Future plan report 2026–2030

Adapting AI-GEOARCH Work Packages for Resilience and Scientific Diplomacy in the Persian Gulf

Executive Summary

The Persian Gulf is experiencing unprecedented pressures from both environmental extremes and geopolitical instability. Rising sea levels, intensifying storms, and shoreline erosion are compounded by the ongoing conflict in Iran, which has heightened risks for vulnerable coastal communities and heritage sites. These conditions underscore the urgency of AI-GEOARCH's mission to decode extreme events and strengthen human resilience in the region.

UNESCO and the UNITWIN Cooperation Programme provide a vital framework for scientific and cultural diplomacy in this fragile context. By fostering international collaboration, knowledge transfer, and shared responsibility for safeguarding heritage, these initiatives ensure that research and preservation efforts transcend political boundaries. For the Persian Gulf, UNITWIN is not only a scientific platform to advance coastal hazard research but also a diplomatic bridge that promotes peace through cultural understanding and resilience.

To maintain momentum under current conditions, AI-GEOARCH will adapt its work packages. Field-intensive components such as geoarchaeological excavations and sediment coring (WP1, WP3) will be rescheduled or scaled back, while remote sensing, AI-driven modeling, and laboratory collaborations abroad (WP2, WP4) will be prioritized. Knowledge transfer and virtual workshops (WP5) will ensure continuity of capacity-building and community engagement. This adaptive strategy safeguards scientific progress, reinforces UNESCO's mission, and positions AI-GEOARCH as a model for resilience research in conflict-affected regions.

Future plan: adapting AI-GEOARCH to current conditions

1. Acknowledgement of Current Challenges

The current conflict in Iran has created significant obstacles for logistics, field operations, and international mobility. Nevertheless, the AI-GEOARCH consortium remains committed to advancing UNESCO's priorities of heritage preservation, climate resilience, and sustainable development. By acknowledging these challenges openly, the project demonstrates transparency and readiness to adapt under crisis conditions.

2. Adaptation Strategies

- Remote sensing & AI focus: Satellite data, Landsat imagery, and GeoAI will ensure continuity of research even when fieldwork is restricted.
- Virtual workshops: In-person workshops will be replaced or postponed with online knowledge-sharing sessions to maintain collaboration.
- International lab partnerships: Reliance on European partners (Aix-Marseille, Montpellier, Southampton, Calgary, CAS) will secure laboratory analyses (OSL, pollen, radiocarbon) while Iranian labs face disruption.
- Data resilience: Open-source data platforms will guarantee accessibility and transparency despite local instability.

3. Revised Timeline & Work Packages

Field-intensive packages (WP1, WP3) may face delays, while AI-driven modeling, sedimentological analysis, and paleoclimate reconstructions (WP2, WP4) can progress remotely. A phased approach is proposed:

2026–2027: Remote sensing, AI training, and international lab analyses.

2028–2029: Resumption of intensive fieldwork and heritage site assessments once conditions stabilize.

4. Resilience & UNESCO Alignment

This adaptive strategy directly supports SDG 13 (Climate Action) and SDG 11 (Sustainable Cities & Communities). Conducting research under conflict conditions demonstrates the importance of scientific diplomacy and cultural heritage protection in times of crisis. AI-GEOARCH is positioned as a model for UNESCO's UNITWIN Cooperation Programme in conflict-affected regions.

5. **Future Vision**

AI-GEOARCH will evolve into a regional hub for resilience research, integrating Persian Gulf data with global coastal hazard studies. UNESCO's support for capacity-building in post-conflict recovery will ensure that heritage sites and vulnerable coastal communities benefit from the project's findings. This vision strengthens both scientific collaboration and cultural diplomacy, ensuring long-term impact beyond the immediate crisis.

Progress to Date

Since the launch of AI-GEOARCH, the consortium has made significant strides in advancing interdisciplinary research on extreme events and resilience in the Persian Gulf and wider Middle East. Despite logistical challenges, several milestones have already been achieved:

1. **Regional Climate Diagnostics**
   - Conducted comprehensive analyses of drought intensification using the Standardized Precipitation–Evapotranspiration Index (SPEI).
   - Identified a structural shift toward long-term aridification since the late 1990s, with persistent negative drought indices across all major climate zones.
   - Highlighting socio-hydrological hotspots where groundwater depletion and land subsidence converge.
2. **Hydrological & Land-Use Studies**
   - Developed reproducible workflows in Python and ArcGIS Pro to monitor cropland turnover, erosion, and new cultivation under drought stress.
   - Documented critical hydrological thresholds, including the near-collapse of Lake Urmia, and contrasted these with more resilient Anatolian lakes.
   - Analyzed dam construction surges in Turkey and Iran, showing how national strategies reconfigured basin hydrology and redistributed water scarcity.
3. **Urban Expansion & Migration**
   - Linked rural-to-urban migration to climate stress and agricultural decline, highlighting the concentration of populations in vulnerable coastal and industrial hubs.
   - Demonstrated how environmental pressures and governance decisions jointly shape urban trajectories.
4. **Subsidence & Groundwater Vulnerability**
   - Mapped aquifer vulnerability zones across Iran, Turkey, Iraq, and Syria.

- Integrated InSAR observations with global subsidence models to identify shared risk patterns across the region.
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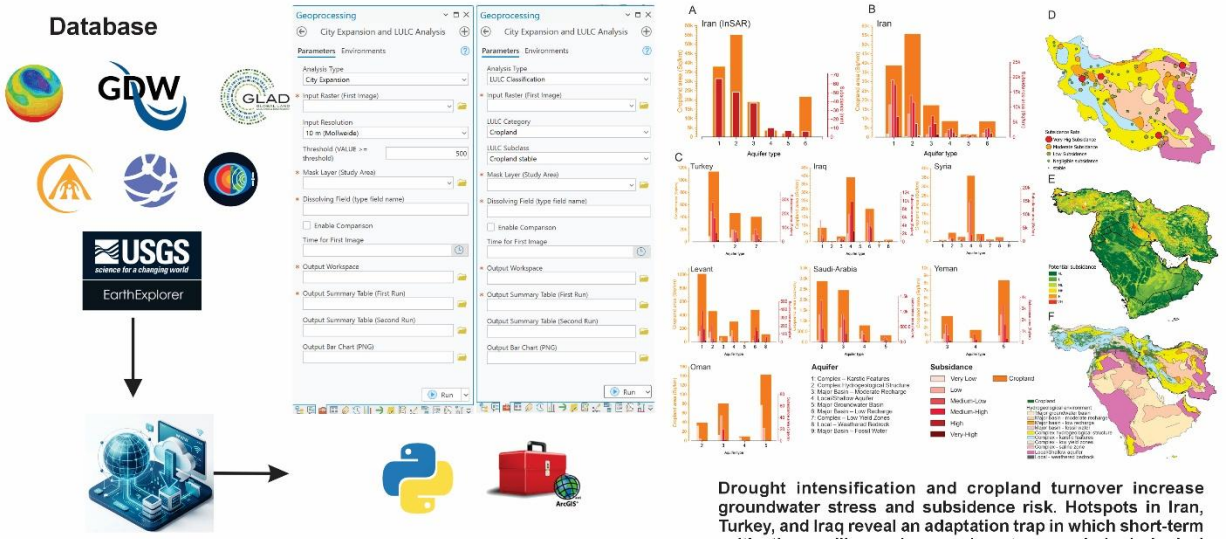
Drought, groundwater depletion, and land subsidence: socio-hydrological hotspots in the Middle East and Anatolia



Global datasets are integrated with automated Python–ArcGIS Pro tools to map land-use change, cropland turnover, and urban expansion.

Drought intensification and cropland turnover increase groundwater stress and subsidence risk. Hotspots in Iran, Turkey, and Iraq reveal an adaptation trap in which short-term cultivation resilience deepens long-term socio-hydrological vulnerability.

Graphical abstract descriptions:
The graphical abstract summarizes the integrated geospatial framework used to identify socio-hydrological vulnerability hotspots across the Middle East and Anatolia. The first panel presents the main input datasets, including global settlement, land-cover, hydrogeological, and remote-sensing products such as GDW, GLAD, USGS EarthExplorer, and InSAR-derived deformation information. These datasets are processed through an automated Python–ArcGIS Pro workflow designed to classify land-use/land-cover change, detect cropland turnover, assess urban expansion, and identify subsidence-prone areas. The output panels illustrate how drought intensification and aridification interact with land-use adaptation and groundwater dependency to reshape regional vulnerability patterns. The mapped and statistical results highlight critical hotspots, particularly in Iran, Turkey, and Iraq, where cropland dynamics, aquifer stress, and ground deformation converge. The graphical abstract emphasizes the central finding of the study: cultivation can temporarily buffer socioeconomic stress during prolonged drought, but it may also accelerate aquifer depletion, land degradation, and subsidence. This creates an adaptation trap in which short-term resilience increases long-term socio-hydrological risk under structural aridification.

Collaboration and Persian Gulf Climate Studies

In parallel with regional drought and socio-hydrological research, AI-GEOARCH has expanded its scope through strategic collaboration. A key achievement has been the development of a partnership with the Iran National Science Foundation (INSF) and Kharazmi University, establishing a post-doctoral fellowship program dedicated to climate change impacts in the Persian Gulf. This initiative aligns directly with the UNITWIN Cooperation Programme by fostering advanced training, capacity-building, and the integration of young researchers into international scientific networks.

Building on this collaboration, our studies have deepened into the Persian Gulf itself, highlighting how climate change factors drive seawater variability and reshape hydrodynamic regimes. Using reproducible computational workflows, we have shown that basin morphology and climate teleconnections (La Niña, Indian Ocean Dipole) amplify dense water formation, alter flushing dynamics, and intensify bottom current anomalies. These processes directly affect high-population coastal zones along the Gulf, where urban expansion and oil-gas related industries concentrate communities in areas of heightened vulnerability. The findings underscore the Gulf's dual role as both an ecological hotspot and a socio-economic hub, making it a priority region for UNESCO's mission in climate resilience, sustainable cities, and cultural heritage protection.

Through INSF and Kharazmi University, this fellowship program ensures continuity of expertise, strengthens national research capacity, and embeds Persian Gulf climate studies within a broader framework of scientific diplomacy and UNITWIN collaboration. Together, these efforts demonstrate how AI-GEOARCH is not only advancing scientific knowledge but also building institutional resilience and international cooperation in one of the world's most fragile coastal regions.

AI-Enhanced Geoarchaeological and Geomorphological Insights: Decoding Extreme Environmental Events and Human Resilience in the Persian Gulf

ID	Task Name	Head	Start	Finish	Duration	Complete
1	**Field Works**	M. Pourkeman H. Nazari H. Lahijani R. Lak	2027-01-19	2027-06-17	150.0 d.	0.0%
2	**Field observation & dating sampling**		2027-01-19	2027-03-19	60.0 d.	0.0%
3	Identifying high wave energy trace		2027-01-19	2027-03-19	60.0 d.	0.0%
4	OSL Sampling		2027-01-19	2027-03-19	60.0 d.	0.0%
5	Radio carbon sampling		2027-01-19	2027-03-19	60.0 d.	0.0%
6	**Coring**		2027-03-20	2027-06-17	90.0 d.	0.0%
7	COBRA		2027-03-20	2027-06-17	90.0 d.	0.0%
8	**WP1: Persian Gulf chrono-stratigraphy and bio-stratigraphy**	S. Amjadi M.R. Majidifard H. Mosadegh	2026-02-07	2030-07-02	1607.0 d.	0.7%
9	Magnetic Suscepibility analysis		2027-06-18	2027-07-17	30.0 d.	0.0%
10	Core description		2027-07-17	2027-08-15	30.0 d.	0.0%
11	**Sediment preparation**		2027-10-16	2028-02-12	120.0 d.	0.0%
12	Dating sampling		2027-10-16	2028-02-12	120.0 d.	0.0%
13	**Sediment sampling**		2027-10-16	2028-02-12	120.0 d.	0.0%
14	Foraminifera analysi		2027-10-16	2028-02-12	120.0 d.	0.0%
15	Pollen analysis		2027-10-16	2028-02-12	120.0 d.	0.0%
16	Granulometry analysis		2027-10-16	2028-02-12	120.0 d.	0.0%
17	Chronostratigraphic		2027-10-16	2028-06-11	240.0 d.	0.0%
18	Sedimentology		2027-10-16	2028-04-12	180.0 d.	0.0%
19	Biostratigraphy		2028-04-13	2030-07-02	811.0 d.	0.0%
20	Geochemical Analysis		2028-02-13	2028-07-11	150.0 d.	0.0%
21	**WP2: Paleoenvironments and Paleoclimatic conditions**	N. Marriner D. Kaniewski R. Lak H. Lahijani	2027-04-13	2029-10-29	931.0 d.	0.0%
22	Preparation and shipping		2027-10-16	2028-02-12	120.0 d.	0.0%
23	Pollen analysis		2027-04-13	2029-10-29	931.0 d.	0.0%
24	**WP3: Geo-archaeological studies and mapping**	M. Pourkerman L. Blue K. Schorle	2027-04-19	2028-12-09	601.0 d.	0.0%
25	Ancient harbor mapping		2027-04-19	2028-01-13	270.0 d.	0.0%
26	Landsat images analysis		2027-04-19	2027-09-15	150.0 d.	0.0%
27	Evaluation coastal erosion		2027-09-16	2027-12-14	90.0 d.	0.0%
28	Land use Land changes model running		2027-12-15	2028-10-09	300.0 d.	0.0%
29	Assessing Ancient Site Damages.		2028-10-11	2028-12-09	60.0 d.	0.0%
30	Core analysis		2027-10-16	2028-06-11	240.0 d.	0.0%
31	Evaluation high wave energy periods		2027-06-13	2028-08-10	425.0 d.	0.0%
32	**WP4:Remote Sensing, Data Integration, Analysis and education**	M. Pourkerman H. Nazari N. Karami	2026-02-07	2029-12-31	1424.0 d.	2.8%
33	Modeling		2026-02-07	2026-12-03	300.0 d.	15.0%
34	AI Training		2026-02-08	2027-07-07	515.0 d.	0.0%
35	Mapping		2026-07-07	2027-09-02	423.0 d.	0.0%
36	Transfer of Knowledge		2028-12-04	2029-12-31	393.0 d.	0.0%
37	Publications		2028-01-01	2029-12-01	701.0 d.	0.0%