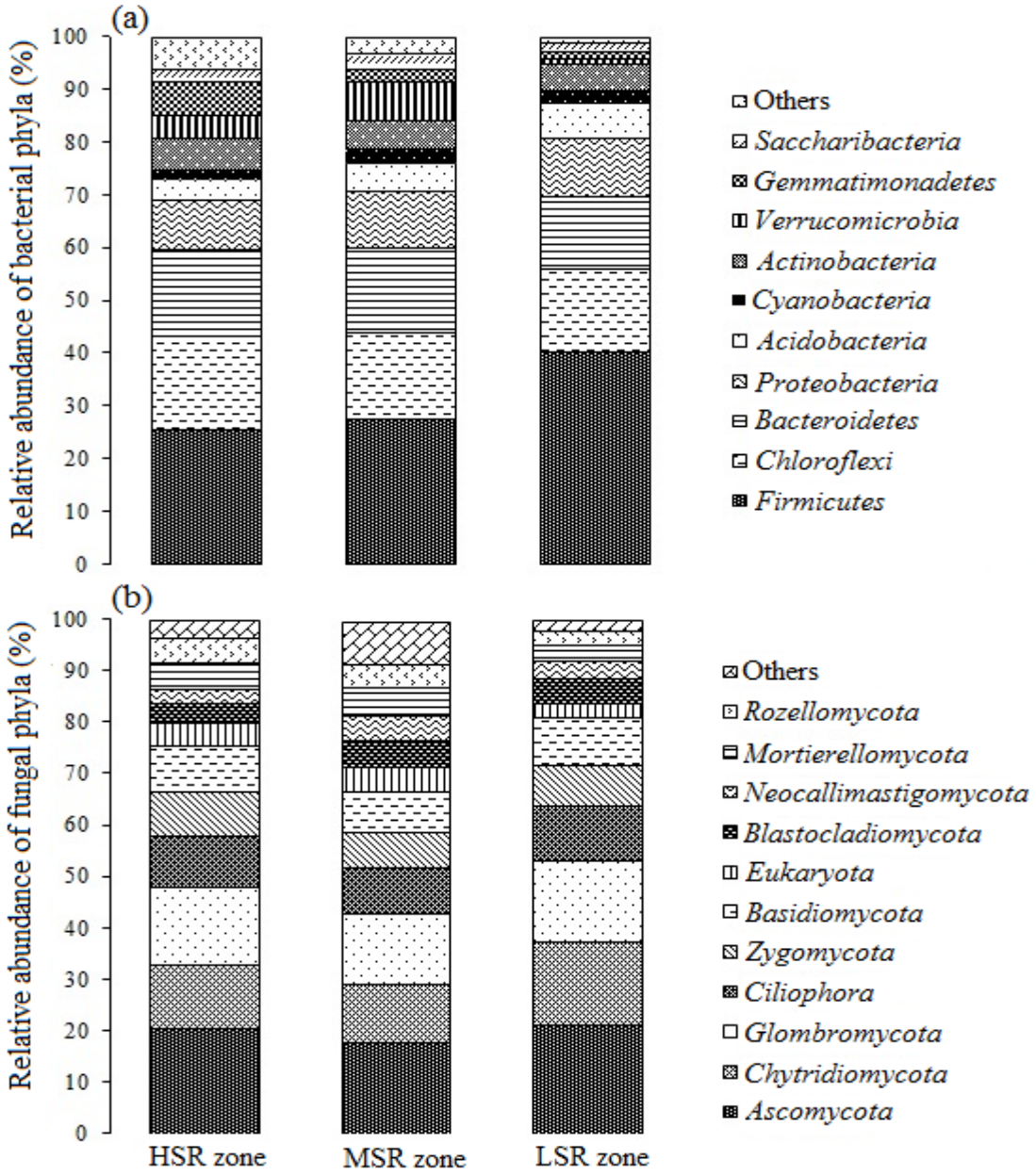
Average ground surface displacement rate (mm/yr) within three representative sites based on Sentinel SAR data

✓ Land subsidence and soil compaction

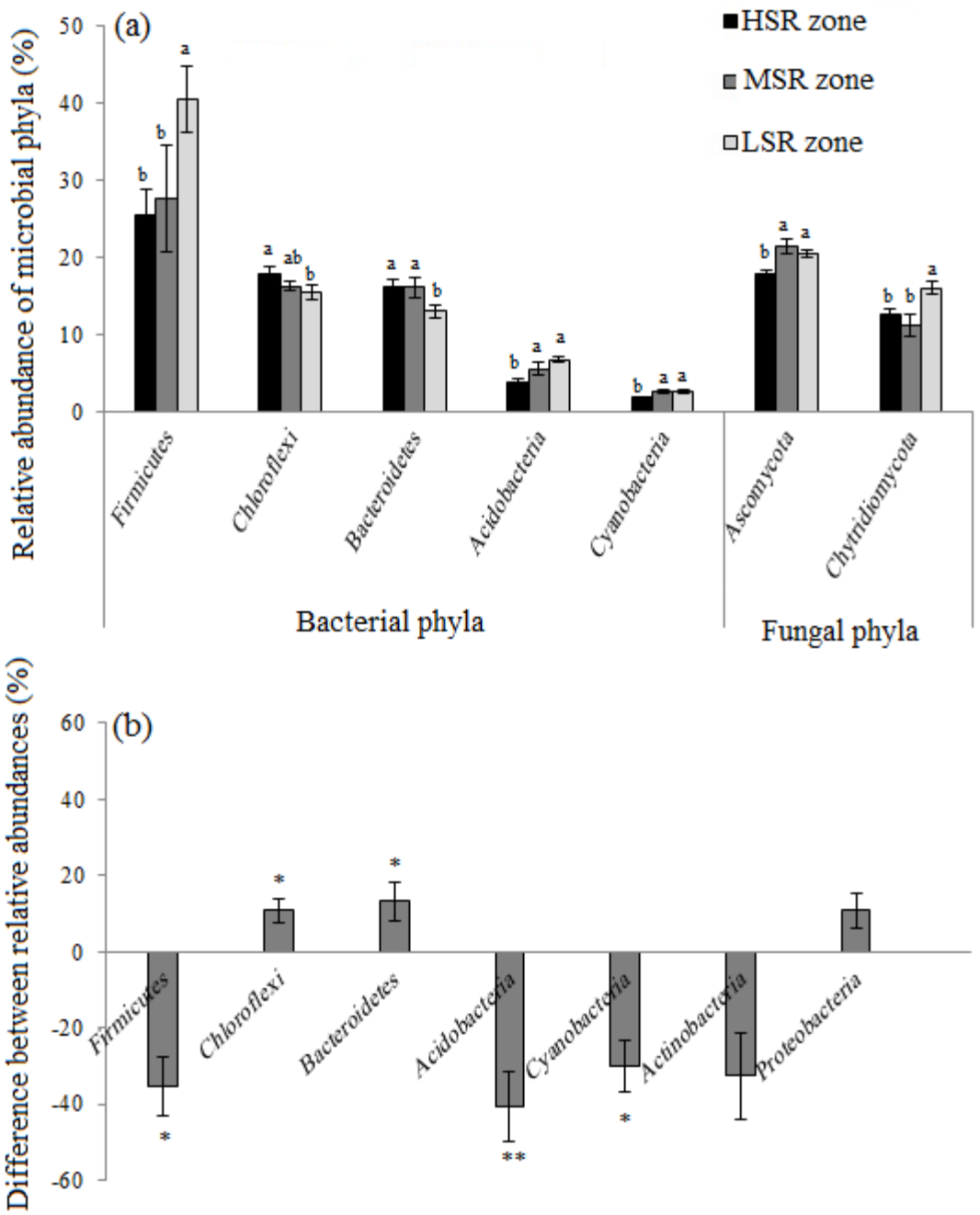


Relationship between variation in the land subsidence rate and soil compaction indicators. Note: ground surface displacement values were defined based on the value of pixels related to GPS points in the study area.

✓ Variation in the rate of land subsidence and its impact on soil biological diversity



Relative abundances of the dominant bacterial (a) and fungal (b) phyla in the zones with a high subsidence rate (HSR), moderate subsidence rate (MSR), and low subsidence rate (LSR).



(a) Relative abundances of the dominant bacterial-fungal phyla that exhibited statistically significant differences (lowercase letters) among the zones with a high subsidence rate (HSR), moderate subsidence rate (MSR), and low subsidence rate (LSR); (b) Difference percentages between the relative abundances of the aerobic and anaerobic bacterial phyla in the HSR zone compared with the LSR zone.


Thank you very much for your attention