ACCESSING WATER INDICES FOR SUSTAINABLE AGRICULTURE IN PUNJAB

PRESENTED BY-

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AIM AND OBJECTIVES OF THE RESEARCH

AIM: To assess temporal and spatial changes in water availability and vegetation health in Punjab from 2000-2025 using remote sensing indices and groundwater data for promoting sustainable agricultural practices.

OBJECTIVES:

- This study aims to study the ground water table levels from years 2000-2025 in 5 years span to analyse the changes that have resulted in the reduced ground water table levels in the state.
- To study the changing Surface Water Index of the state.
- To study the changes in Vegetation Index of the State.
- To evaluate the relationship between ground water levels, surface water levels and vegetation levels in the context of agriculture of Punjab.

METHODOLOGY

- Ground Water Table data is collected from Indian Water Resources Information System, Department of Water Resources, RD and GR, Ministry of Jal Shakti, Government of India.
- Chloropleth maps were created showing changes in ground water levels in districts of Punjab across the years considered.
- Two decades were considered while doing the research- 2000-2010 and 2010-2025 in order to show changes in the Vegetative Index, Surface Water Index of Punjab.
- The raster data is collected was from USGS Earth Explorer. This platform provided Landsat 7 satellite data from 2000-2010 and Landsat 8 satellite data was downloaded for the 2010-2025 decade.
- NDVI, NDWI of the decades was calculated before and then the difference in each technique provided the change map.
- The change map showed the changes that have occurred in NDVI, NDWI using red, blue and white coloured values which showed increase, decrease and no change respectively.

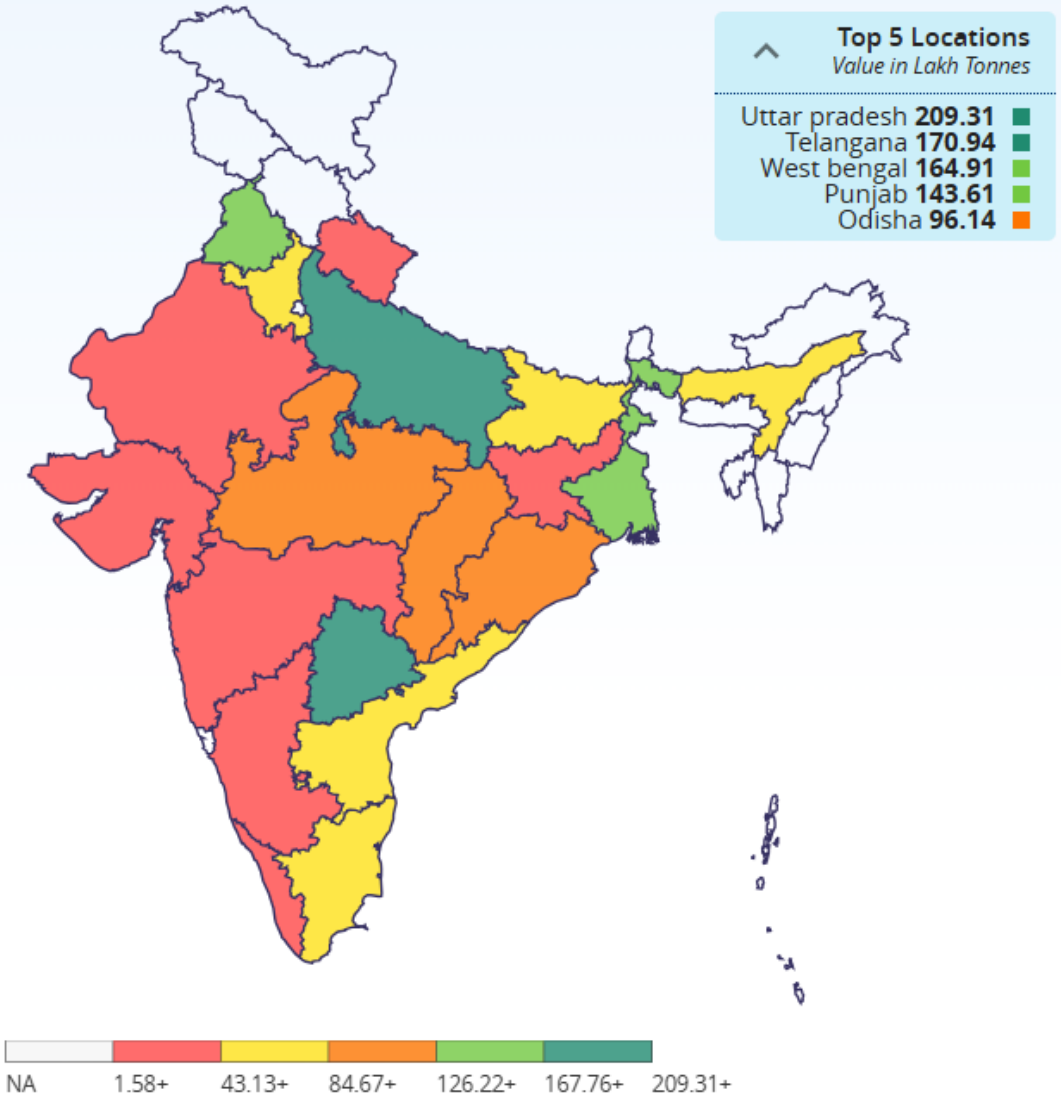
RESEARCH PROBLEM

- Punjab is a agrarian economy of India. The state exports much of wheat, rice and maize to other states and other countries. It is the third largest producer of wheat and fifth largest producer of rice in India.
- The Indus River Basin, one of the largest in the world, with five of its principal tributaries: the Sutlej, Beas, Chenab, Jhelum, and Ravi passes through this state. Owing to this extensive river system, the region has seen one of the first civilizations of the world- the Harappan Civilization. Punjab remains a major agro-economic hub since long, supplying rice, wheat, and other agricultural staples both nationally and internationally.
- Green Revolution was started in Punjab in the early 1960s which provided the state with High Yielding Variety (HYV Seeds), improved irrigation methods and other mechanics which improved the agriculture of the State.
- As the years progressed, the climate has changed a lot in the State as the result of increasing global warming and rising temperatures. The increased demands of irrigation have significantly reduced the ground water table levels also. The daily temperatures have increased and downpour patterns have changed too which has changed the agricultural lands in the state.

Rice Production, Third Advance Estimate, 2024-25

Advance Estimates covers only major states

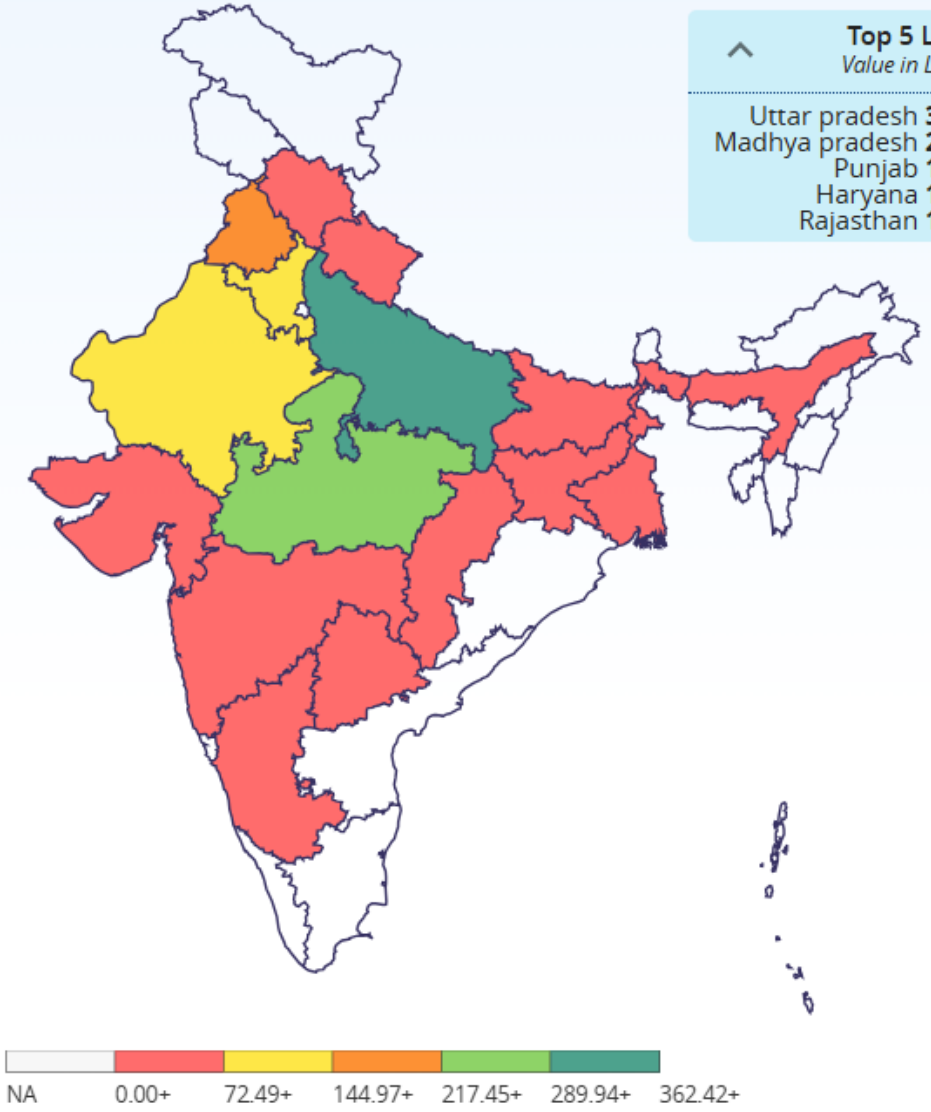
Rice



Wheat Production, Third Advance Estimate, 2024-25

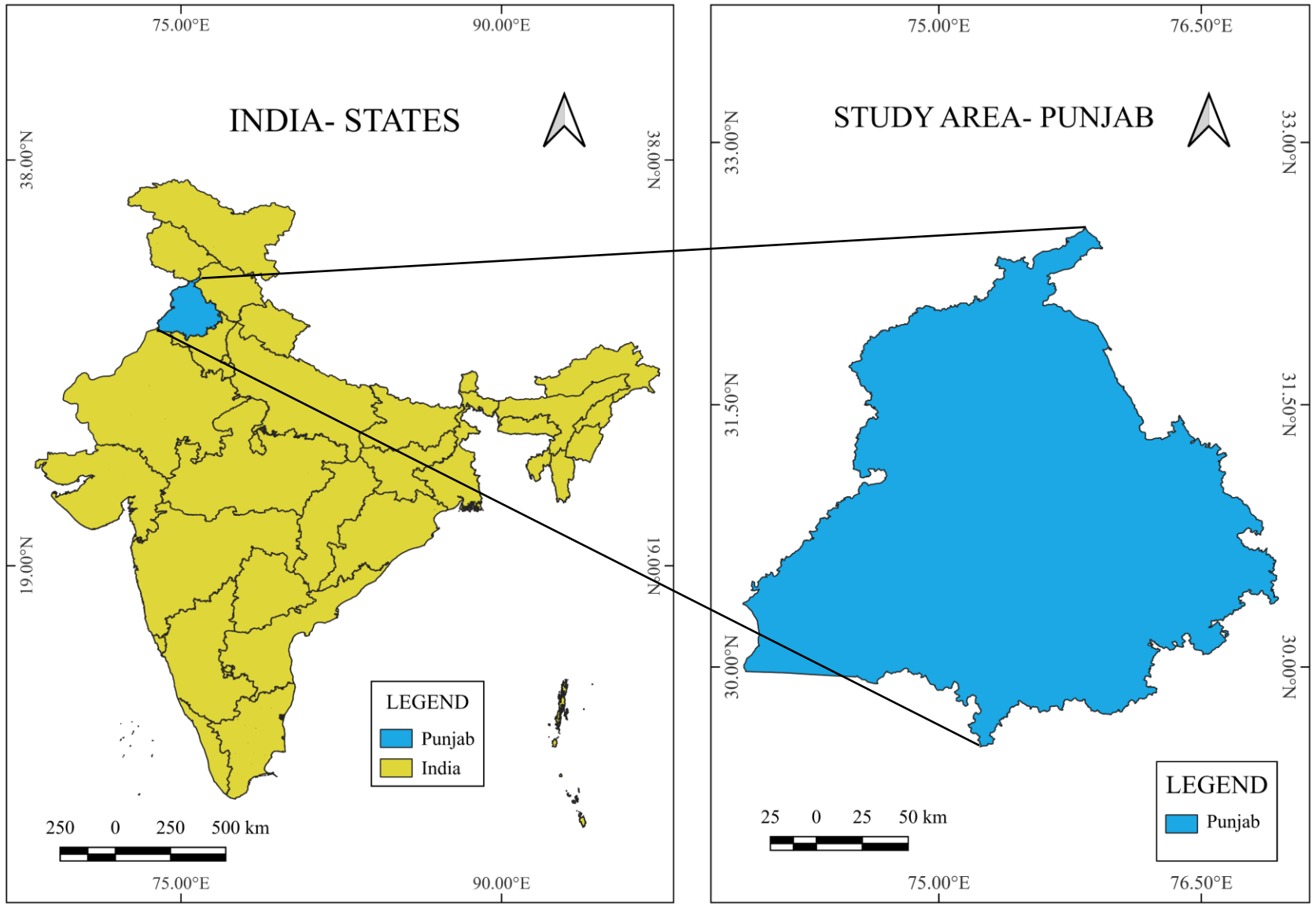
Advance Estimates covers only major states

Wheat



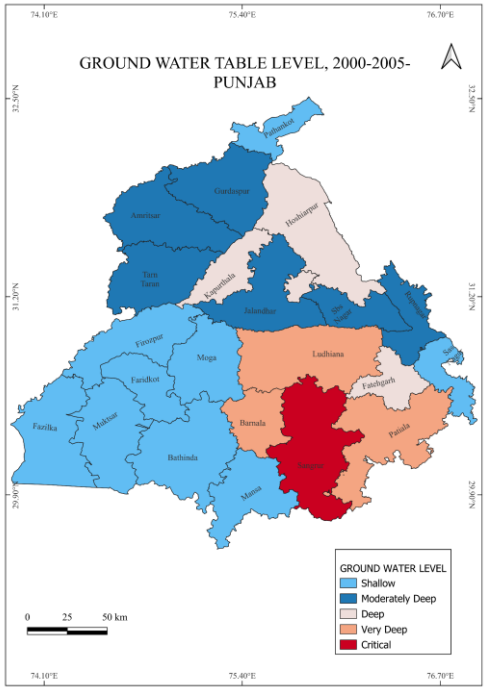
SOURCE: UNIFIED PORTAL FOR AGRICULTURAL STATISTICS, MINISTRY OF AGRICULTURE & FARMERS WELFARE, GOVERNMENT OF INDIA

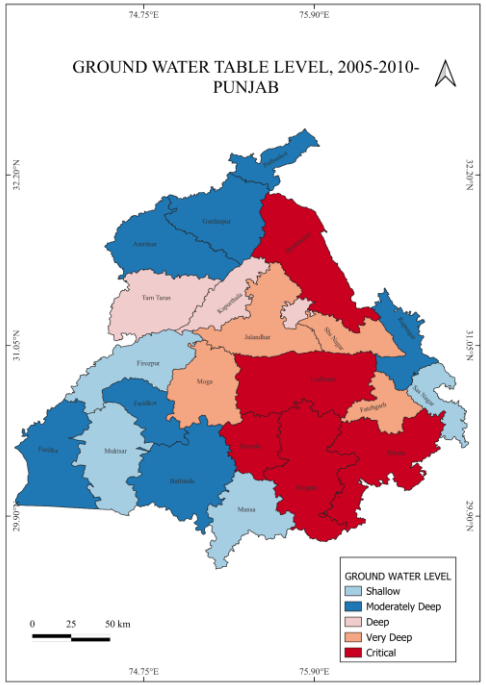
STUDY AREA

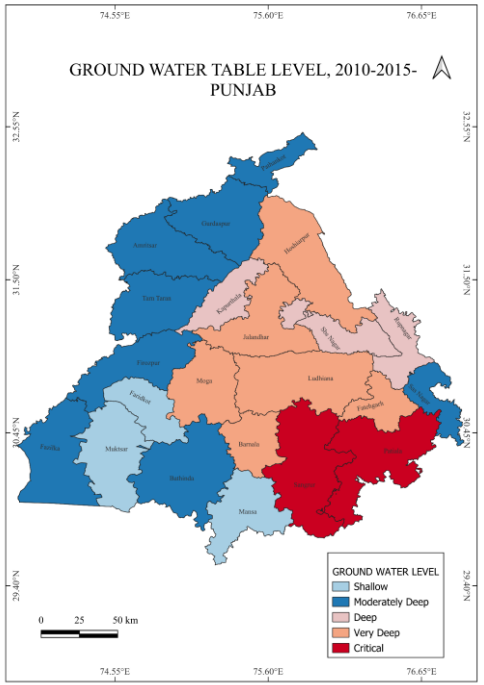


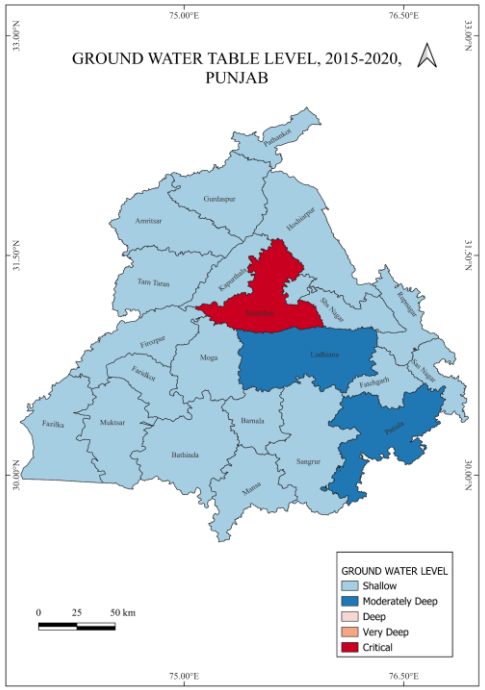
Punjab, state of India, located in the northwestern part of the subcontinent. It is bounded by Jammu and Kashmir union territory to the north, Himachal Pradesh state to the northeast, Haryana state to the south and southeast, and Rajasthan state to the southwest and by the country of Pakistan to the west. Punjab in its present form came into existence on November 1, 1966, when most of its predominantly Hindi-speaking areas were separated to form the new state of Haryana. The city of Chandigarh, within the Chandigarh union territory, is the joint capital of Punjab and Haryana.

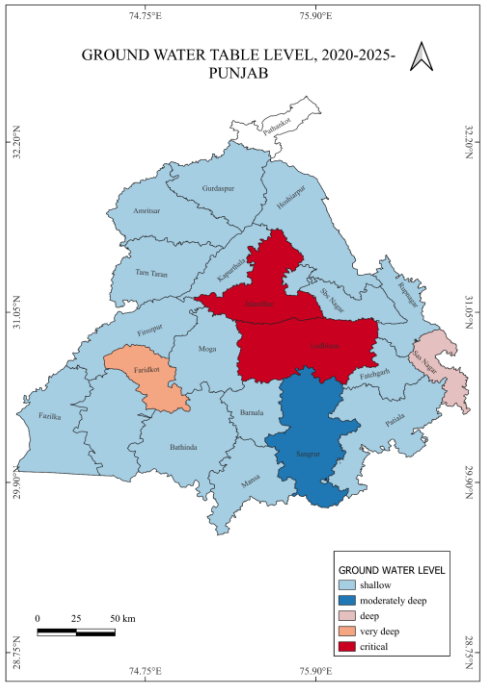
CHANGES IN GROUND WATER LEVEL FROM 2000-2025



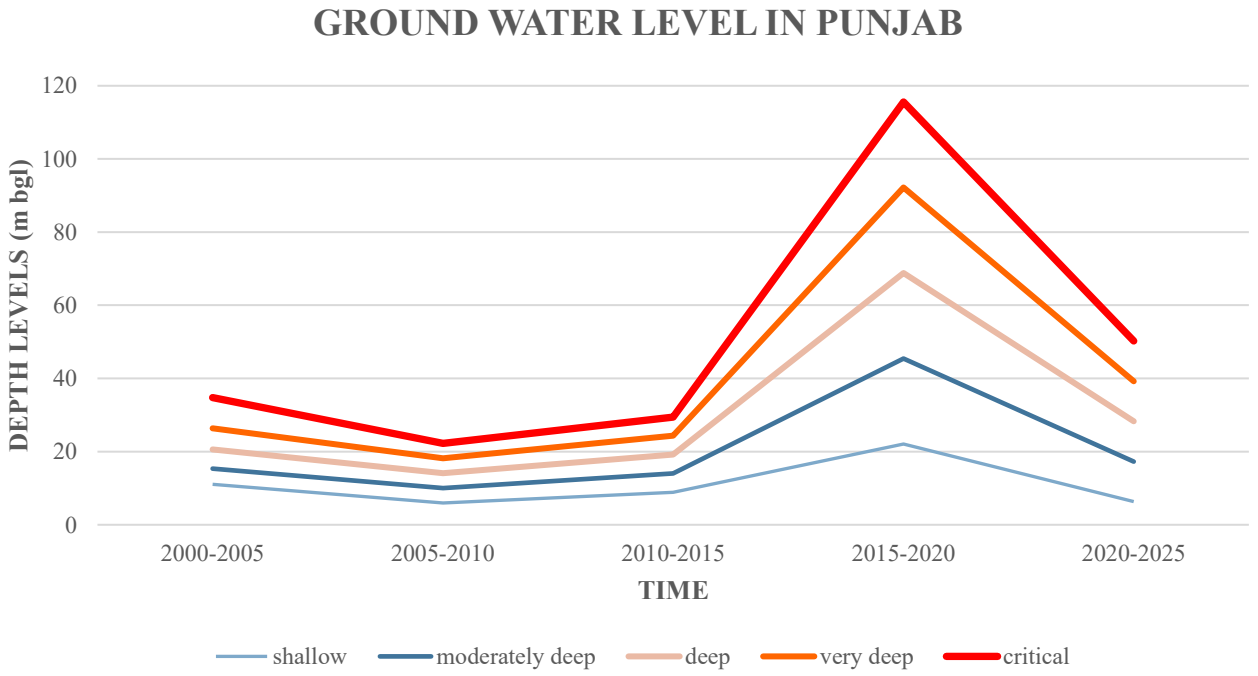


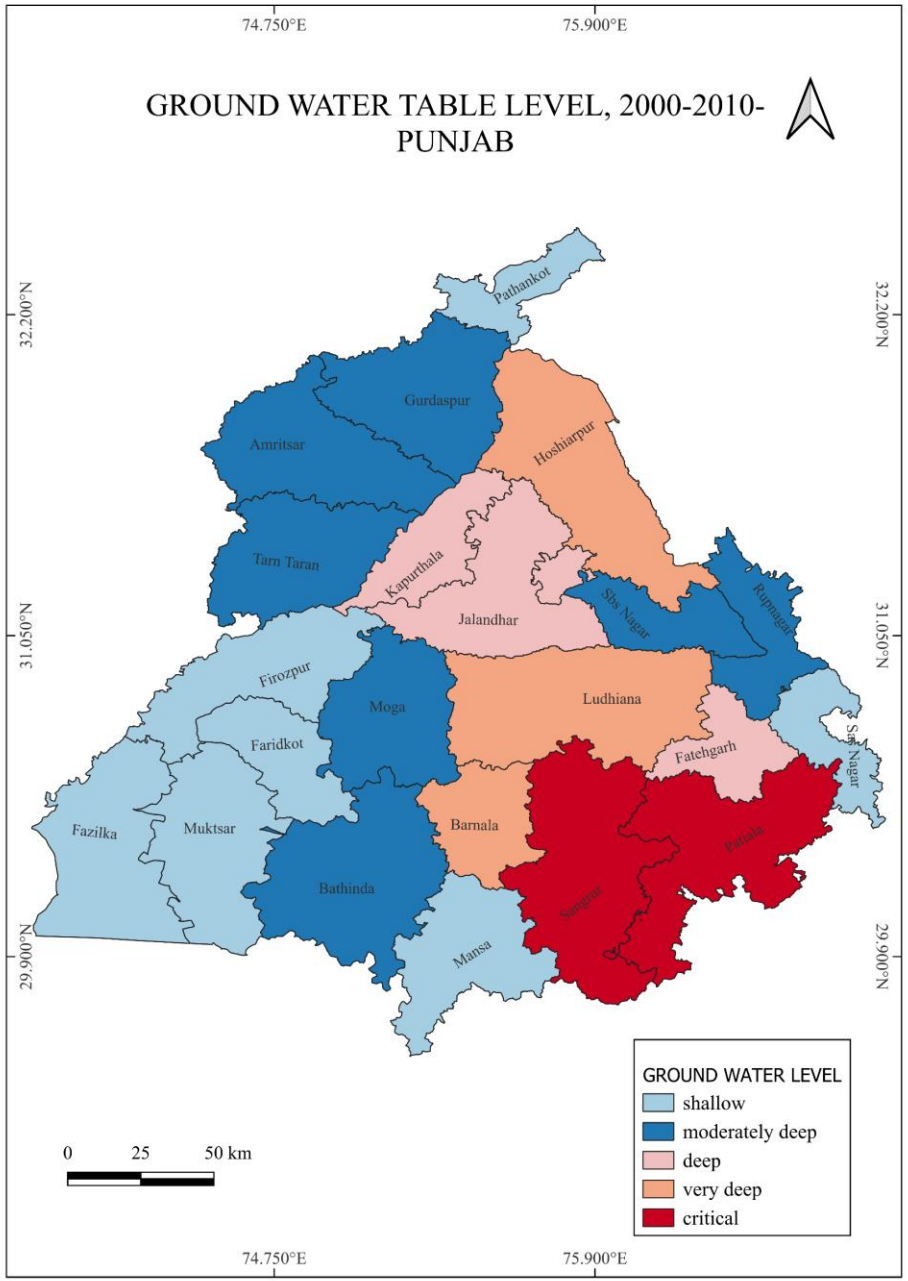


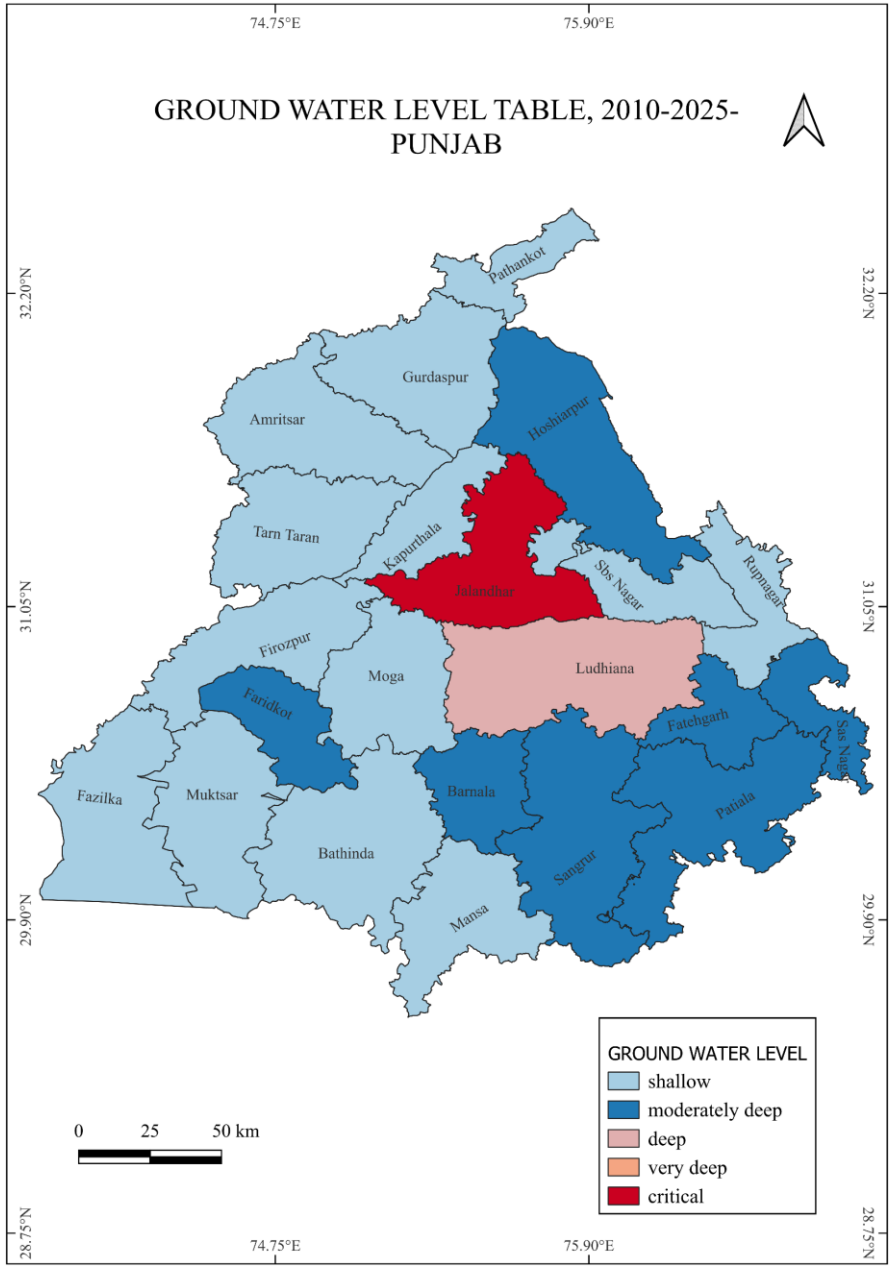




GROUND WATER LEVEL DATA, 2000-2025- PUNJAB DISTRICTS					
	2000-2005	**2005-2010**	**2010-2015**	**2015-2020**	**2020-2025**
SHALLOW	9.95-12.22	3.915-7.988	6.280-11.433	10.39-33.76	0.83-11.81
MODERATELY DEEP	12.22-18.49	7.988-12.061	11.433-16.586	33.76-57.113	11.81-22.79
DEEP	18.49-22.75	12.061-16.134	16.586-21.739	57.13-80.51	22.79-33.76
VERY DEEP	22.75-30.02	16.134-20.207	21.739-26.892	80.51-103.88	33.76-44.74
CRITICAL	30.207-39.280	20.207-24.280	26.892-32.045	103.88-127.25	44.74-55.72

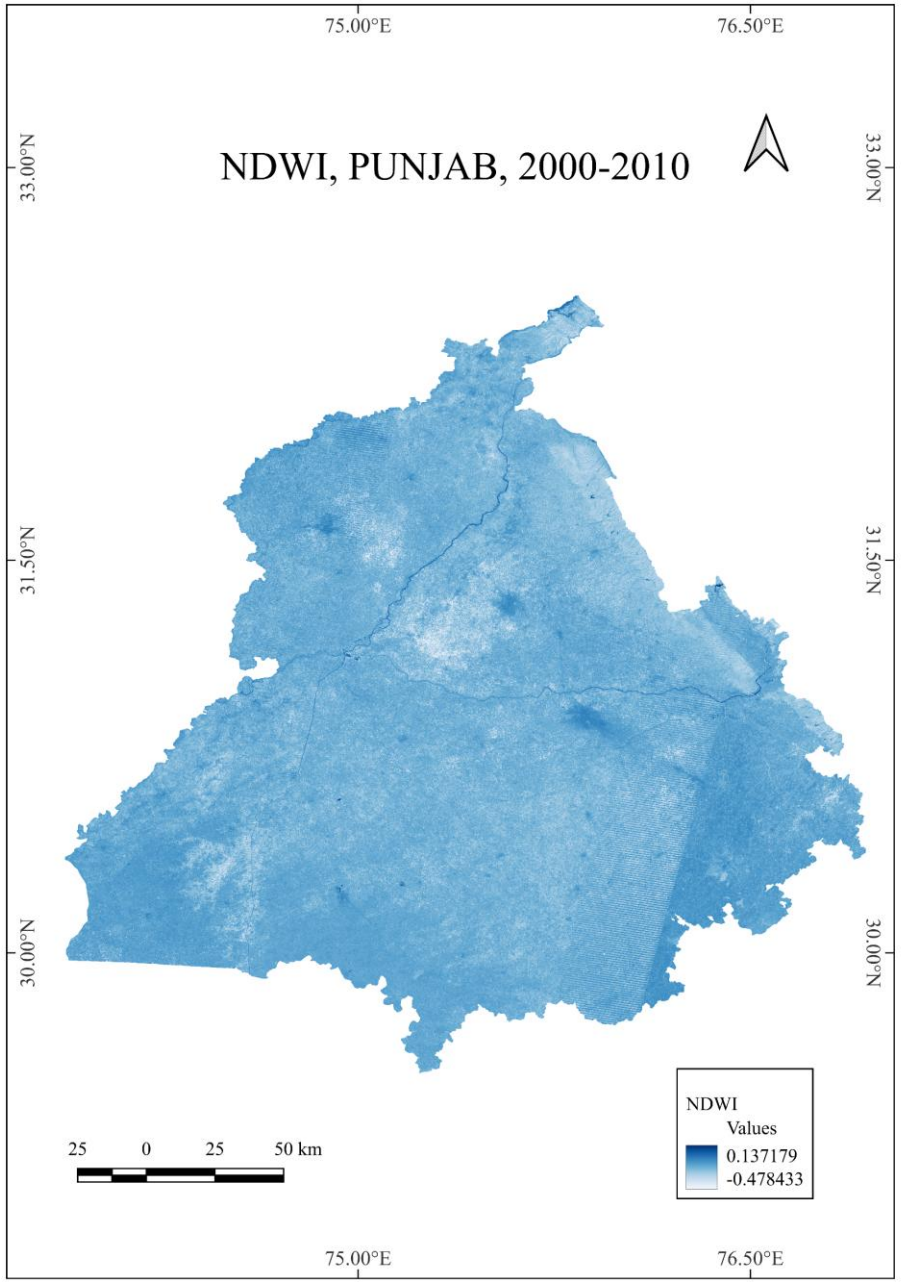


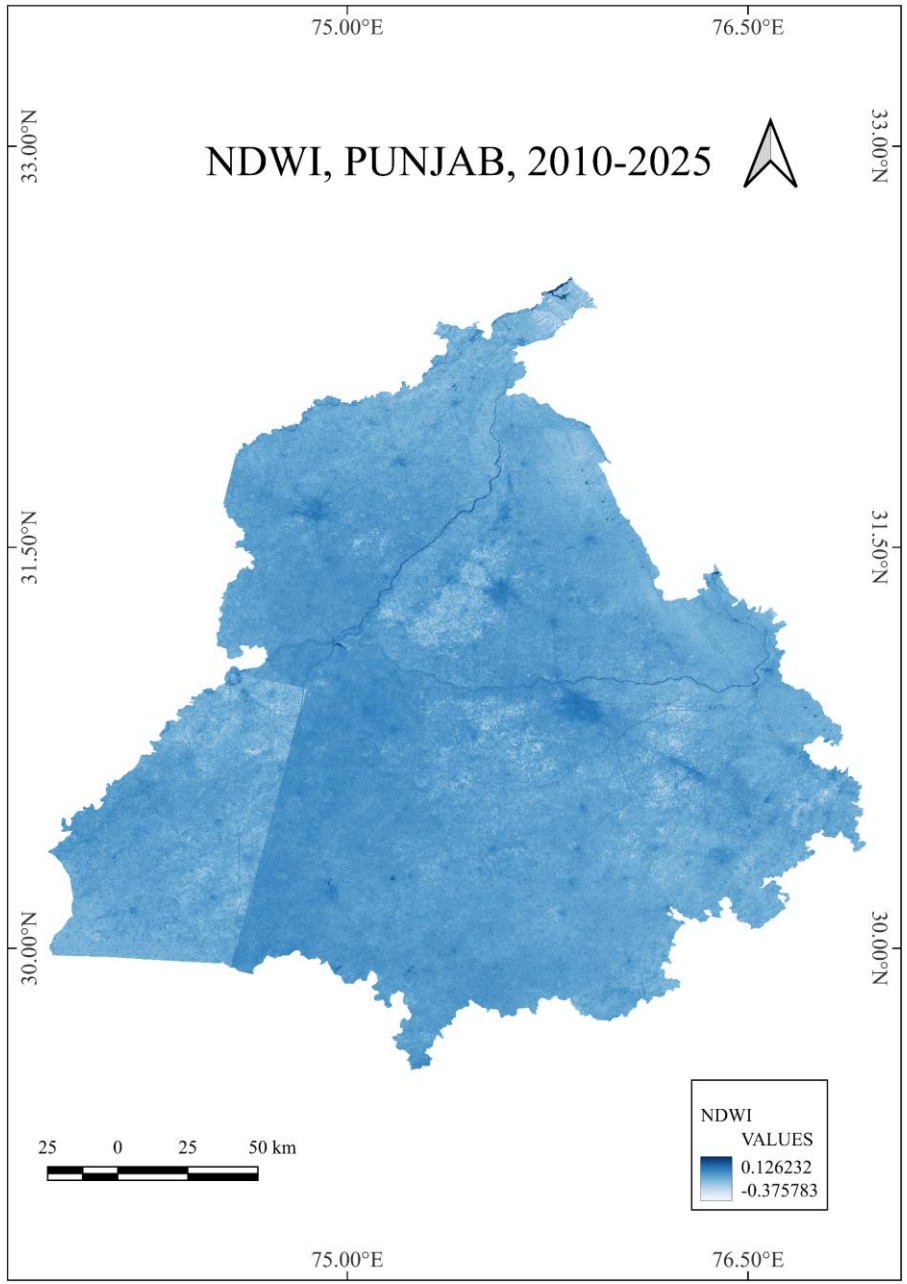




CHANGES IN GROUND WATER LEVELS- A COMPARISON OF 2 DECADES

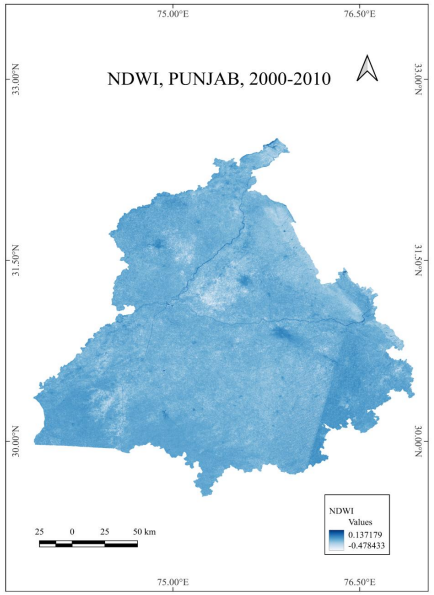
Districts of Jalandhar and Ludhiana have shown major changes with values reaching critical level.
However, the south western and western districts have shown a rise in their ground level tables.

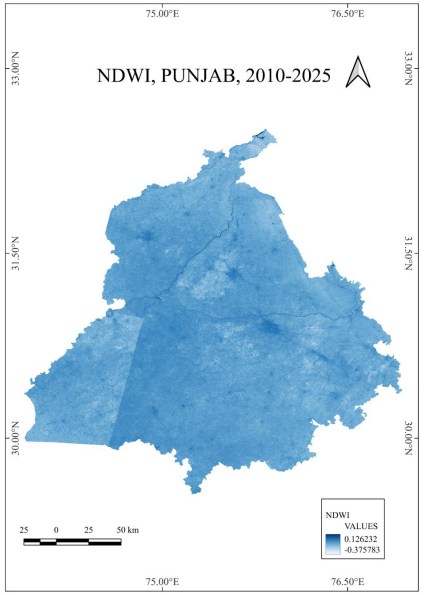


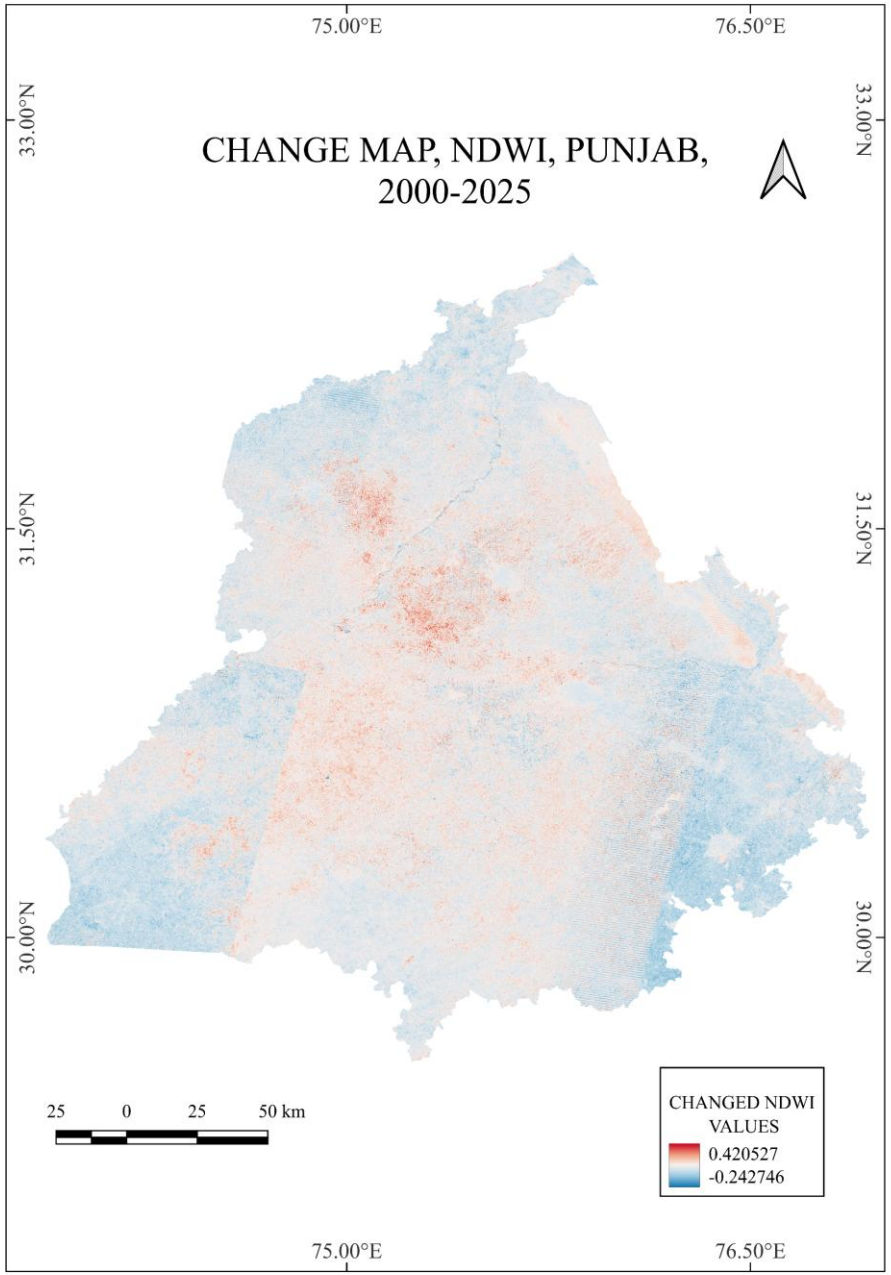


CHANGES IN NDWI- A COMPARISON OF 2 DECADES

Major change- Water in Western part has decreased and in other areas, the deep colour shows an increase

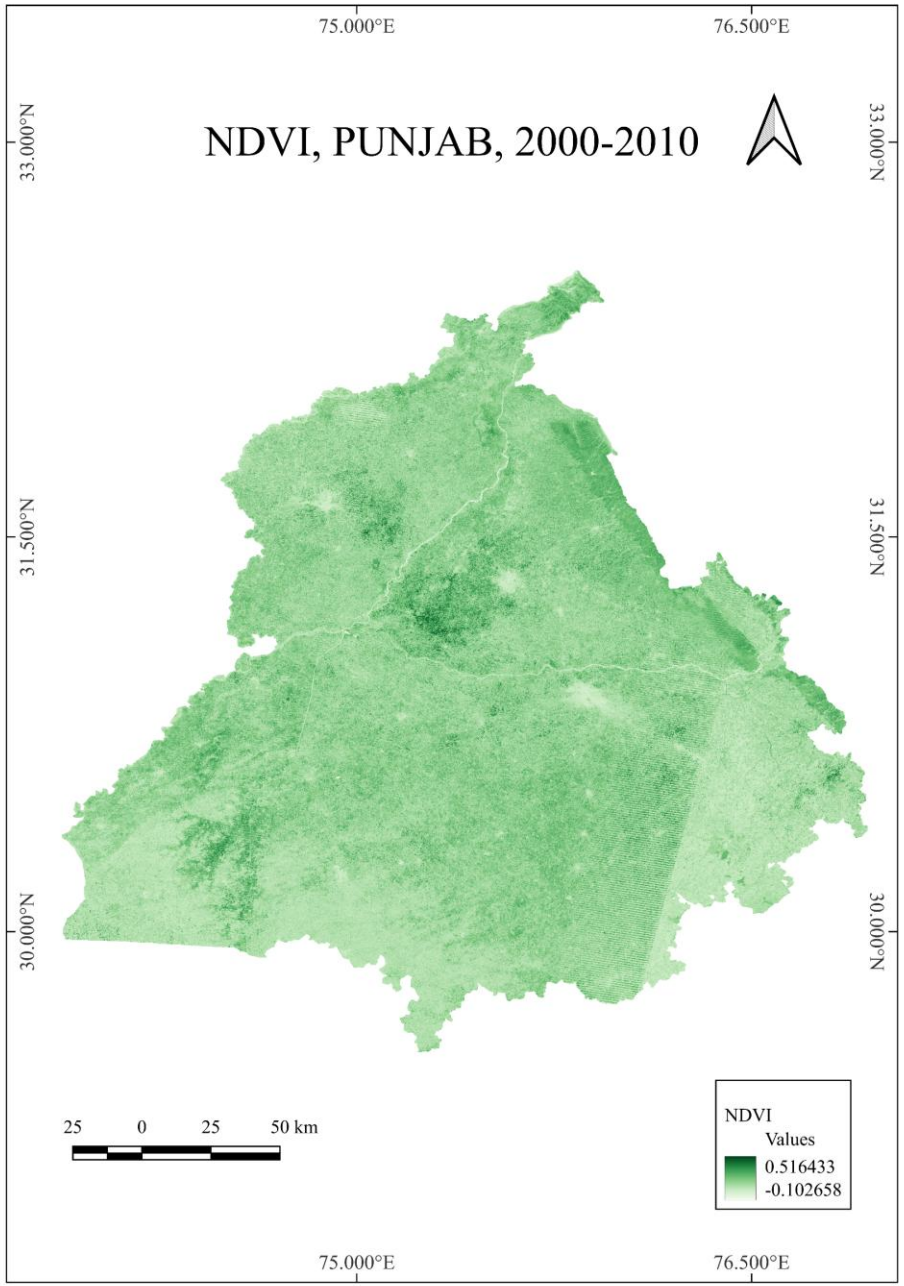


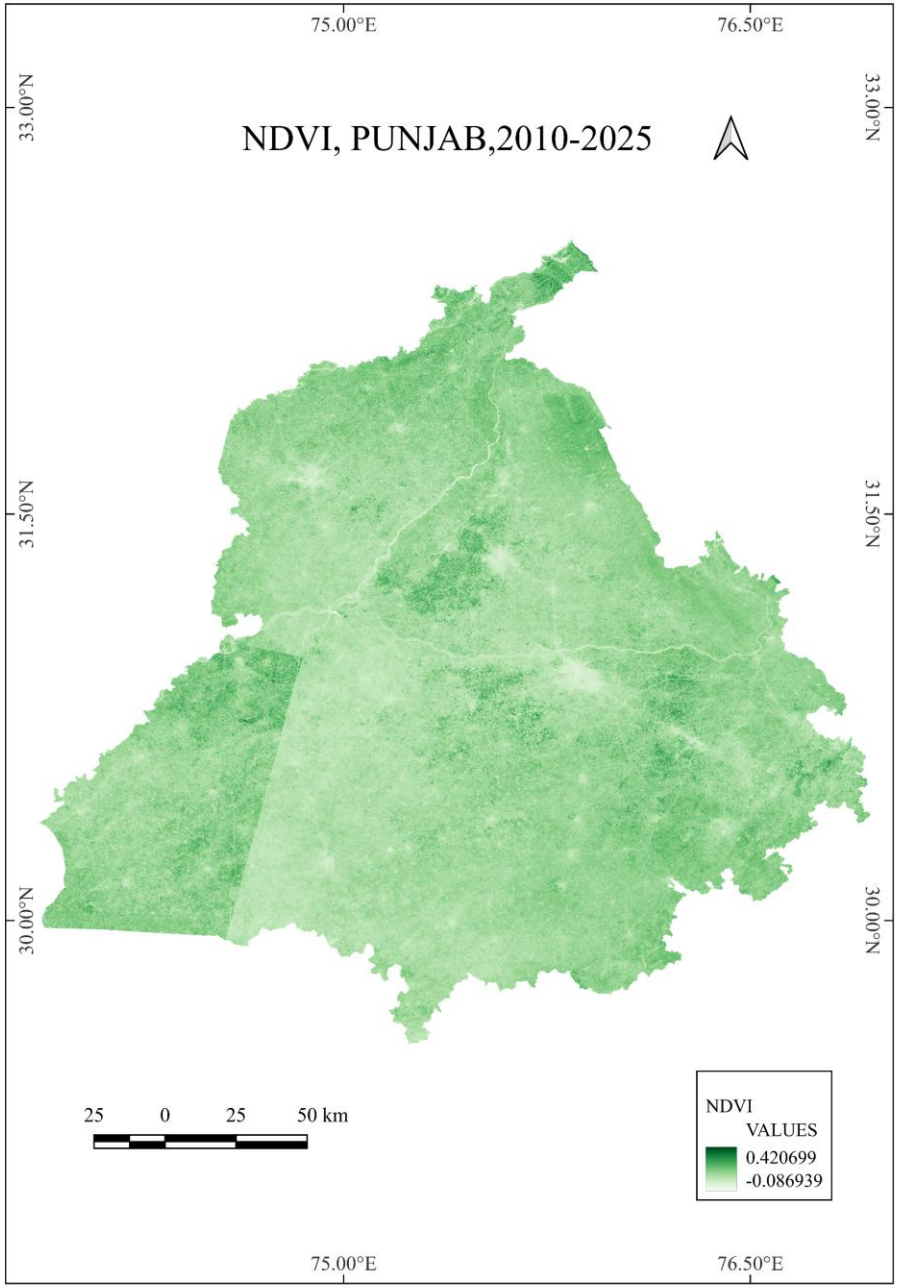




The change map of NDWI between 2000 and 2025 shows the following-

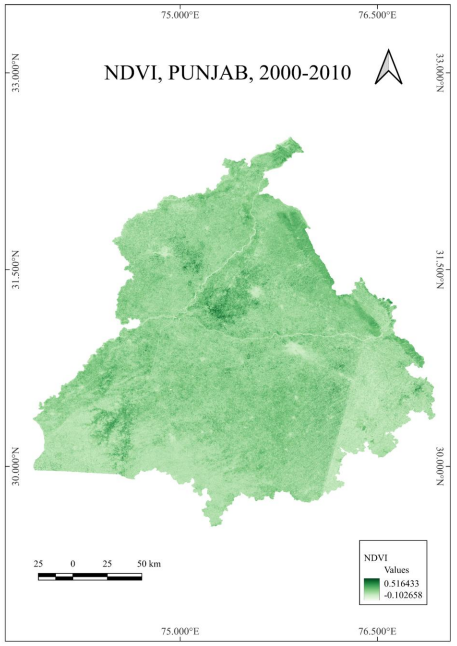
- The lower western and eastern part- water index has decreased(blue colour shows decrease). This could mean groundwater stress, irrigation failure, drought-affected areas. The districts included are- Fazilka, Muktsar, Bathinda, Patiala and Fatehgarh Sahib.
- Majorly the central Punjab has shown an increase in the Water Index which could mean well-irrigated, water-retentive cropland. This area includes the districts of Jalandhar, Kapurthala, Tarn Taran, Ludhiana and Moga.
- Majorly, the colours aren't too deep so the change is extremely minor.

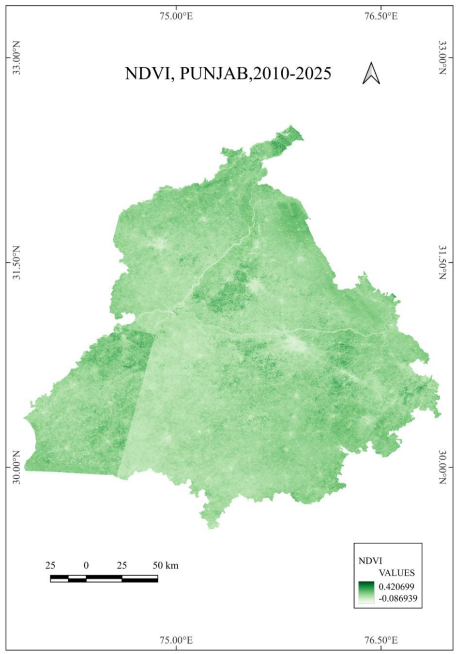


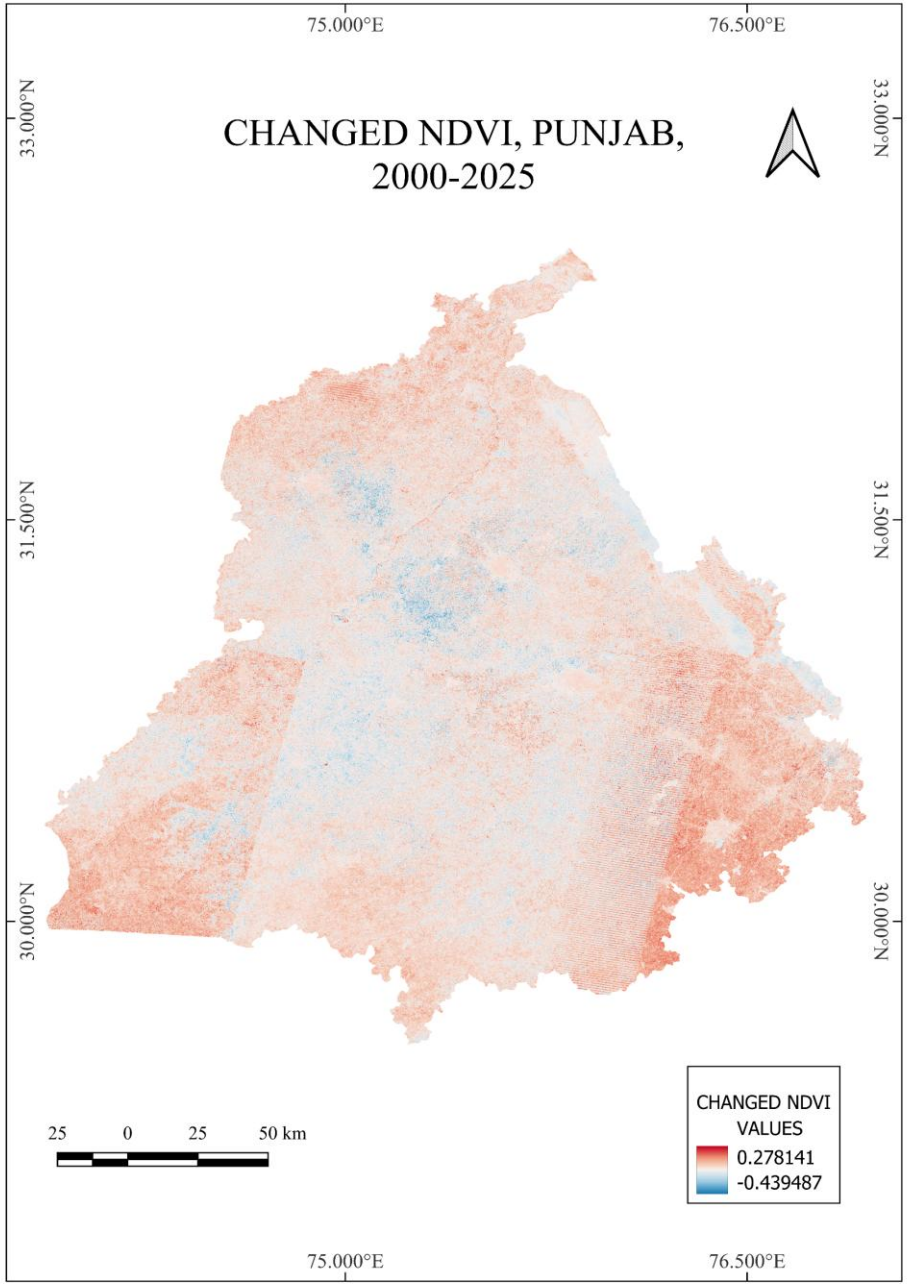


CHANGES IN NDVI- A COMPARISON OF 2 DECADES

Major change- Vegetative in Western part has increased and in other areas, the lighter colour shows the decrease



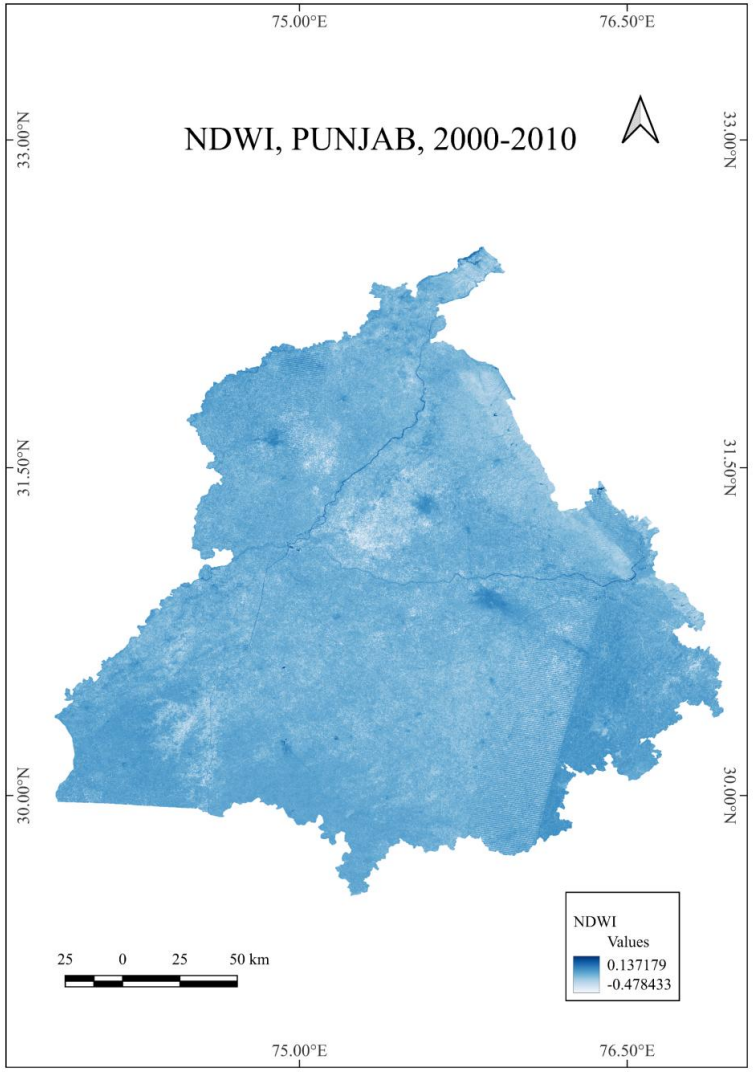


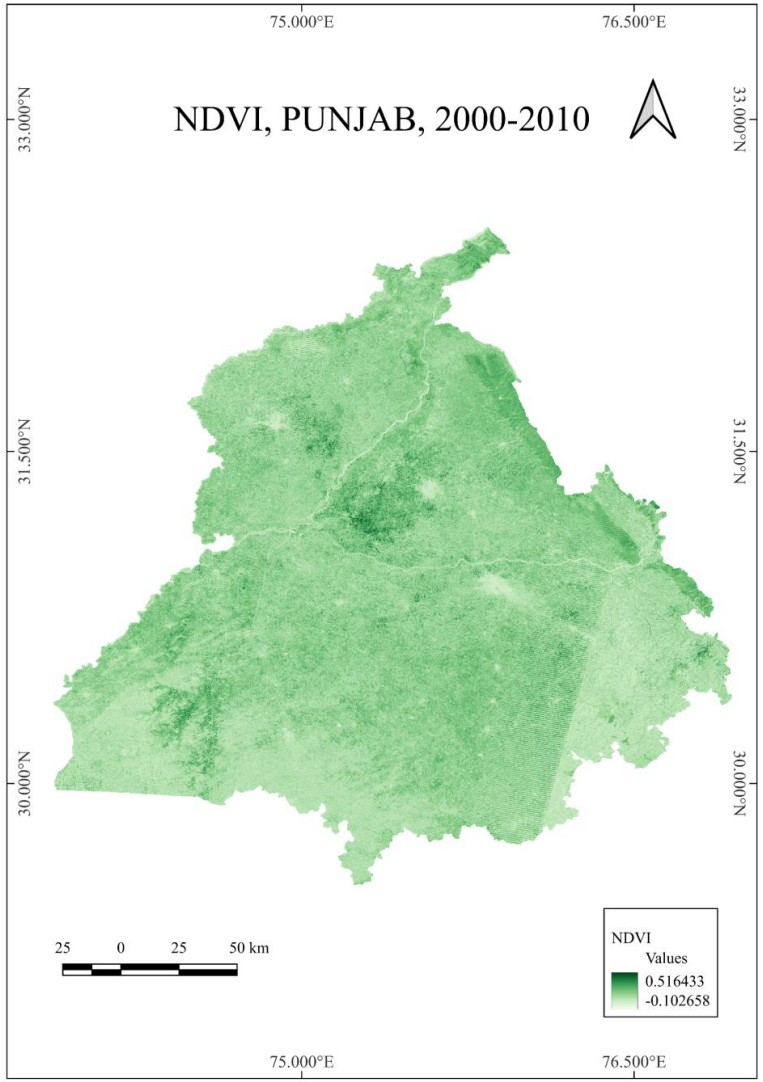


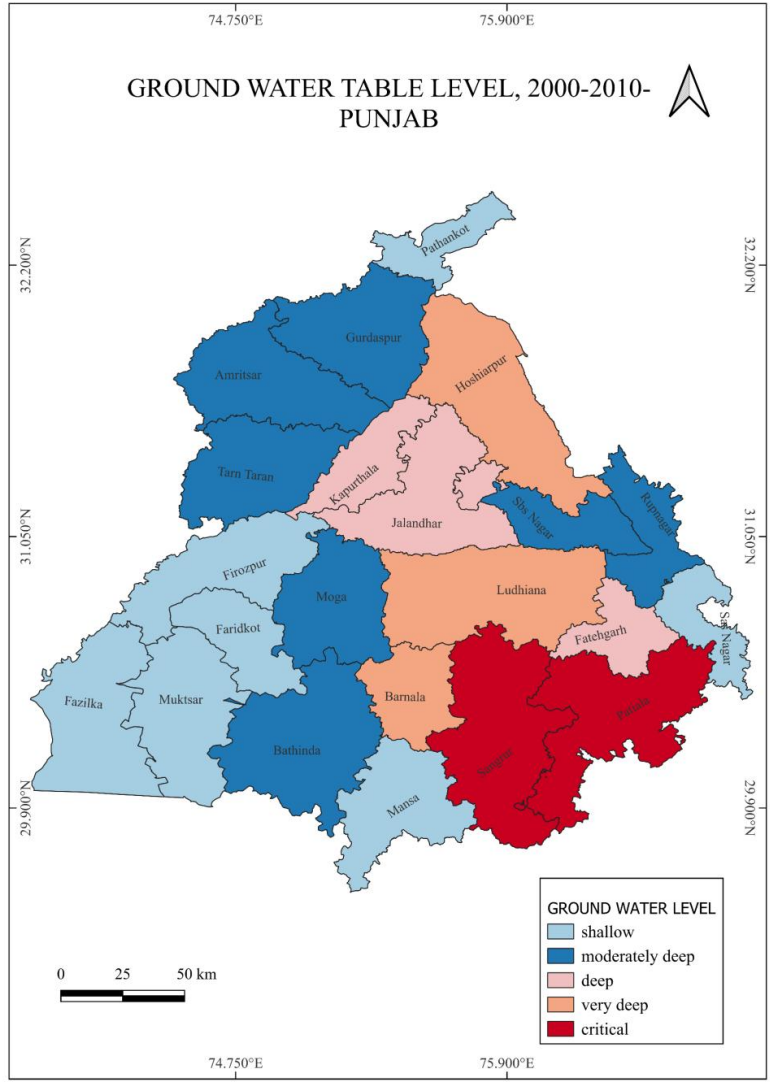
The change map of NDVI between 2000 and 2025 shows the following-

- The lower western and eastern part- vegetative index has increased(red colour shows increase). This could mean dense, healthy vegetation or actively growing crops. The districts included are- Fazilka, Muktsar, Bathinda, Patiala and Fatehgarh Sahib.
- Majorly the central Punjab has shown a decrease in the vegetative Index which could mean fallow or harvested fields, drought affected crops or urban land. This area includes the districts of Jalandhar, Kapurthala, Tarn Taran, Ludhiana and Moga.
- Majorly, the colours aren't too deep so the change is extremely minor.

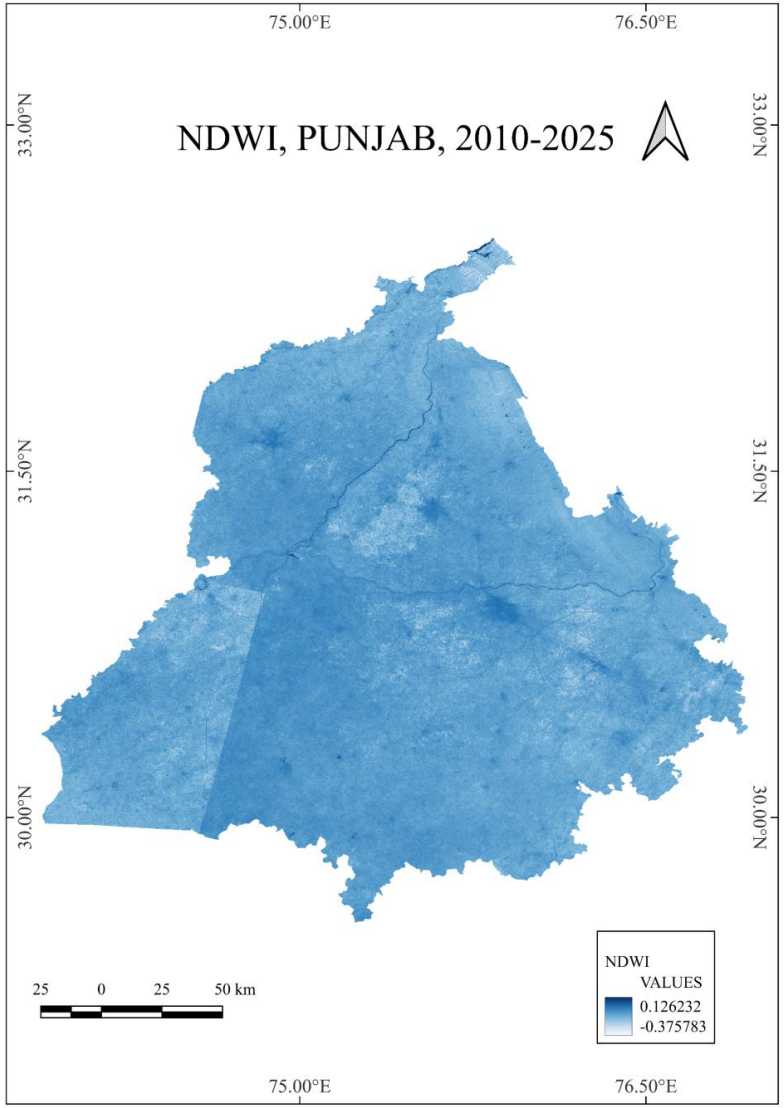
COMPARING THE MAPS SIDE BY SIDE- 2000-2010

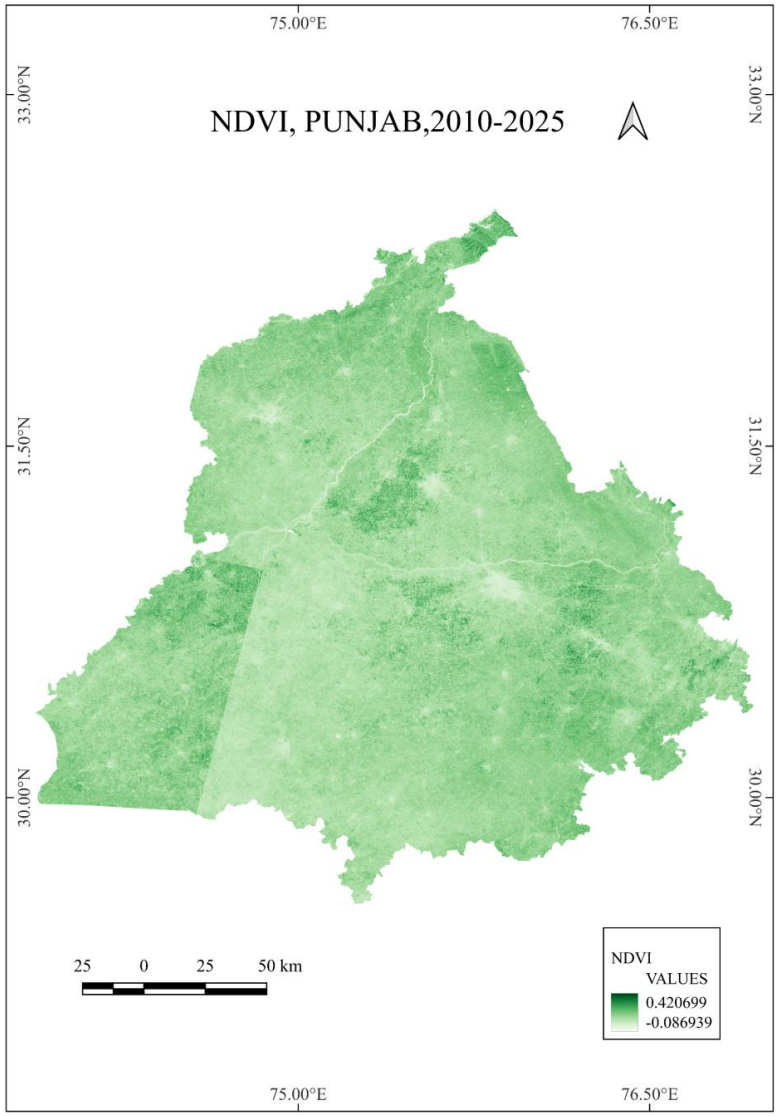


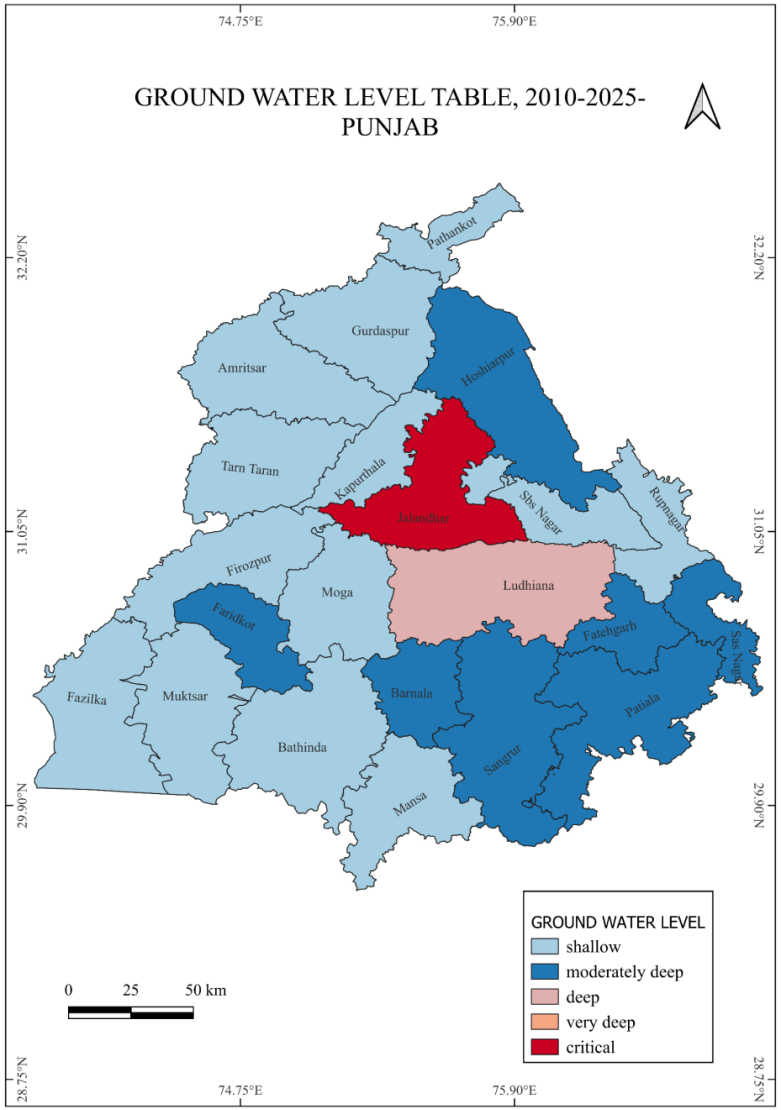




COMPARING THE MAPS SIDE BY SIDE- 2010-2025







ESTABLISHING THE RELATIONSHIP BETWEEN NDVI, NDWI AND GROUND WATER LEVEL

- More vegetation shows more depth in ground water levels and lesser values in NDWI.
- Inverse Relationship between NDWI and NDVI.
- Direct relationship between Ground Water levels and NDWI.
- consistent groundwater withdrawal for irrigation has caused a lag between vegetation growth (NDVI rise) and water availability (NDWI and groundwater fall).

Spatial correlation:

Northwestern districts (Amritsar, Gurdaspur) → higher NDWI and shallower water levels.

Central and southern districts (Ludhiana, Sangrur, Bathinda) → lower NDWI, deeper groundwater.

RESULTS-

- Changes in the Normalised Difference Water index show
  - Areas with higher NDWI are may represent well-irrigated croplands or regions with higher soil moisture retention
  - Areas with Lower NDWI may be facing groundwater stress, poor irrigation, or drought-prone conditions.
  - This could mean- The western and southern belts of Punjab may be experiencing water scarcity or irrigation decline. NDWI change aligns with possible groundwater depletion trends.
- Changes in the Normalised Difference Vegetative index show
  - Areas with higher NDVI are Indicates healthy, actively growing crops or denser vegetation in these districts.
  - Areas with Lower NDVI are Possibly due to harvested or fallow fields, urban expansion, or vegetation stress.
  - This could mean- NDVI increase in water-stressed zones may reflect cropping shifts or intensive irrigation, even under groundwater pressure. NDVI decrease in high-NDWI zones may indicate recent harvests, fallowing, or urban land conversion

CONCLUSION

Higher NDWI + Lower NDVI + Deeper Groundwater → Indicates surface water presence but poor vegetation performance, suggesting unsustainable irrigation and soil degradation.

• Decline in NDVI despite higher NDWI implies inefficient water use and reduced crop productivity.

• Overall, Punjab shows a trend toward surface water excess, groundwater depletion, and vegetative stress, revealing imbalanced agro-hydrological conditions.