

Supplementary Material

A Novel GIS-Based Multi-Criteria Framework for Climate-Induced Water Scarcity Assessment

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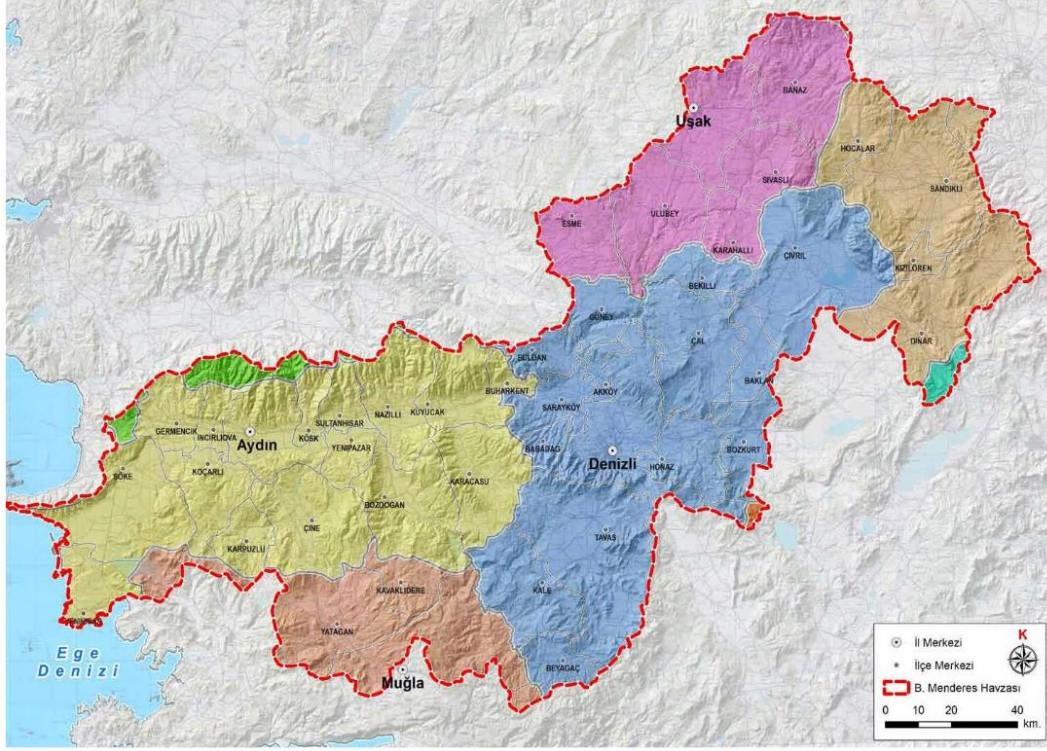


Fig. S.1 Provinces and districts within the BMB.

Table S.1. List of provinces and districts within the BMB.

Province	District	Province	District	Province	District	Province	District
Afyon	Başmakçı	Aydın	Koçarlı	Denizli	Bozkurt	İzmir	Selçuk
	Dazkırı		Köşk		Buldan		Tire
	Dinar		Kuşadası		Çal	Kütahya	Altıntaş
	Evciler		Kuyucak		Çardak		Dumlupınar
	Hocalar		Merkez		Çivril		Gediz
	Kızılören		Nazilli		Güney	Manisa	Sarıgöl
	Sandıklı		Söke		Honaz	Muğla	Kavaklıdere
	Sincanlı		Sultanhisar		Kale		Köyceğiz
	Şuhut		Yenipazar		Merkez		Merkez
Aydın	Bozdoğan	Burdur	Merkez	Isparta	Sarayköy		Milas
	Buharkent		Yeşilova		Serinhisar		Yatağan
	Çine	Denizli	Acıpayam		Tavas	Uşak	Banaz
	Didim		Akköy	İzmir	Keçiborlu		Eşme
	Germencik		Babadağ		Beydağ		Karahallı
	İncirliova		Baklan		Kiraz		Merkez
	Karacasu		Bekilli		Ödemiş		Sivaslı
	Karpuzlu		Beyağaç				

Table S.2. Importance comparison methodology for pairwise comparison of parameters.

Assigned Value	Definition
1	Parameters are of equal importance
3	Parameter x is of weak importance compared with parameter y
5	Essential or strong importance of parameter x compared with y
7	Demonstrated importance
9	Absolute importance
2, 4, 6, 8	Intermediate valued between two adjacent judgments

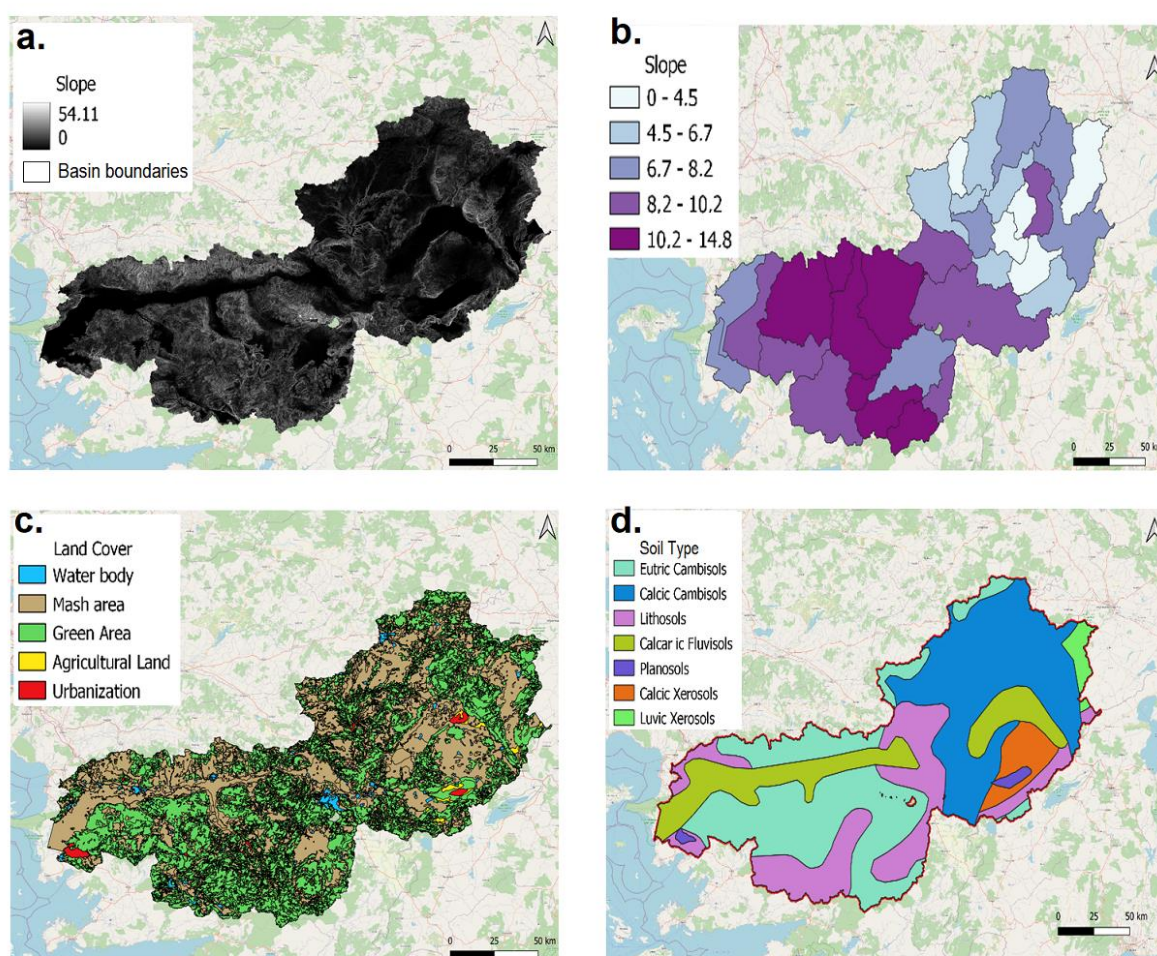


Fig. S.2. GIS-based maps of the BMB: **a.** slope, **b.** average slope at the sub-basin scale, **c.** land cover and **d.** soil type.

Table S.3. Data requirements and conversion methods.

Data	Source	Data type	Resolution	Time period	Transformation method
Climatic parameters					
Precipitation	EU Climate Data Store Portal (Copernicus) of EU Commissions (EC-Earth Consortium 2020). https://cds.climate.copernicus.eu/datasets Last accessed on: 05/09/2022	Raster	~ 30m	2050 (Daily)	Weighted mean, considering intersecting area
Temperature		Raster	~ 30m	2050 (Daily)	
Evaporation		Raster	~ 30m	2050 (Montly)	
Socio-economic parameters					
Population	TÜİK (2021)	Tabular	By District	2050 (Annual Projection)	Percentage of urban lands in the intersecting area
Water consumption per capita	TÜİK (2021), Graham et al. (2018)	Tabular	By District	2050 (Daily)	Weighted mean, considering intersecting area
Agricultural water demand	TÜİK (2021), Water to Food (CWASI)	Tabular	By District	2050 (Seasonal / Monthly)	Percentage of agricultural lands in the intersecting area
Livestock number	TÜİK (2021), Graham et al. (2018)	Tabular	By District	2050 (Projected)	Percentage of green lands in the intersecting area
Tourism, number of beds	TÜİK (2021)	Tabular	By District	2021 (Annual)	Percentage of urban lands in the intersecting area
Industry, percentages of industries	Provincial Industrial Due Diligence Report (Republic of Türkiye Ministry of Industry and Technology 2014)	Tabular	By Province	2013 (Annual)	Weighted mean, considering intersecting area
Infrastructural parameters					
Percentage of population receiving water supply service	Province based environmental due diligence reports (Republic of Türkiye Ministry of Environment and Urbanization 2016)	Tabular	By Province	2020 (Annual)	Weighted mean, considering intersecting area
Percentage of population receiving wastewater treatment service		Tabular	By Province	2020 (Annual)	
Water level in dams and impact area	State Hydraulic Works (DSI) (Republic of Türkiye Ministry of Agriculture and	Tabular	By Reservoir	2017 (Monthly)	

	Forestry, General Directorate of State Hydraulic Works 2021)				
Geographical parameters					
Soil type	FAO Digital Soil Map of World	Vector	1:5,000,000 (Scale)	2007	Conversion to 30m raster
Land Cover	CORINE Land Cover Map (EEA 2018)	Vector	100 m (MMU)	2018	

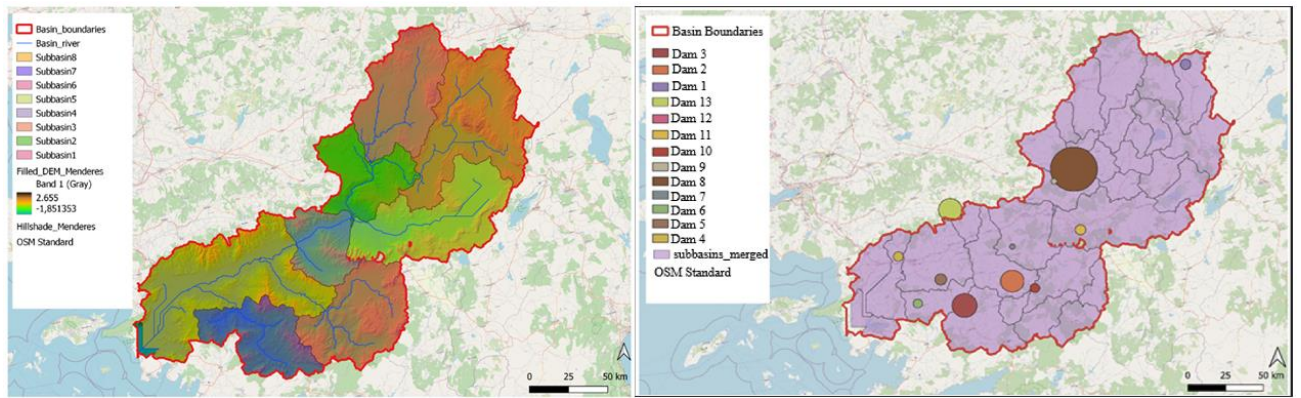


Fig. S.3. a. Main sub-basins of the BMB b. Location of dams and intersections with sub-basins.

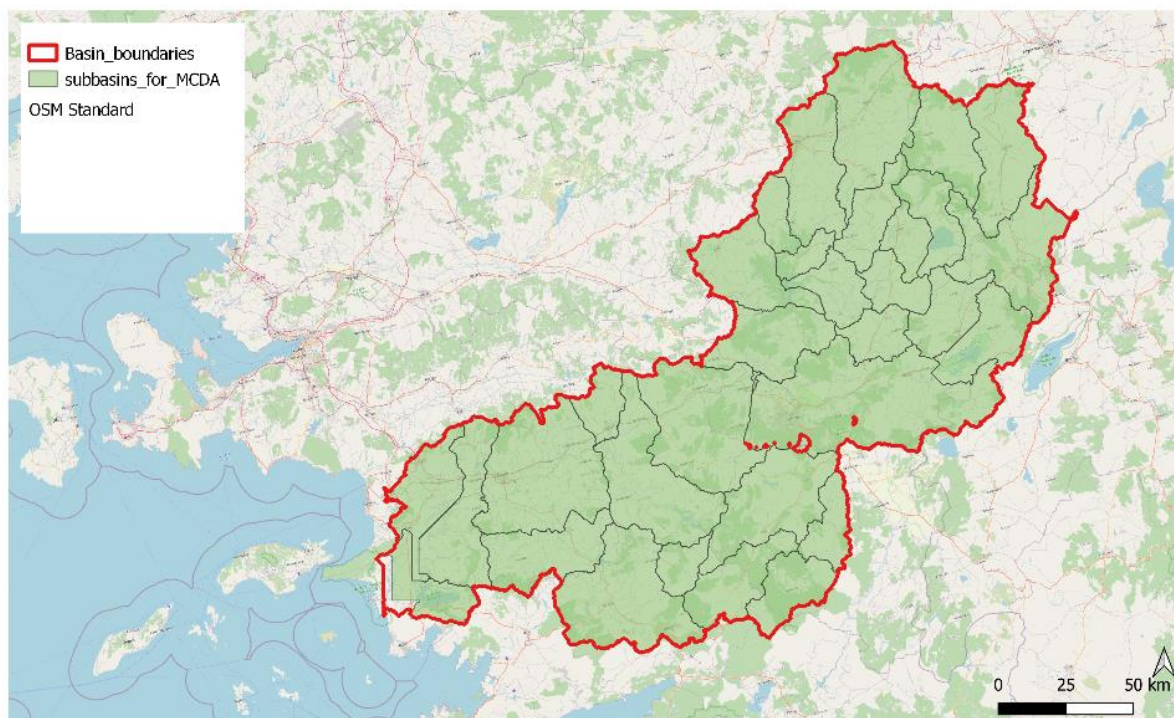


Fig. S.4. Smallest sub-basins within the BMB generated to be used in MCDA.

Table S.4. Water consumption per person raw data.

Province	L/day-capita
Afyon	227
Aydın	188
Burdur	220
Denizli	207
Isparta	226
Kütahya	211
Manisa	156
Muğla	364
Uşak	183
İzmir	192

Table S.5. An example of intersection analysis performed for converting land cover data to sub-basin scale.

Sub-basin	Land Cover Type	Area (m ²)	Rank	Average permeability rank
S13	Water body	74,74122623	1	3.97
	Mash area	21516,93159	4	
	Green area	195,2364736	2	
	Agricultural land	336,5308116	3	
	Urbanization	181,4998389	5	
S18	Water body	53,90903251	1	2.72
	Mash area	4130,210651	4	
	Green area	7231,257241	2	
	Agricultural land		3	
	Urbanization		5	

Table S.6. *RI* indices and matrix sizes.

Size	1	2	3	4	5	6	7	8	9	10
<i>RI</i>	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Table S.7. Pairwise comparison table for climatic water scarcity risk assessment.

	Evaporation	Temperature	Precipitation
Evaporation	1	3.0	0.333
Temperature	0.333	1	0.2
Precipitation	3	5.0	1

Table S.8. Pairwise comparison matrix used for socio-economic water scarcity risk assessment.

	Agricultural water use	Domestic water use	Population density	Livestock	Tourism activities	Industrial activities
Agricultural water use	1	3.0	3.0	7.0	5.0	5.0
Domestic water use	0.333	1	2.0	5.0	3.0	3.0
Population density	0.333	0.5	1	5.0	3.0	3.0
Livestock	0.143	0.2	0.2	1	0.333	0.333
Tourism activities	0.2	0.333	0.333	3.0	1	2.0
Industrial activities	0.2	0.333	0.333	3.0	0.5	1

Table S.9. Pairwise comparison matrix used for industrial water scarcity risk assessment

	Food	Chemicals	Textile	Mining	Leather
Food	1	0.333	0.2	0.111	0.2
Chemicals	3.0	1	0.333	0.2	0.333
Textile	5.0	3.0	1	0.333	2.0
Mining	9.0	5.0	3.0	1	3.0
Leather	5.0	3.0	0.5	0.333	1

Table S.10. Pairwise comparison matrix generated for geographical water scarcity risk assessment.

	Land Cover	Soil type	Average slope
Land Cover	1	0.2	0.333
Soil type	5	1	3
Average slope	3	0.333	1

Table S.11. Pairwise comparison matrix for infrastructural water scarcity risk assessment

	Water availability in dams	% Population getting water supply service	% Population getting WWT service
Water availability in dams	1	5.0	3.0
% Population getting water supply service	0.2	1	0.333
% Population getting WWT service	0.333	3.0	1

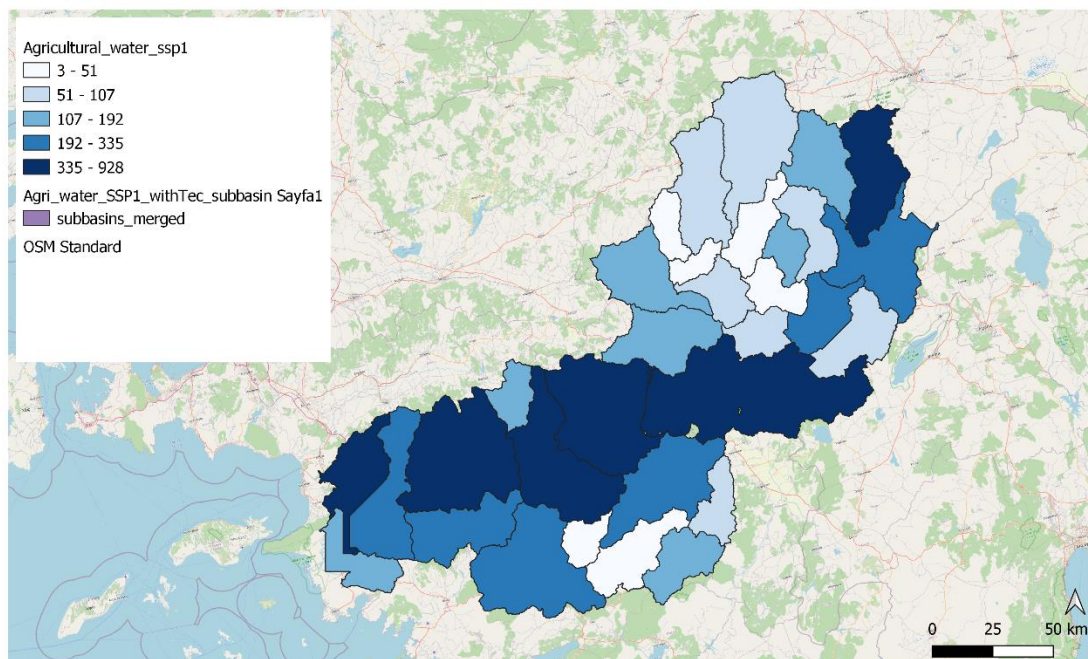


Fig. S.5. Agricultural water demand for SSP1-1.9

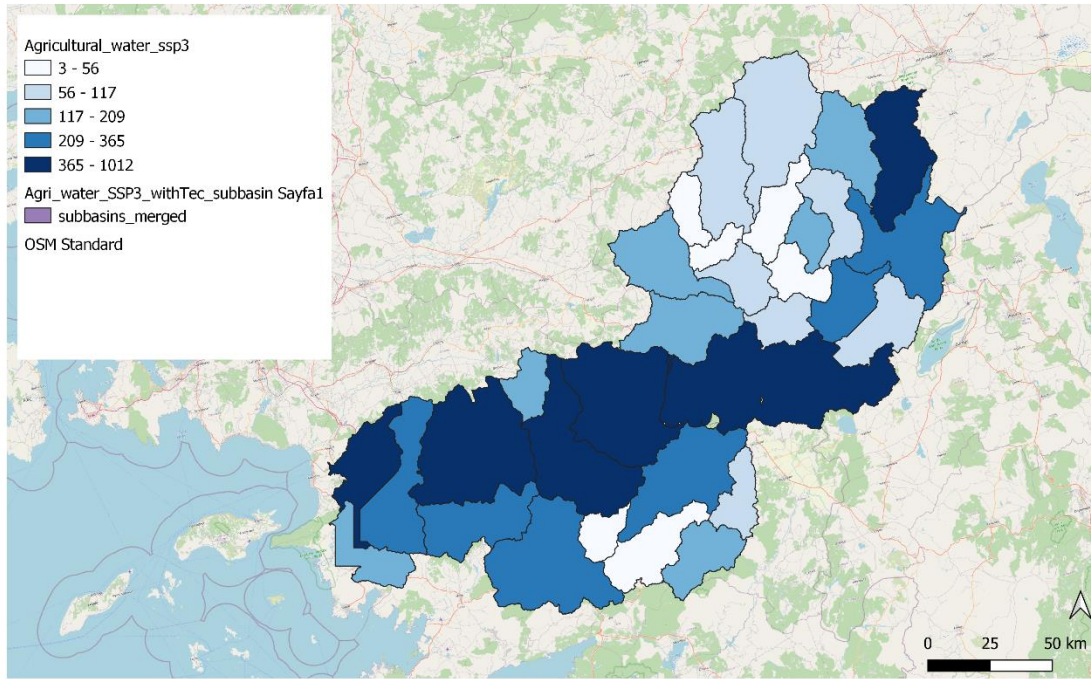


Fig. S.6. Agricultural water demand for SSP3-2.6

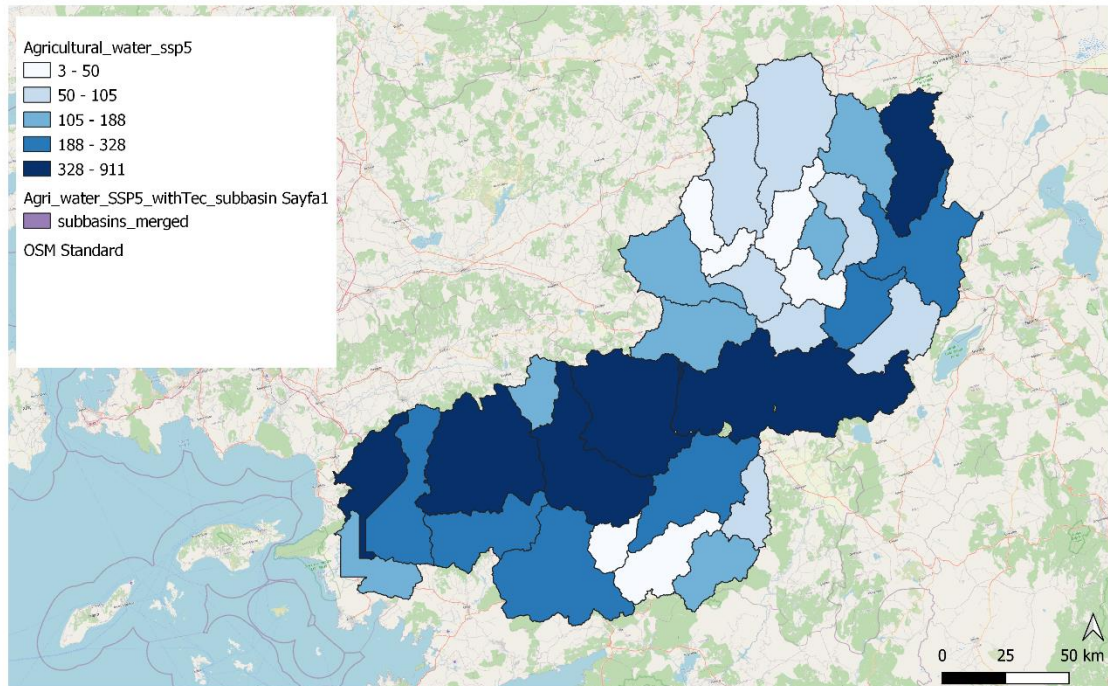


Fig. S.7. Agricultural water demand for SSP5-8.5

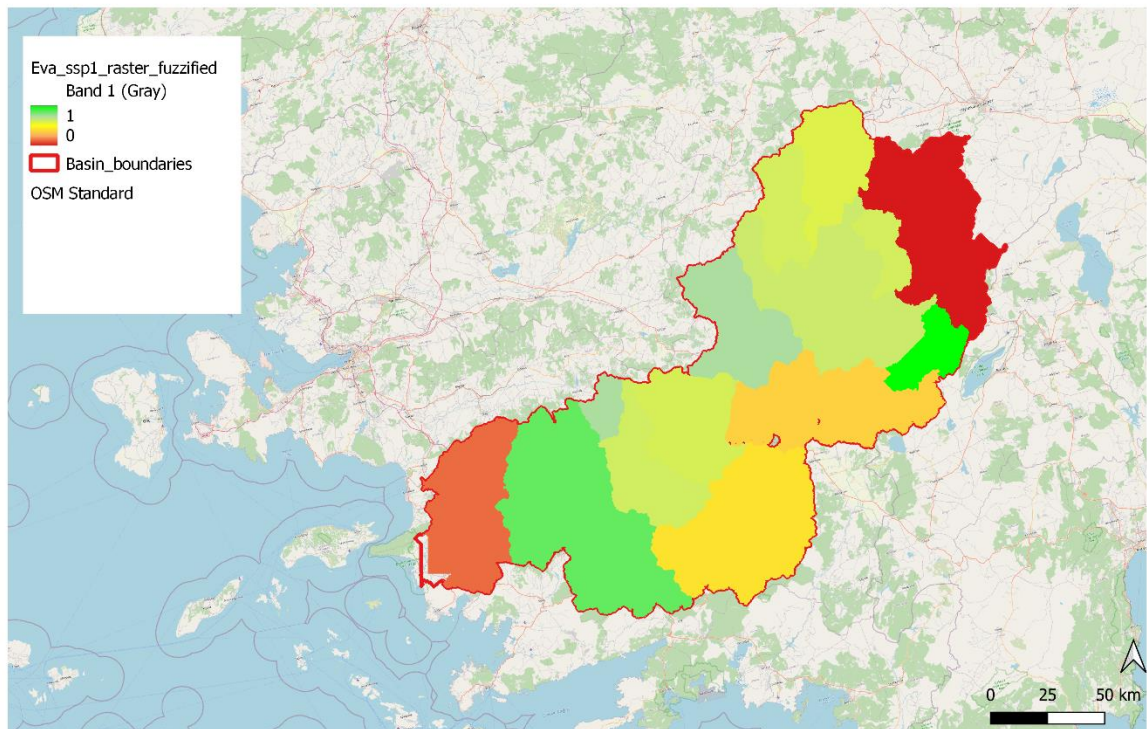


Fig. S.8. Fuzzified map for evaporation induced water scarcity risk for SSP1-1.9.

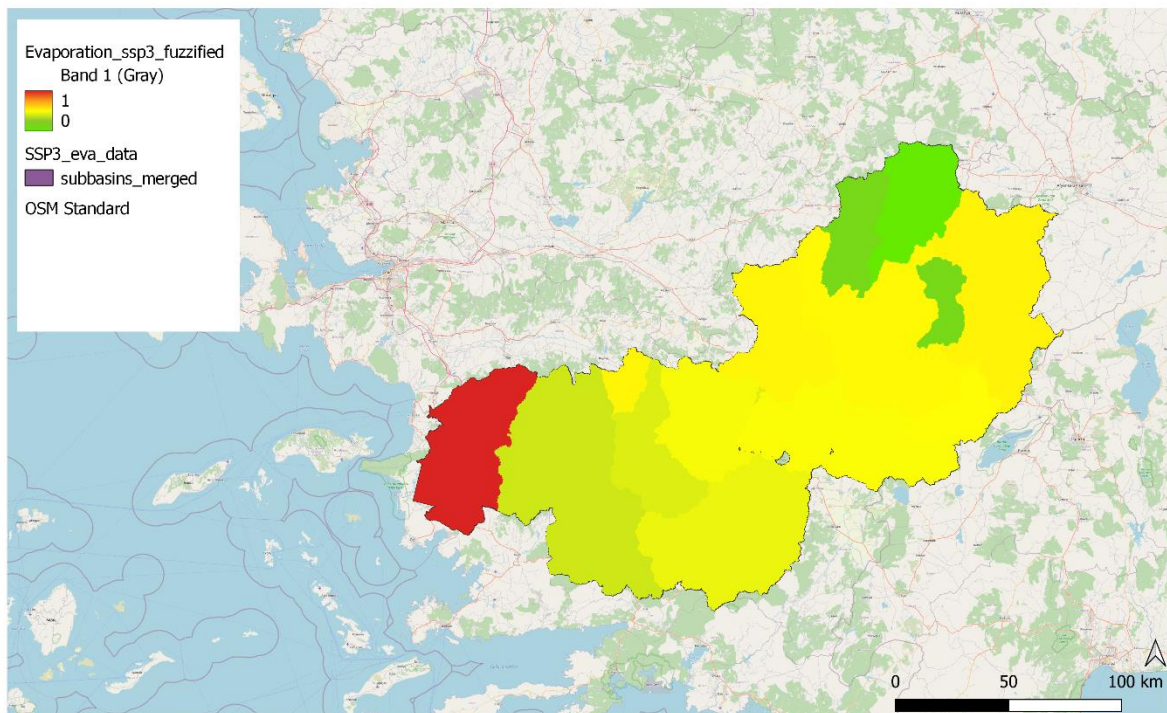


Fig. S.9. Fuzzified map for evaporation induced water scarcity risk for SSP3-2.6.

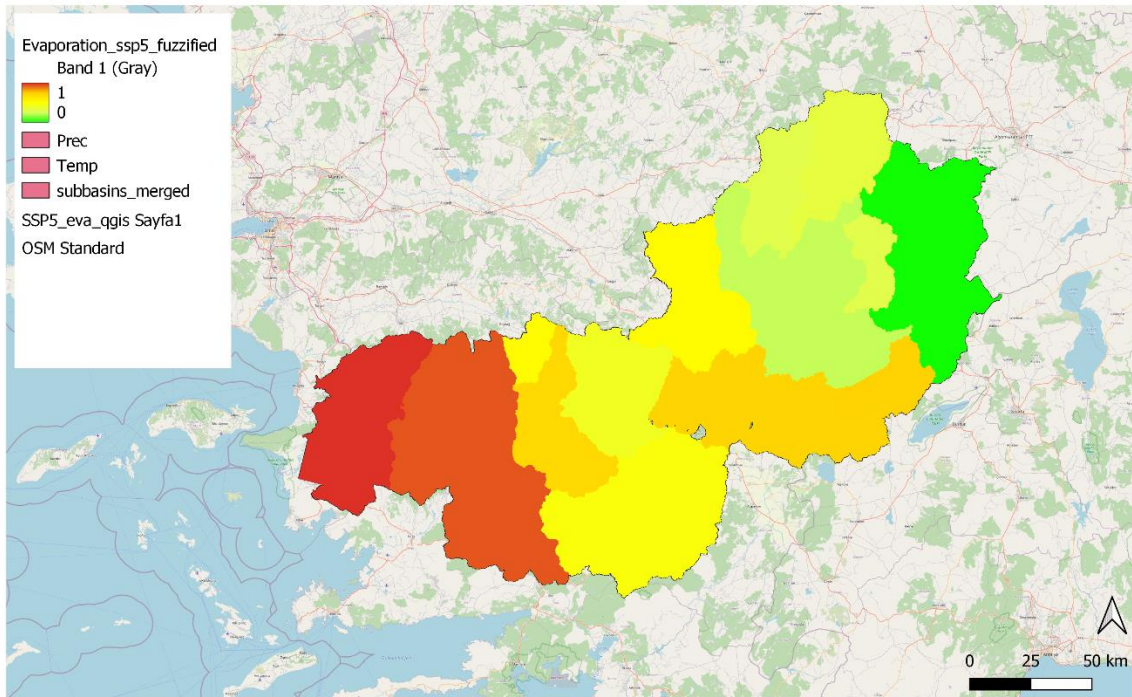


Fig. S.10. Fuzzified map for evaporation induced water scarcity risk for SSP5-8.5.

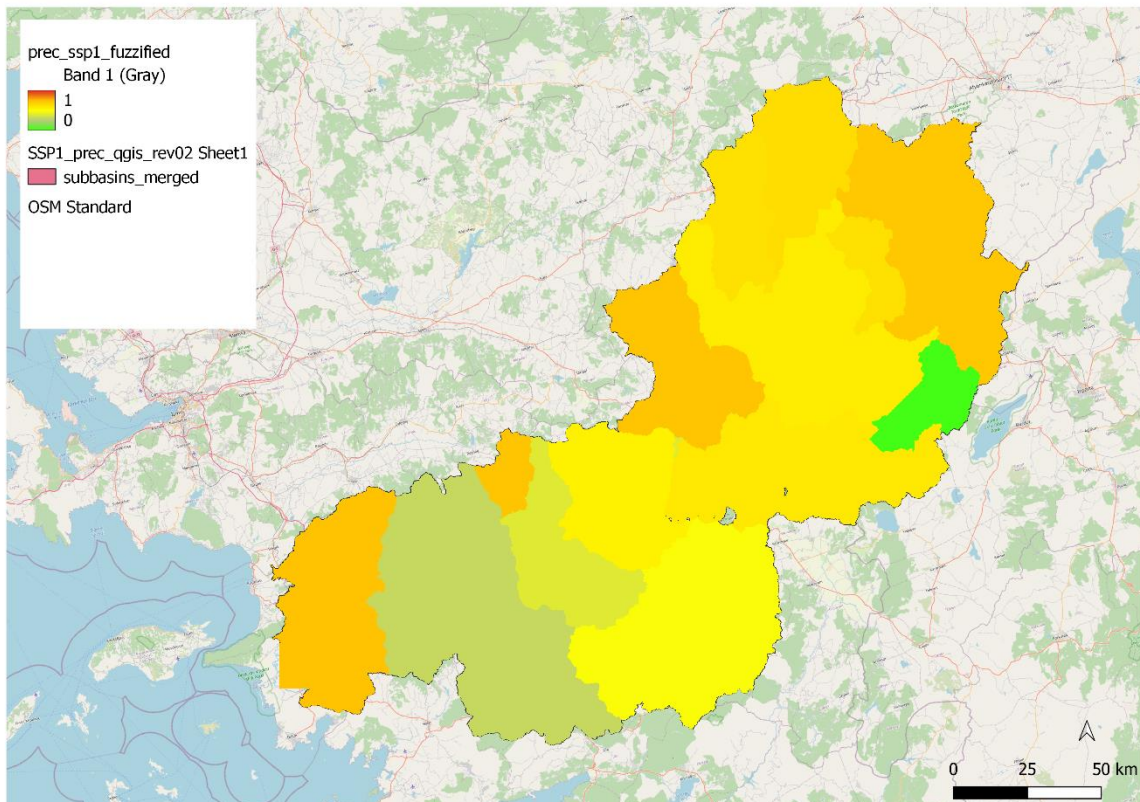


Fig. S.11. Fuzzified map for precipitation induced water scarcity risk for SSP1-1.9.

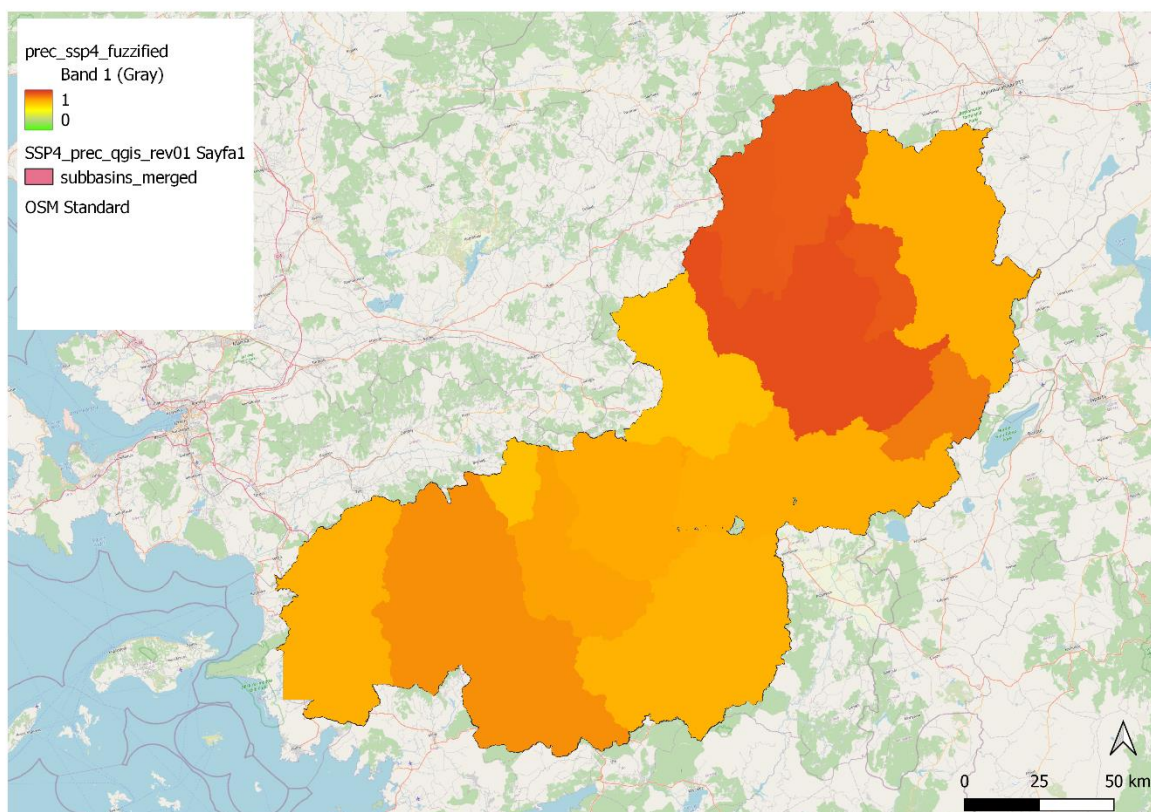


Fig. S.12. Fuzzified map for precipitation induced water scarcity risk for SSP3-2.6.

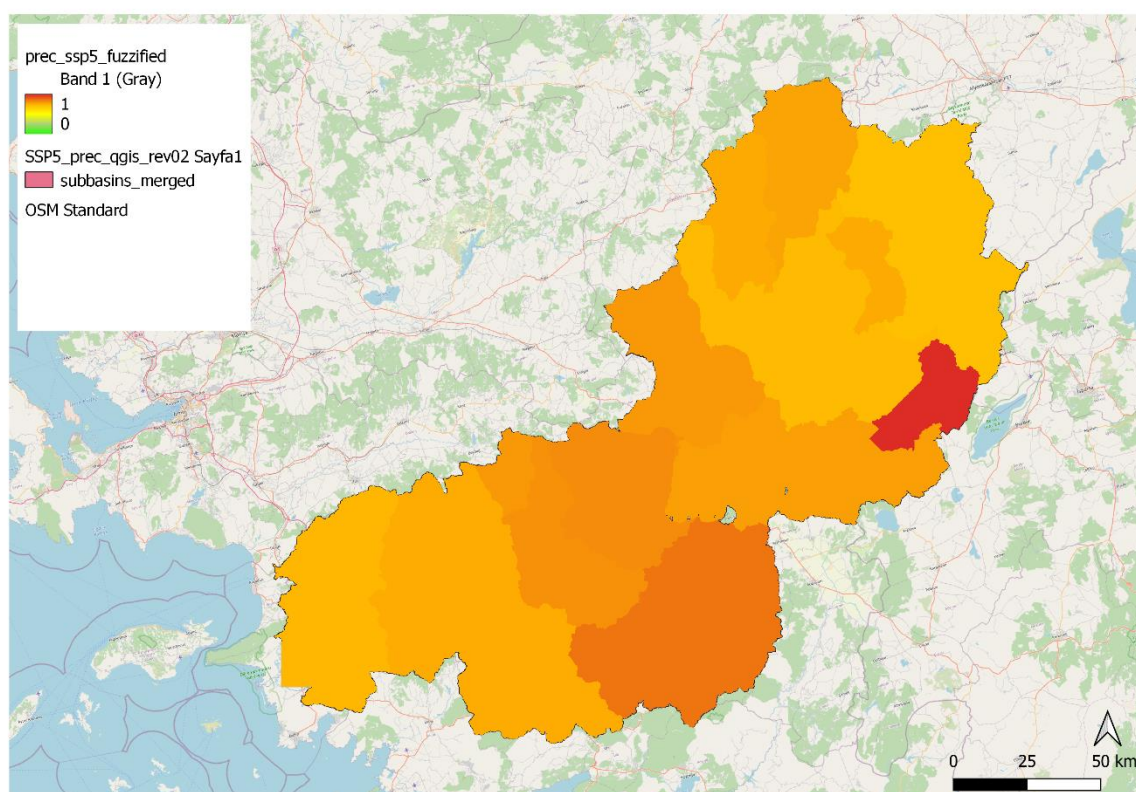


Fig. S.13. Fuzzified map for precipitation induced water scarcity risk for SSP5-8.5.

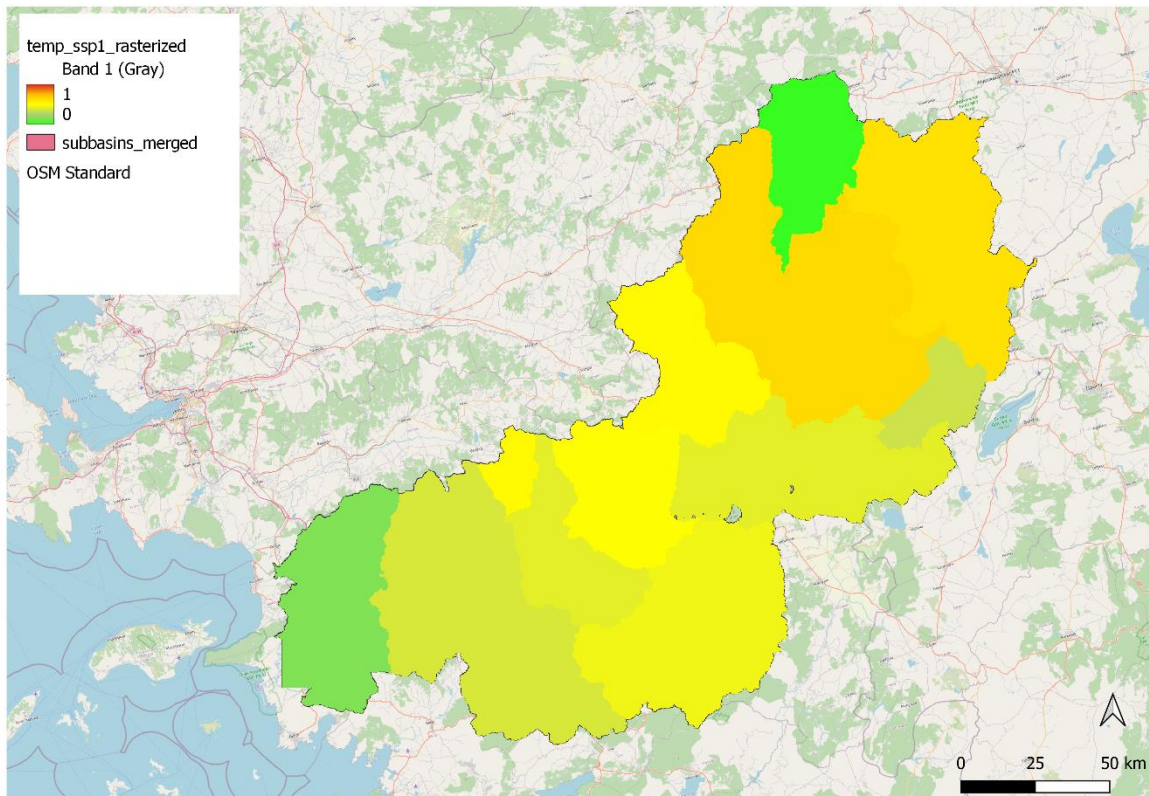


Fig. S.14. Fuzzified map for temperature induced water scarcity risk for SSP3-2.6.

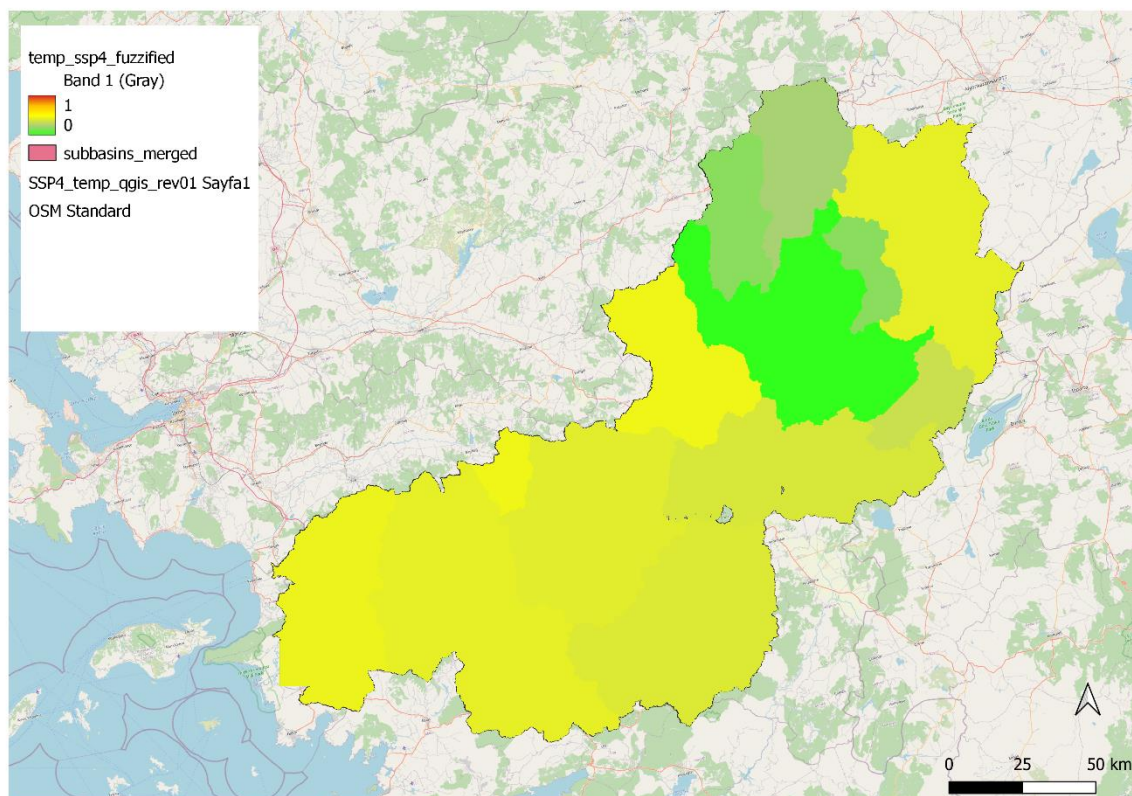


Fig. S.15. Fuzzified map for temperature induced water scarcity risk for SSP5-8.5.

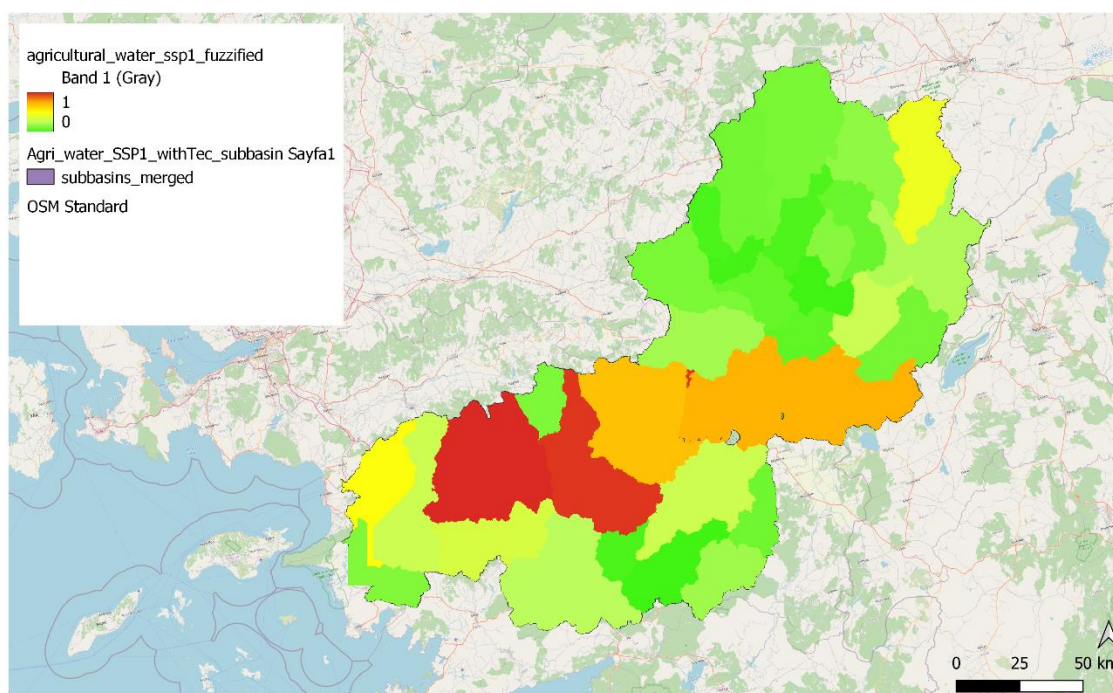


Fig. S.16. Fuzzified map for agricultural water demand in 2050 for SSP1-1.9.

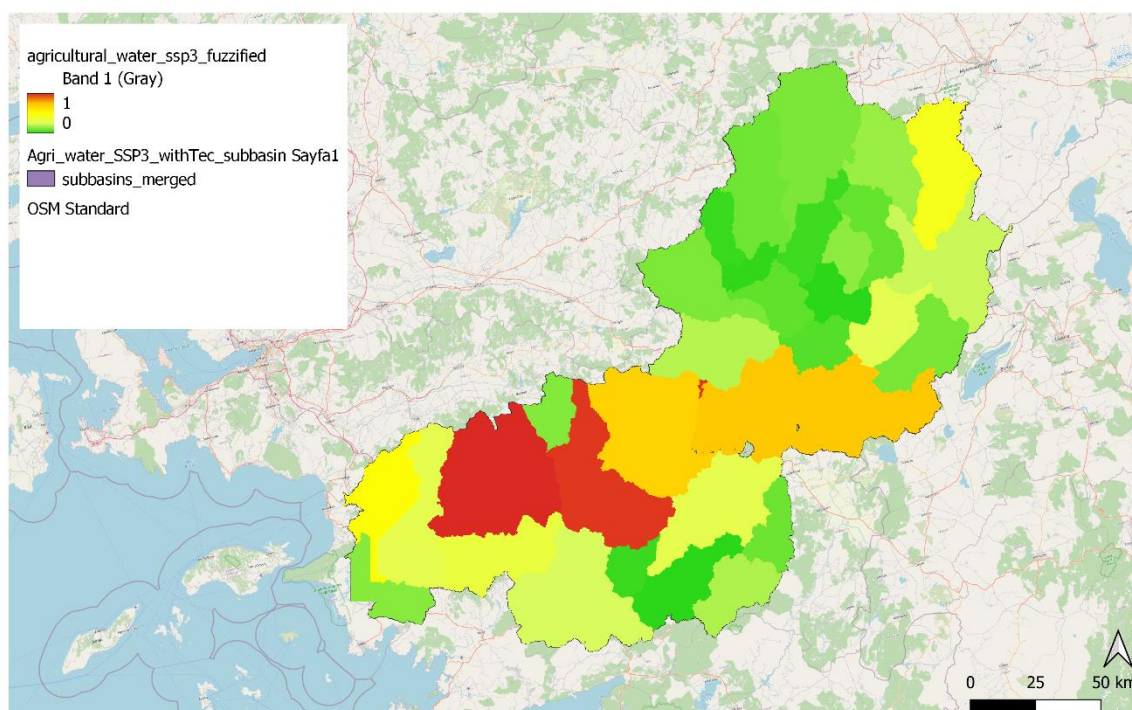


Fig. S.17. Fuzzified map for agricultural water demand in 2050 for SSP3-2.6.

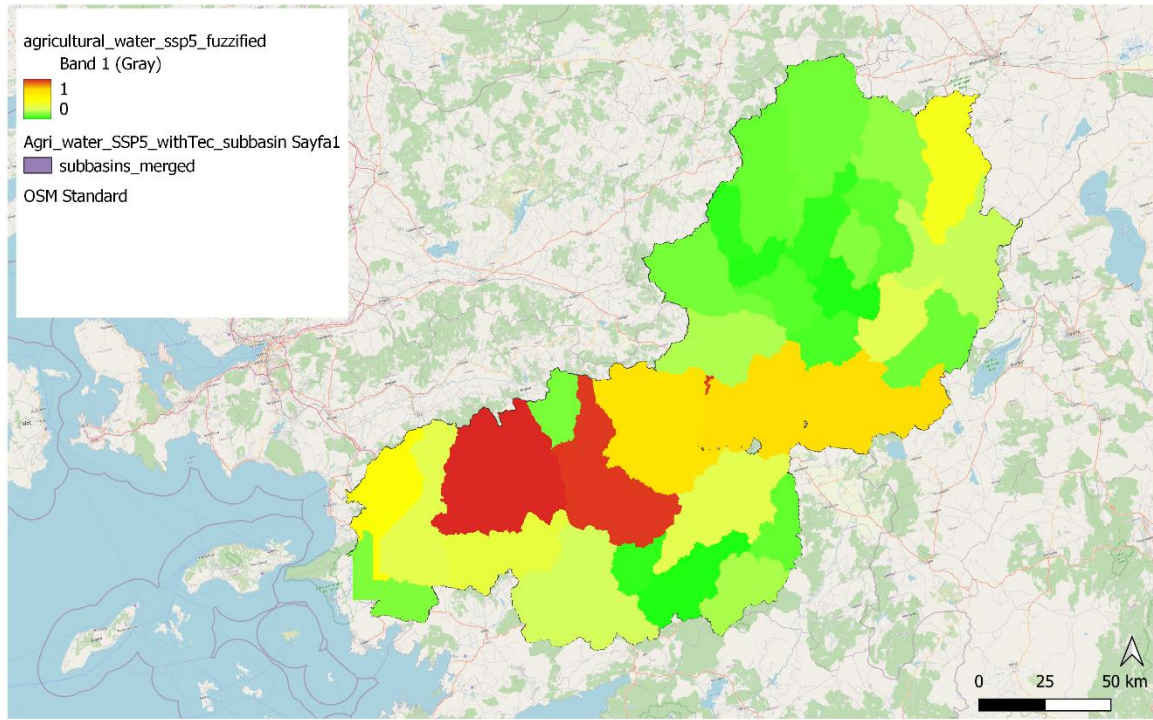


Fig. S.18. Fuzzified map for agricultural water demand in 2050 for SSP5-8.5.

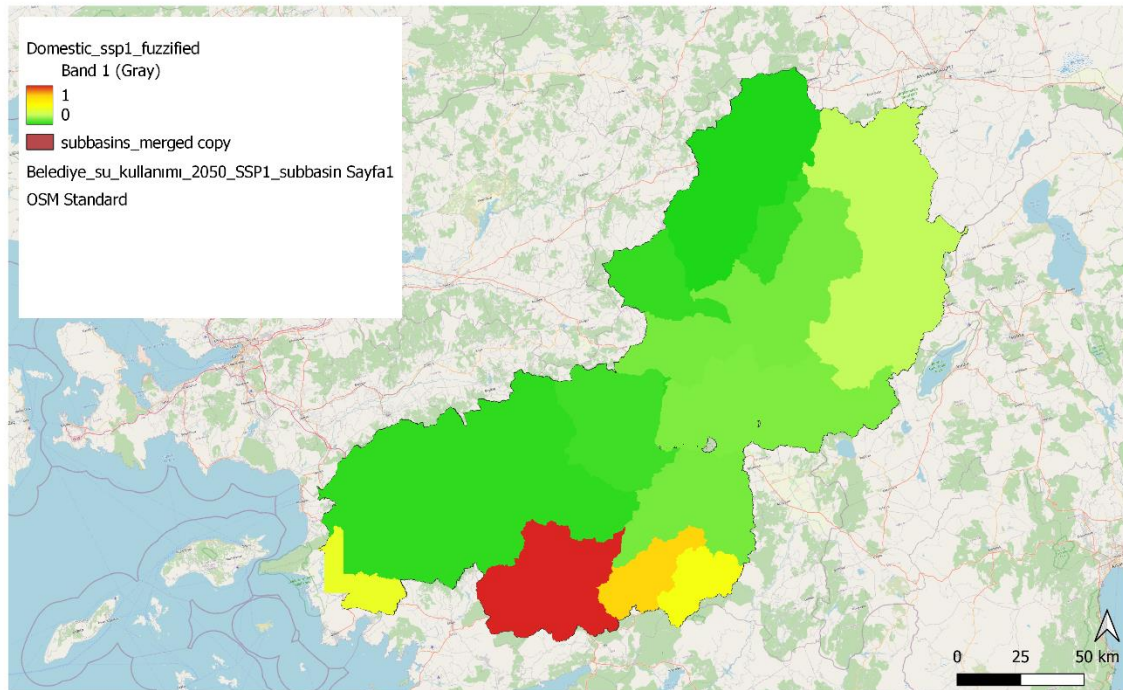


Fig. S.19. Fuzzified map for domestic water demand in 2050 for SSP1-1.9.

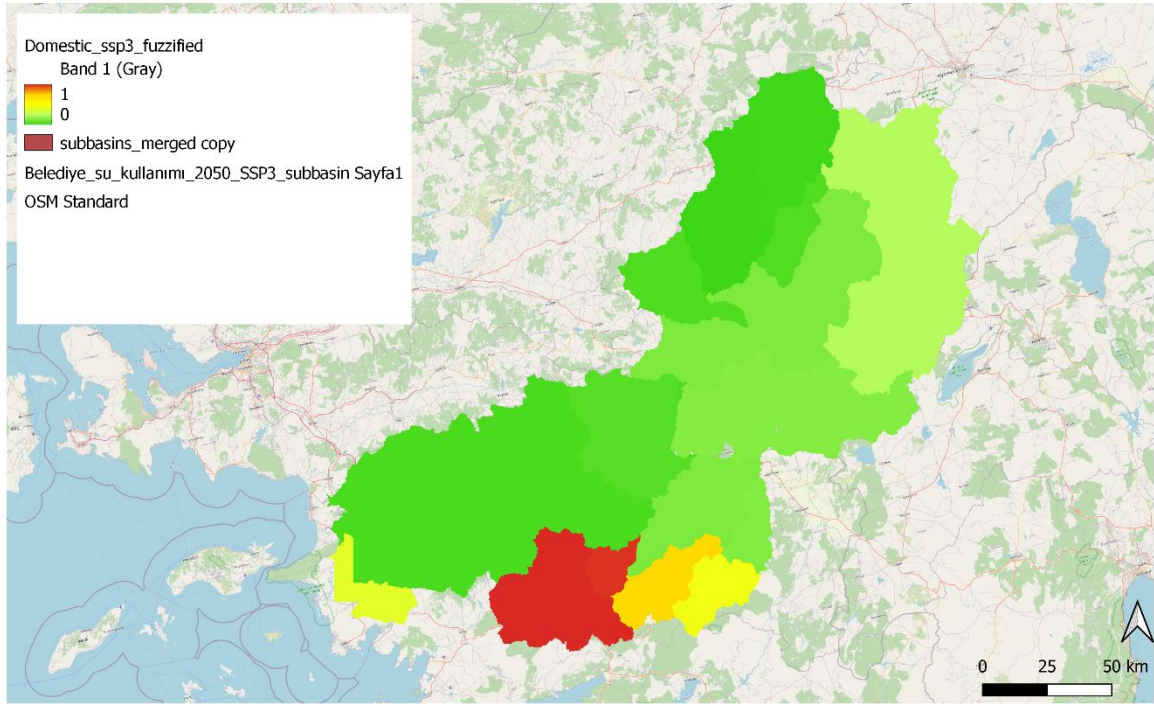


Fig. S.20. Fuzzified map for domestic water demand in 2050 for SSP3-2.6.

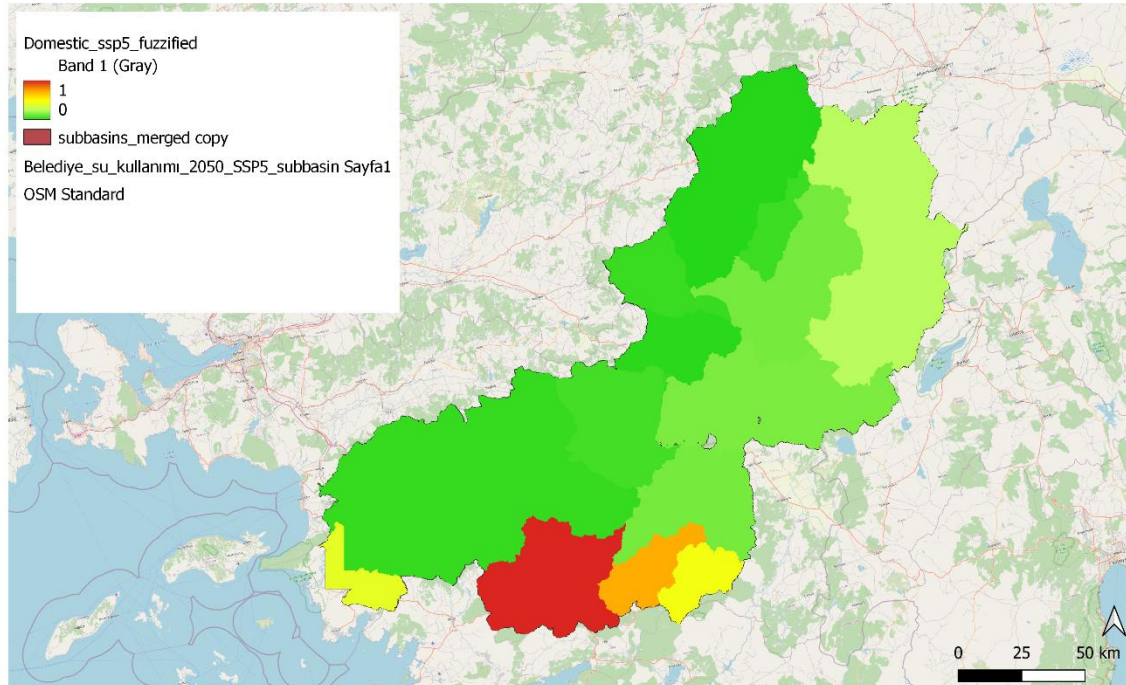


Fig. S.21. Fuzzified map for domestic water demand in 2050 for SSP5-8.5.

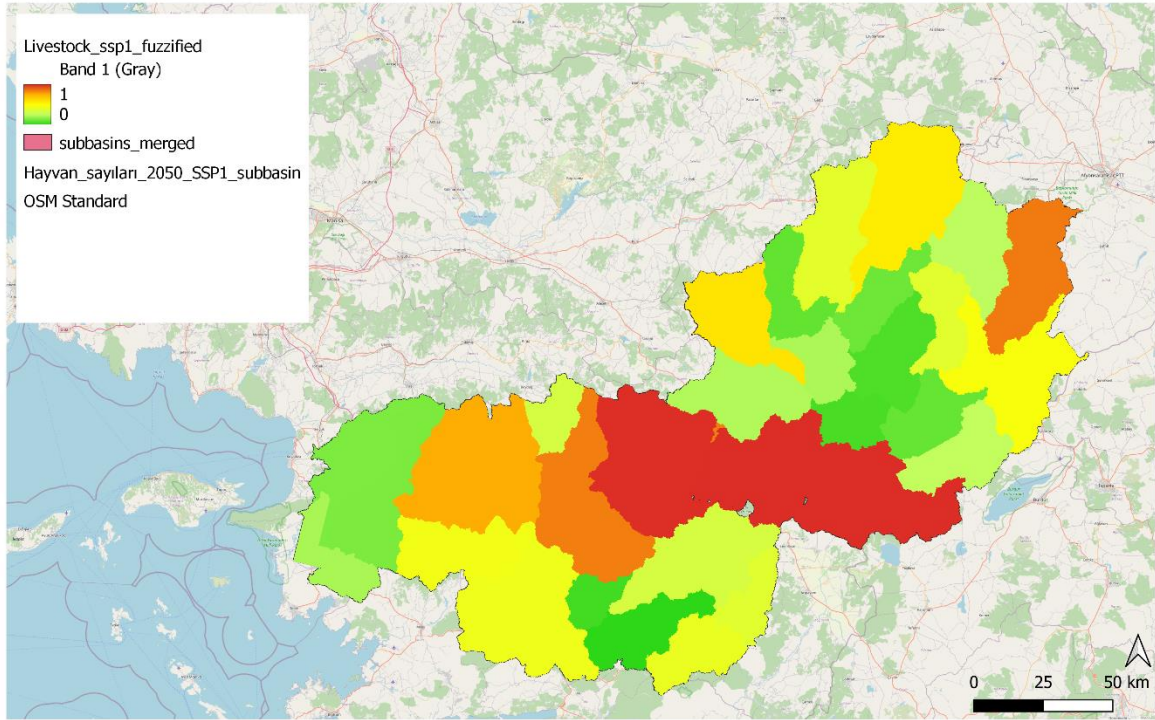


Fig. S.22. Fuzzified map for livestock numbers in 2050 for SSP1-1.9.

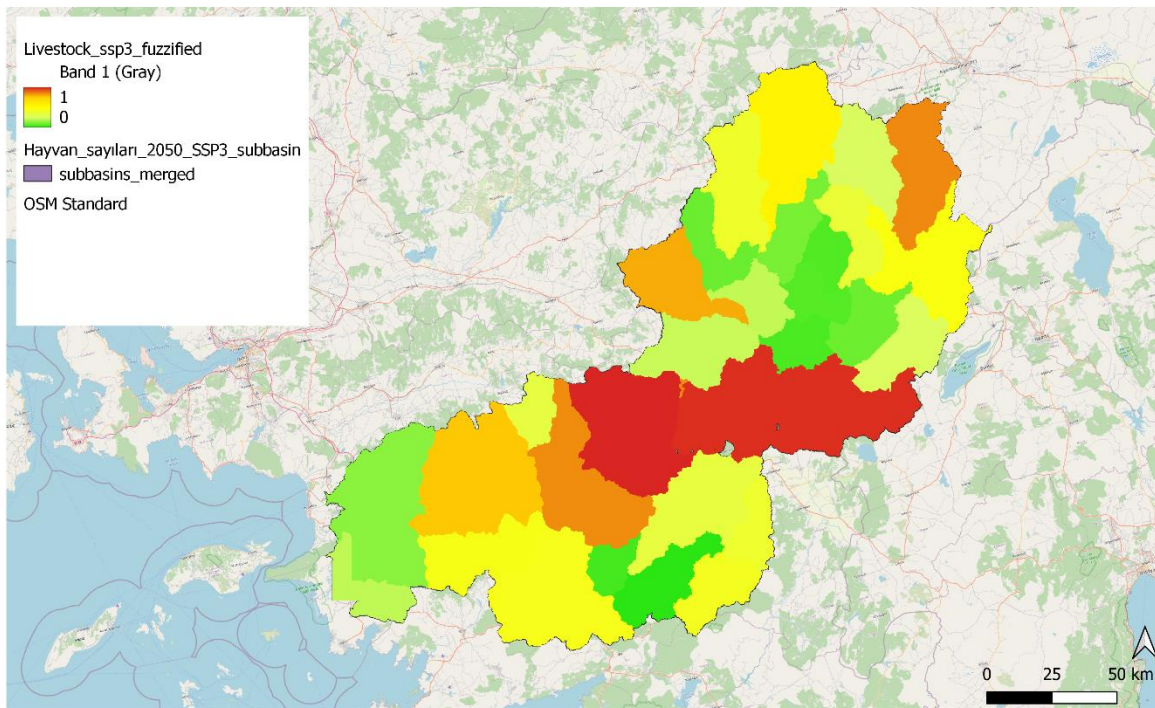


Fig. S.23. Fuzzified map for livestock numbers in 2050 for SSP3-2.6.

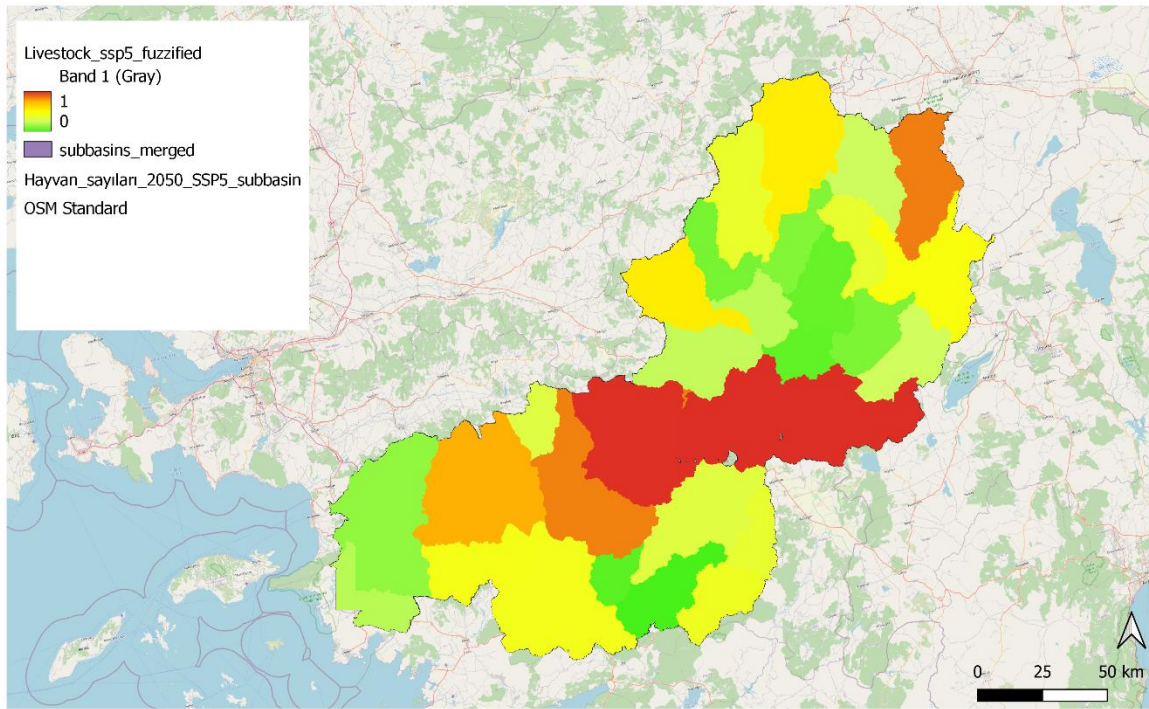


Fig. S.24. Fuzzified map for livestock numbers in 2050 for SSP5-8.5.

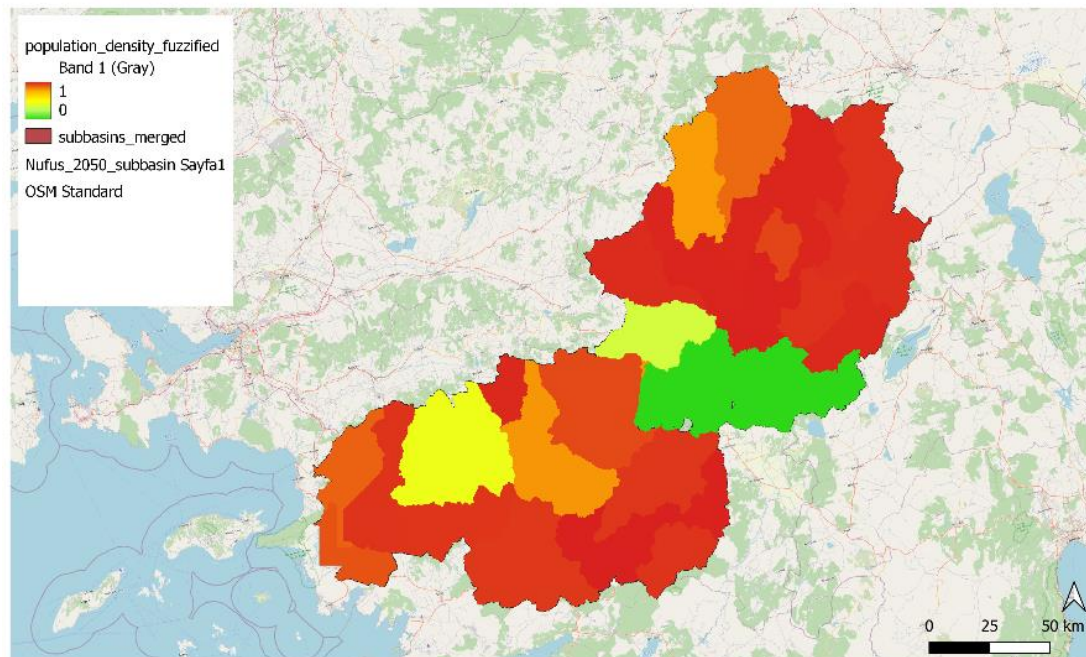


Fig. S.25. Fuzzified population density map in sub-basin level for 2050.

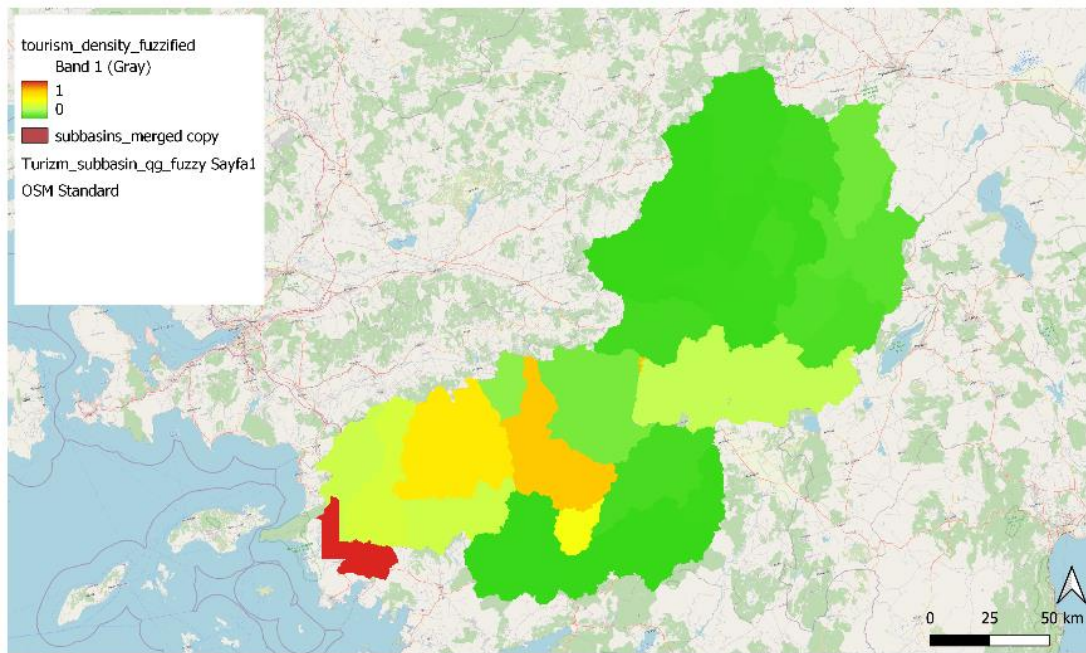


Fig. S.26. Fuzzified map for tourism activity density at sub-basin level.

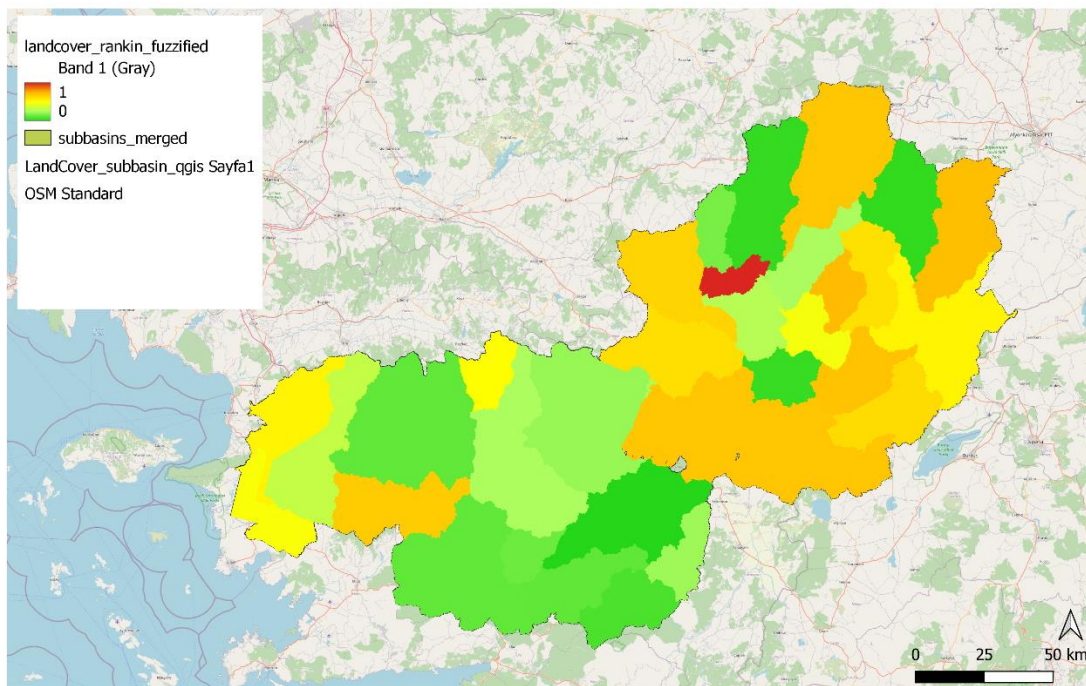


Fig. S.27. Fuzzified map for land cover type induced water scarcity.

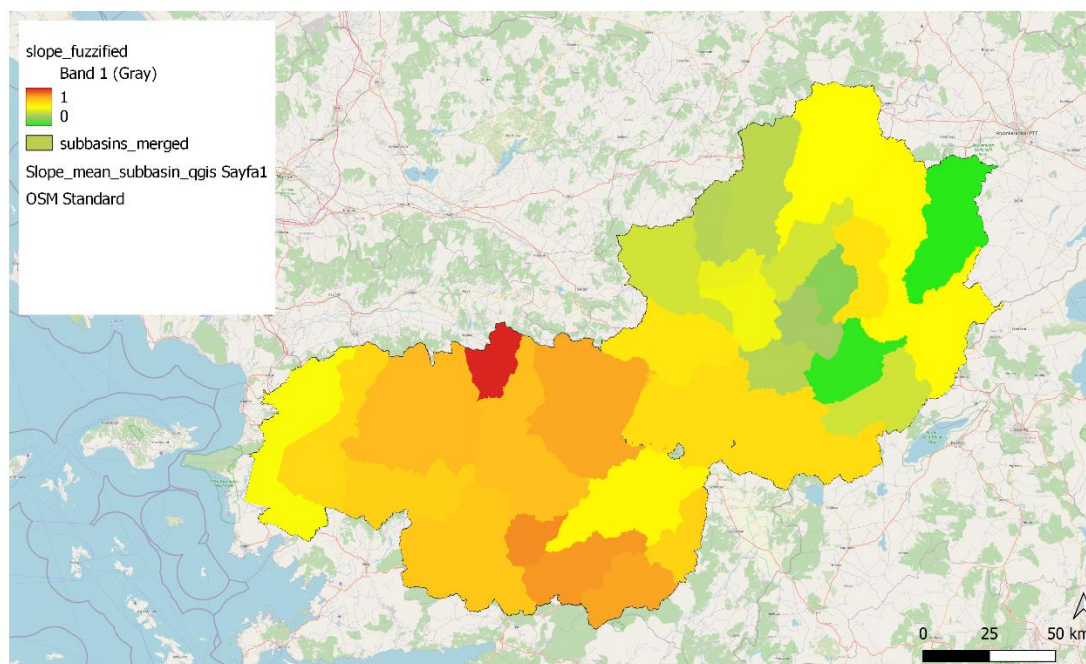


Fig. S.28. Fuzzified map for slope induced water scarcity.

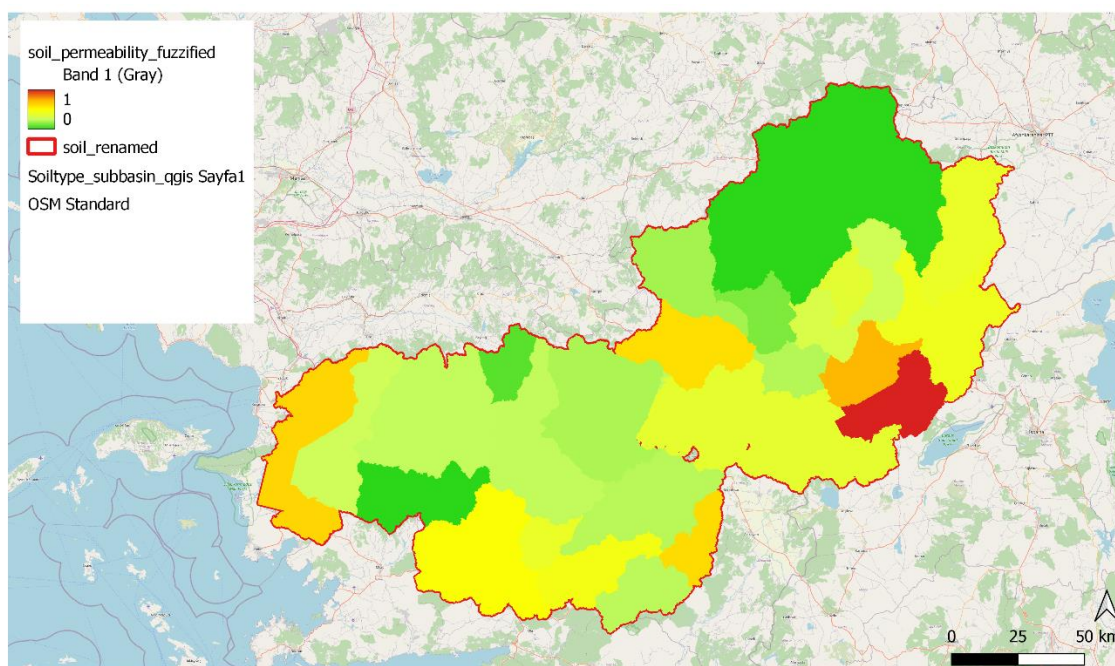


Fig. S.29. Fuzzified map for soil type induced water scarcity.

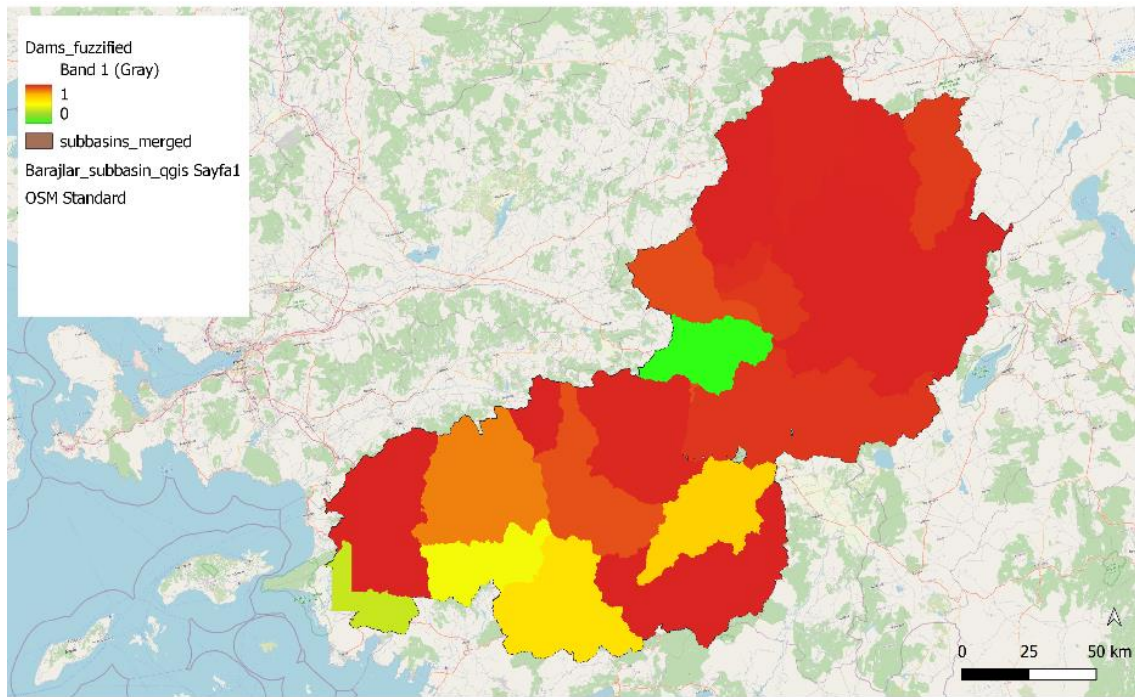


Fig. S.30. Fuzzified map for available water levels in dams within the basin boundaries.

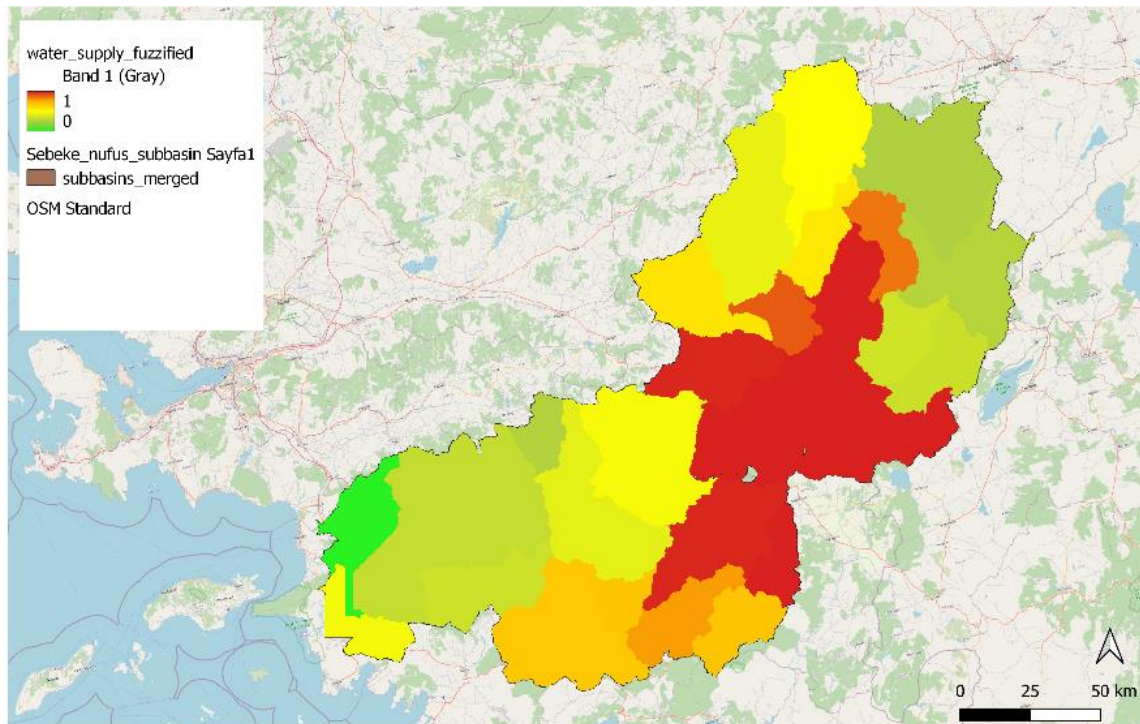


Fig. S.31. Fuzzified map for % of population receiving water supply services in sub-basin level.

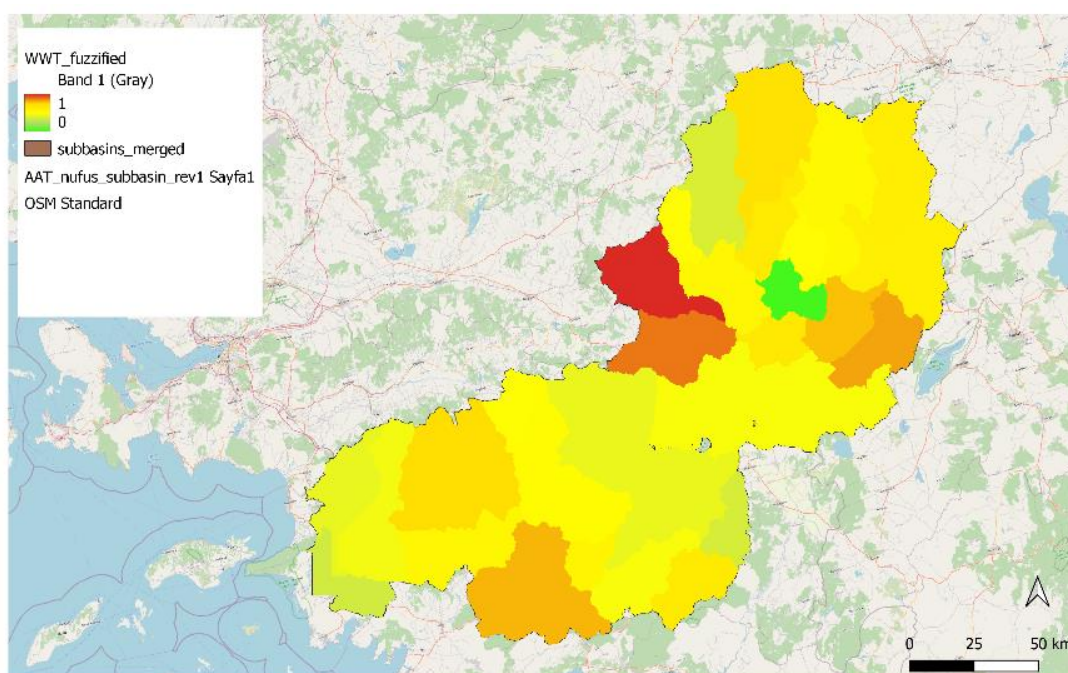


Fig. S.32. Fuzzified map for % of population receiving wastewater treatment services at sub-basin level.

References

EC-Earth Consortium (2020) EU Climate Data Store Portal (Copernicus) of EU Commissions. <https://cds.climate.copernicus.eu/datasets>. Accessed 5 September 2022

EEA (2018) Environmental indicator report 2018 – in support to the monitoring of the seventh environment action programme. Publications Office. <https://data.europa.eu/doi/10.2800/180334>. Accessed 10 March 2026

Graham NT, Davies EGR, Hejazi MI et al (2018) Water sector assumptions for the Shared Socioeconomic Pathways in an integrated modeling framework. *Water Resour Res* 54:6423–6440. <https://doi.org/10.1029/2018WR023452>

Republic of Turkey Ministry of Agriculture and Forestry, General Directorate of State Hydraulic Works (2021) DSI 2020 Annual Report. <https://cdniys.tarimorman.gov.tr/api/File/GetFile/425/KonuIcerik/759/1107/DosyaGaleri/DS%C4%B0%202020-yili-faaliyet-raporu.pdf>. Accessed 2 November 2021

Republic of Türkiye Ministry of Environment and Urbanization (2016) Büyük Menderes River Basin Draft Management Plan WFD Pilot Project Strategic Environmental Assessment Report. https://webdosya.csb.gov.tr/db/scd/menu/buyuk-menderes-nehir-havzasi-scd-raporu_final_tr_20181108013851.pdf. Accessed 20 April 2021

Republic of Türkiye Ministry of Industry and Technology, General Directorate of Industry (2014)
Türkiye's 81 Provincial Industrial Diligence Report.
<http://www.tarsusticaretborsasi.com/dosyalar/pdf/81%20il%20sanayi%20durum%20raporu.pdf>.
Accessed 1 March 2022

TÜİK (2021) Geographical Statistics Portal. <https://cip.tuik.gov.tr/>. Accessed 2 June 2021