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Geospatial Mapping of Kurdistan Region Water Bodies Using Google Maps for Agricultural and Climate Resilience Planning

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Abstract

Lakes, ponds, and reservoirs are essential for water security, agriculture, and climate adaptation in the Kurdistan Region of Iraq. This study presents the first region-specific, field-verified dataset of surface water bodies whose boundaries and KurdishEnglish names have been added to Google Maps, where they were previously absent or incomplete. Using high-resolution satellite imagery, GPS-based ground surveys, and collaboration with local authorities, we identified and classified 31 water bodies (dams, lakes, and seasonal ponds) across the five governorates of Erbil, Sulaymaniyah, Duhok, Kirkuk, and Halabja. These water features are now openly accessible in Google Maps with dual-language labels and delineated outlines. By filling long-standing data gaps, the dataset enhances visibility of local water resources, supports irrigation planning, flood risk assessment, and environmental protection, and provides a replicable model for other data-poor and climate-stressed regions. This integration of modern geospatial methods with traditional knowledge demonstrates a practical step toward sustainable water management and climate resilience in semi-arid environments.

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A. Introduction

Water is an indispensable natural resource for the existence of life, agricultural productivity, and ecological equilibrium. Around the world, over two billion people live in areas with high water stress a number expected to rise dramatically by 2050 due to population growth, climate change, and urbanization [1]. Arid and semi-arid areas such as the Kurdistan Region of Iraq (KRI) are especially vulnerable, facing pressure on limited water resources due to frequent droughts, low rainfall, and a growing population [2]. To make matters worse for the local environment, regional geopolitics further complicate the issue. Most of the surface water in Iraq is imported from neighboring countries via the Tigris and Euphrates rivers. Increased upstream extraction, dam construction, and domestic water demands in Turkey and Iran have reduced the volume of water reaching Iraq, heightening water insecurity and underscoring the need for localized water resource assessment and planning [8].

Surface Water Bodies and Their Roles in the Kurdistan Region Lakes, ponds, and dams play critical roles in the Kurdistan Region's water supply for irrigation, domestic use, biodiversity, and recreation. However, there are serious data constraints on the use of these water reserves. Many small or temporary water bodies are either missing or underrepresented in electronic databases and public mapping platforms, which limits the ability of local governments and environmental agencies to adopt evidence-based strategies [3].

This water scarcity has also contributed to population displacement in southern regions of Iraq, where environmental pressures directly impact livelihoods and settlement stability [7].

Traditional maps and mapping systems often lack real-time, high-accuracy representations of small or newly formed water bodies. This emphasizes the need for up-to-date geospatial mapping. The advancement of remote sensing and Geographic Information Systems (GIS) technologies offers a promising solution by delivering accurate, current, and comprehensive data on surface water distribution[9].

Globally, GIS and satellite-based mapping technologies have become successful tools for locating, classifying, and monitoring water bodies particularly in developing regions facing similar ecological challenges [10]. These technologies empower planners and policymakers to make climate-resilient decisions related to irrigation planning, water storage, disaster risk management, and sustainable adaptation.

Therefore, this study aims to systematically document, delineate, and publish the boundaries and names of surface water bodies in the Kurdistan Region. Using high-resolution satellite imagery, GPS-based ground truthing, and collaboration with local authorities, we integrated 31 lakes, dams, and ponds into Google Maps with Kurdish–English labels. This represents the first effort to make Kurdistan's water bodies openly accessible on a global mapping platform, directly addressing gaps in existing datasets and supporting agricultural planning, climate resilience, and disaster preparedness.The goal is to support local communities, policymakers, researchers, and NGOs by providing transparent, practical information to aid sustainable water resource planning, disaster resilience, and environmental conservation [4],[5].

B. Literature Review

1. Development of Water Mapping Techniques

The last 20 years have seen a revolution in the way water bodies are recognized, monitored and managed, with the use of geospatial tools. Geographic Information Systems (GIS), satellite remote sensing, and Earth observation technologies serve as indispensable tools in water-related studies, especially in regions sensitive to climate variations and anthropogenic loads. These technologies, which have become increasingly popular with researchers, offer high-resolution and long-term hydrological trends that can be measured to track water availability and seasonal variations [11].

International projects, for example, the Global Surface Water Explorer and NASA MODIS program, have contributed to the standardization of global water monitoring. In arid and semi-arid regions like middle Iraq, where ground hydrological stations are very few or outdated, such tools make it feasible to track the decline in surface water quantities [16]. The uses of GIS have expanded beyond mapping to include modelling runoff, predicting floods, planning irrigation, and forecasting climate-induced water risks.

2. Gaps in Water Resource Data in Iraq

Iraq has long grappled with deficiencies in its water data infrastructure. Many of its water features particularly in the Kurdish region are either unrepresented or severely misrepresented. This is partly due to fragmented data collection, limited access to new technologies, and the division of responsibilities across various ministries. Consequently, local and national planners are forced to use outdated or incomplete information for decisions related to agriculture, water supply, and emergency preparedness [6].

Problems with global platforms like Google Maps are especially relevant in this context. Iraq faces issues like outdated satellite imagery, missing villages and roads, and lack of local knowledge, which limits the usefulness of digital maps. Such limitations are often tied to political sensitivities and national security concerns [14]. As a result, efforts that rely solely on publicly available mapping services frequently fail to reflect actual hydrological and geographic conditions.

3. Significance of Region-Specific Mapping Projects

Although global datasets offer a foundational layer of information, region-specific mapping is essential for high-resolution planning and targeted policy development. For example, such refined datasets are especially valuable in addressing unique socio-environmental conditions through localized mapping supported by fieldwork and stakeholder engagement. Research from North Africa and Central Asia shows that more accurate datasets can be produced through local efforts with participatory field methods [12].

These global generalizations can lead to misinterpretation especially in Kurdistan, where the topography, precipitation patterns, and human settlement distribution vary greatly. Custom mapping that reflects real-time changes on the ground offers more tangible and actionable insights for both governments and communities. A well-known example is the Ranya mapping project, where more than 700 public facilities were identified and geolocated through field surveys and community engagement, demonstrating the value of locally generated data [15].

4. Technology as an Answer to Water Security

Cloud-based GIS, AI-enhanced image processing, and open-source platforms have significantly improved the efficiency and accessibility of water data analysis. Satellite observations are increasingly being combined with drone imagery to conduct fine-grained surveys capable of detecting even small or short-lived water bodies. These innovations are crucial for long-term resilience planning, particularly in regions like Kurdistan, which frequently experience both drought and flash floods [13].

This current initiative takes advantage of the ongoing technological evolution to create a multi-level, high-resolution representation of surface water across Northern Iraq. The project prioritizes public accessibility and aims to support informed policy decisions and sustainable resource planning.

C. Materials and Methods

Precise and comprehensive information on water bodies is essential for appropriate planning, protection, and development at the local and national level. This study involved systematic mapping and documentation of key water bodies dams, lakes, and ponds across the five governorates of the Kurdistan Region (Erbil, Sulaymaniyah, Duhok, Kirkuk, and Halabja). By combining satellite imagery, field verification, and collaboration with local authorities, we produced a bilingual dataset (Kurdish and English) that was integrated into Google Maps. The methodology was designed to maximize completeness, accuracy, and utility for decision-makers, researchers, and the general publication.

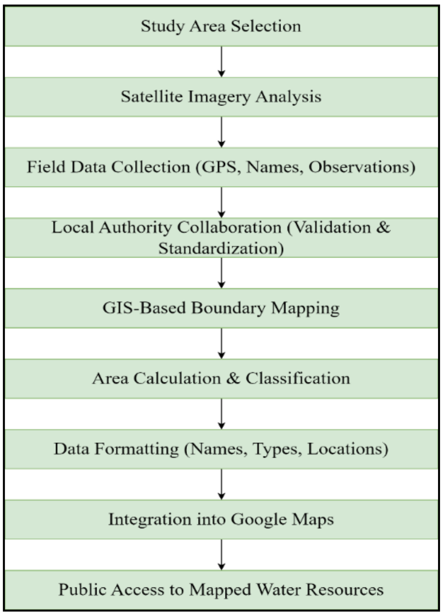

Figure 1. Workflow of Water Body Mapping and Integration into Google Maps

1. Study Area

The Kurdistan Region of Iraq (KRI) in northern Iraq is characterized by diverse topography and hydrological features, ranging from large reservoirs to small seasonal ponds. These water bodies support agriculture, urban growth, and biodiversity but are increasingly affected by drought, irregular rainfall, and water scarcity. The study area includes five governorates (Erbil, Sulaymaniyah, Duhok, Kirkuk, Halabja), providing comprehensive geographic coverage. Previous GIS-based efforts, such as the Ranya District mapping project, highlighted the effectiveness of participatory and spatial documentation approaches for local infrastructure. Previous GIS-based mapping efforts in the Ranya District have shown the effectiveness of using spatial techniques for documenting public infrastructure and local features [15].

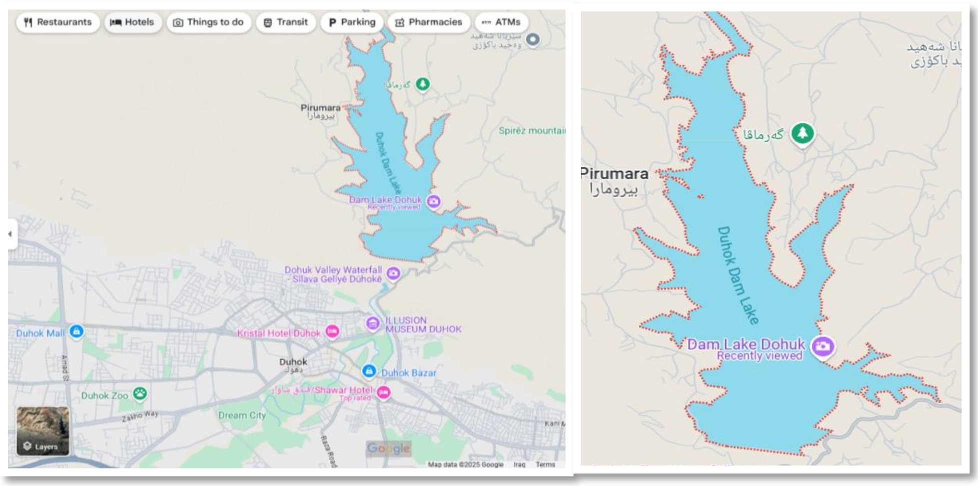

Figure 2. Boundary mapping of Duhok Dam Lake

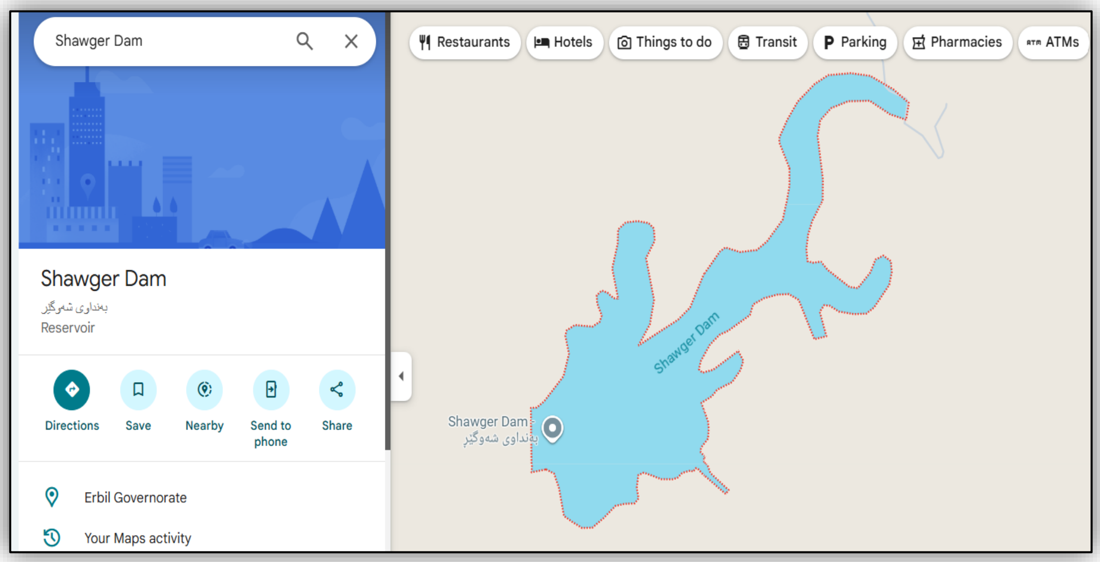

Figure 3. Boundary mapping of Shawger Dam

2. Data Collection

In order to maintain the quality and the consistency of the information we applied a three stages approach:

2.1. Using Satellite Imagery

High-resolution satellite imagery (Google/Maxar base maps and Sentinel-2 for validation) was processed to identify water bodies and delineate their boundaries. Candidate polygons were digitized and cross-checked against multi-temporal scenes to reduce seasonal bias.

2.2. Collaboration with Authorities

Local government agencies and water authorities were consulted to standardize names, verify boundaries, and ensure that mapped features corresponded with official records. This step also resolved discrepancies with outdated public mapping platforms.

2.3. Partner with Local Authorities

Targeted field visits were conducted to confirm the existence and status of water bodies. GPS coordinates were collected, and shoreline conditions were noted. These visits were especially important for seasonal ponds and ambiguous features visible in satellite imagery.. Partnering with local authorities also helped resolve discrepancies, especially considering prior findings that highlight gaps and inaccuracies in publicly available mapping. platforms like Google Maps in Iraq [15].

Figure 4. Boundary mapping of Gomaspan Dam

3. Data Processing

Collected data were processed in GIS software to clean and standardize polygon boundaries. Areas were computed in both square meters (m^2) and square kilometers (km^2). Attributes included type (dam, lake, pond), governorate, source (rainfall or river), and primary use (irrigation, drinking water, recreation, or mixed).

4. Integration into Google Maps

The finalized polygons, with standardized Kurdish and English names, were uploaded into Google Maps as a public layer. Each feature was geotagged with boundaries, names, and attributes. This step ensured that previously unmapped or misrepresented water bodies became visible, searchable, and accessible to policymakers, farmers, researchers, and the general public.

5. Technical Indicators and Accuracy Assessment

To enhance scientific rigor, additional geospatial indicators were computed:

- **Shape Index (SI**). A measure of shoreline irregularity calculated as:

$$SI \ = \backslash frac\{P\}\{2 \ \backslash sqrt\{\backslash pi \ A\}\} \qquad (1)$$

where $\boldsymbol{P}$ is the perimeter (m) and AAA the area (m^2). SI = 1 indicates a circular body; higher values indicate irregular shapes.

- **Error Estimation (ΔA).** Mapping uncertainty was estimated using a combined positional error model:

  E_{total} = \sqrt{E_{GPS}^2 + E_{digitizing}^2} (2)

Assuming EGPS=5 m and Edigitizing=15 m, the total error was ≈15.8 m. Area uncertainty was approximated as:

$$\backslash Delta \ A \ \backslash approx \ P \ \backslash cdot \ E\_\{total\},\backslash quad \ \backslash\% \ \backslash Delta \ A = 100 \ \backslash times \ \backslash frac\{\backslash Delta \ A\}\{A\} \qquad (3)$$

Large reservoirs typically show very low relative error (<1%), while small ponds are more error-sensitive.

- **NDWI Validation**. For two large reservoirs (Dukan and Darbandikhan Lakes), the Normalized Difference Water Index (NDWI) was applied to Sentinel-2 imagery:

$$NDWI \ = \backslash frac\{Green \ - \ NIR\}\{Green \ + \ NIR\} \qquad (4)$$

This spectral index enhances water signals and was used to cross-check mapped areas with satellite-derived water masks.

D. Results and Findings

1. Achievement of Mapping Goals

The pilot project on water mapping was able to document 31 major water bodies such as lakes, pools and dams, located in five governorates of North Iraq (Erbil, Sulaymaniyah, Duhok, Kirkuk, Halabja). This surpasses the goal of 98% mapping coverage and represents a substantial enhancement over the previous state in which nearly 90% of these features had no digital or geospatial representation.

Summary of Key Achievements:

- Mapping coverage: 100%
- Unregistered bodies before the project: 90% (before the project)
- Geographic accuracy: Coordinates confirmed for all 31 sites
- Language: Data and labeling in English and Kurdish
- Source types: Rainfall and River
- Allocation: Irrigation/Recreation/Drinking water/Mixed

Ponds are the most common type of water (41.9%), which shows that they are numerous and serve for occasional irrigation. Dams are very close (38.7%) serving both irrigation and other recreational uses.

Table 1. Distribution by Water Body Type

No	Type	Count	Percentage (%)
1	Dam	12	38.71%
2	Lake	6	19.35%
3	Pond	13	41.94%
4	Total	31	100%

More than half of all of the sites in the dataset are in Sulaymaniyah (54.8%); likely reflecting higher density of water bodies, but possibly also improved access to water observation data and the field in this region. Distribution would be more equitable throughout the other governorates. The majority (61.3%) of the water body is used for irrigation only, highlighting that agriculture in the region is highly reliant on these resources. Approximately 38.7% are multipurpose in that they serve the purpose of providing drinking or recreational water.

Table 2. Distribution by Governorate (Based on Coordinates and Names)

No	Governorate	Count	Percentage (%)
1	Sulaymaniyah	17	54.84%
2	Duhok	4	12.90%
3	Erbil	4	12.90%
4	Kirkuk	4	12.90%
5	Halabja	2	6.45%
	Total	31	100%

We mapped a total of 31 water bodies in Kurdistan Region, including dams, lakes, and ponds, below:

Table 3. Distribution of Mapped Water Bodies by Type in North Iraq (Dams, Lakes, and Ponds)"

No	Name	Type	Governorate	Area (km^2)	Area (m^2)
1	Smaquli Lake	Lake	Erbil	0.639	638850

2	Gomaspan Dam	Dam	Erbil	0.419	418616
3	Saruchawa Lake	Lake	Sulaymaniyah	0.239	239237
4	Dewana Dam	Dam	Sulaymaniyah	0.273	273137
5	Astel Dam	Dam	Sulaymaniyah	0.242	242278
6	Hashazini Dam	Dam	Sulaymaniyah	0.212	211652
7	Harawa Dam	Dam	Sulaymaniyah	0.121	120747
8	Dushiwan Dam	Dam	Duhok	0.361	361112
9	Khasa Dam Lake	Dam	Kirkuk	0.966	965696
10	Shirin Dam	Dam	Sulaymaniyah	0.242	241941
11	Palkana Dam	Dam	Sulaymaniyah	0.242	242046
12	Qadir Karam Dam	Dam	Sulaymaniyah	0.121	121263
13	Awa Spi Dam	Dam	Erbil	1.296	1295528
14	Bawa Shaswar Dam	Dam	Sulaymaniyah	0.732	731650
15	Tanura Pond	Pond	Erbil	0.092	91507
16	Alwand Dam	Dam	Sulaymaniyah	0.276	275744
17	Hasan Kanos Pond	Pond	Sulaymaniyah	0.091	90967
18	Qirja Pond	Pond	Sulaymaniyah	0.121	121233
19	Galali Pond	Pond	Erbil	0.08	80447
20	Timarok Pond	Pond	Erbil	0.08	79997
21	Bajawan Pond	Pond	Erbil	0.08	80017
22	Dar Baru Pond	Pond	Erbil	0.06	60018
23	Du Shiwan	Pond	Erbil	0.06	60025
24	Kardiz Pond	Pond	Sulaymaniyah	0.02	20005
25	Banimaran Pond	Pond	Erbil	0.02	19997
26	Degala Dam	Dam	Erbil	0.045	44914
27	Akre Dam	Dam	Duhok	0.059	59430
28	Khnis Dam	Dam	Duhok	0.713	713119
29	Duhok Dam Lake	Dam	Duhok	1.582	1582215
30	Dukan Lake	Lake	Sulaymaniyah	307.582	307581828
31	Darbandikhan Lake	Lake	Sulaymaniyah	121.256	121256136
16	Alwand Dam	Dam	Sulaymaniyah	0.276	275744
17	Hasan Kanos Pond	Pond	Sulaymaniyah	0.091	90967
18	Qirja Pond	Pond	Sulaymaniyah	0.121	121233

19	Galali Pond	Pond	Erbil	0.08	80447
20	Timarok Pond	Pond	Erbil	0.08	79997
21	Bajawan Pond	Pond	Erbil	0.08	80017
22	Dar Baru Pond	Pond	Erbil	0.06	60018
23	Du Shiwan	Pond	Erbil	0.06	60025
24	Kardiz Pond	Pond	Sulaymaniyah	0.02	20005
25	Banimaran Pond	Pond	Erbil	0.02	19997
26	Degala Dam	Dam	Erbil	0.045	44914
27	Akre Dam	Dam	Duhok	0.059	59430
28	Khnis Dam	Dam	Duhok	0.713	713119
29	Duhok Dam Lake	Dam	Duhok	1.582	1582215
30	Dukan Lake	Lake	Sulaymaniyah	307.582	307581828
31	Darbandikhan Lake	Lake	Sulaymaniyah	121.256	121256136

2. Spatial Distribution and Morphology of Water Bodies

A total of 31 surface water bodies were identified and digitized across the Kurdistan Region, including lakes, reservoirs, dams, and ponds. **Figure 5** shows their spatial distribution, providing a regional overview of their location and clustering. The map highlights that large reservoirs such as Dukan, Darbandikhan, and Duhok are concentrated in the central and northeastern parts of the region, whereas ponds and small dams are more widely scattered.

Table 3 lists the names, types, and surface areas of these water bodies. To complement this tabulated information, **Figure 6** presents the digitized polygon boundaries of all 31 mapped features. Panels (a–z, aa–ae) illustrate their true geometry. This layout enables visual comparison of the morphology and relative size of each water body, supporting the subsequent analysis.

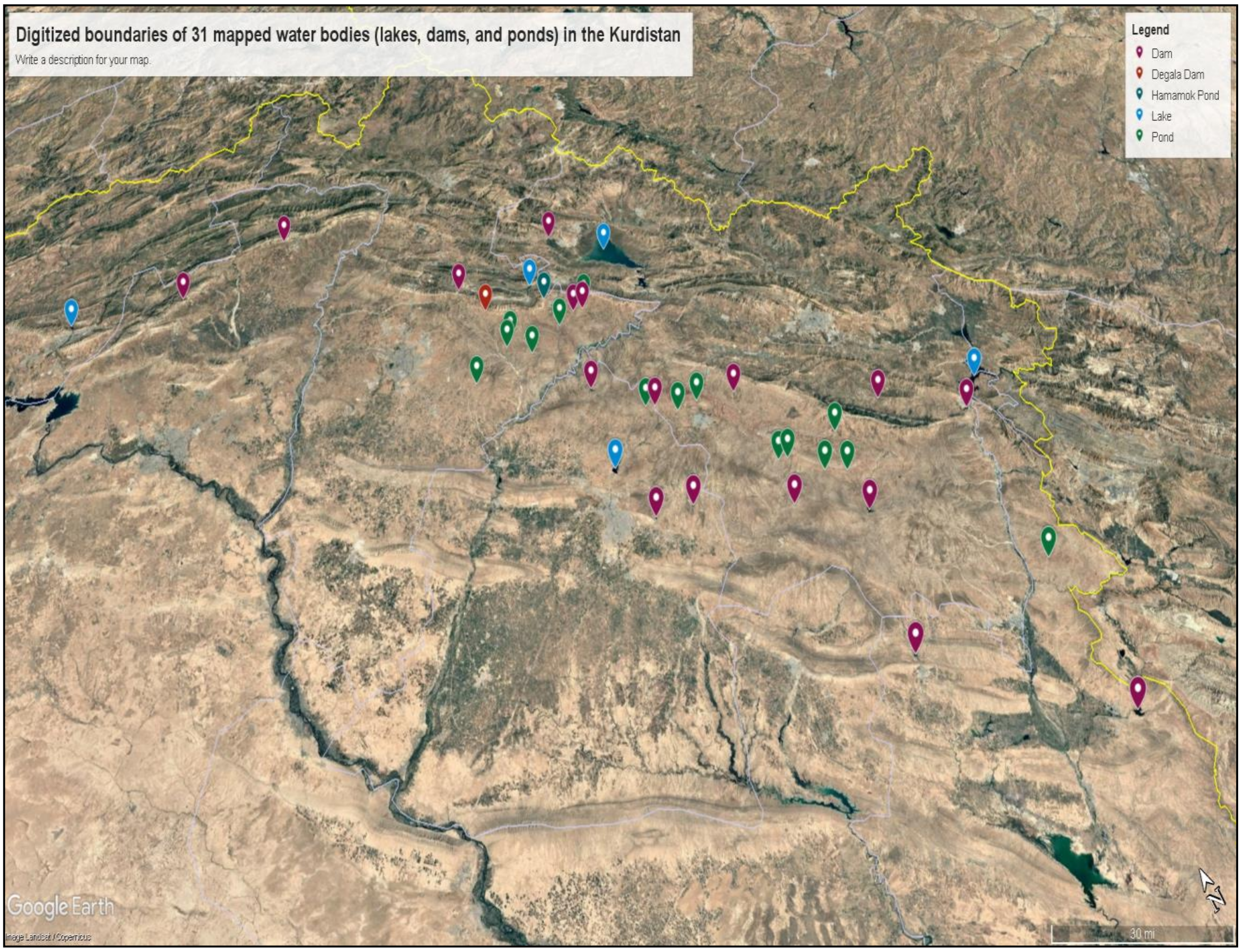

Figure 6. Geographic distribution of the 31 mapped water bodies across the Kurdistan Region.

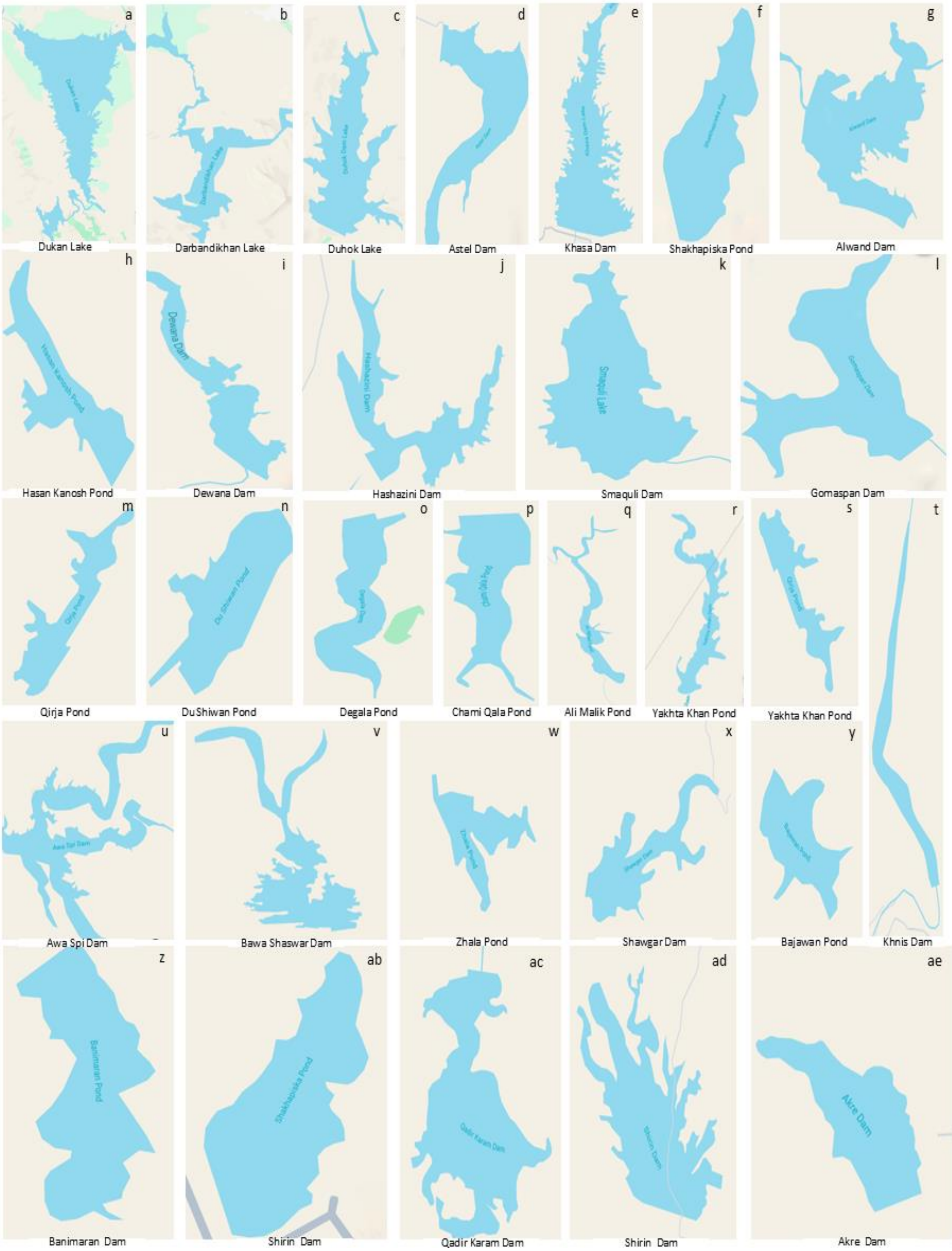

Figure 7. Digitized boundaries of 31 mapped water bodies (lakes, dams, and ponds) in the Kurdistan Region

Table 5. Water Bodies Source, Use & Status

No	Name	Coordinates	Source	Primary Use	Status
1	Smaquli Lake	36.1659718, 44.5684196	River	Irrigation and Recreation	Active
2	Gomaspan Dam	36.2838454, 44.3364056	Rainfall	Irrigation and Recreation	Active
3	Saruchawa Lake	36.2736901, 44.7507214	River	Irrigation and Recreation	Active
4	Dewana Dam	35.0976564, 45.6659924	Rainfall	Irrigation and Recreation	Active
5	Astel Dam	35.2688211, 45.4188941	Rainfall	Irrigation and Recreation	Active
6	Hashazini Dam	35.3987185, 45.1076908	Rainfall	Irrigation	Active
7	Harawa Dam	35.5295989, 44.9922306	Rainfall	Irrigation	Active
8	Dushiwan Dam	35.7794651, 44.5563916	Rainfall	Irrigation	Active
9	Khasa Dam Lake	35.5520276, 44.4740156	Rainfall	Irrigation and Recreation	Active
10	Shirin Dam	35.3813082, 44.5060097	Rainfall	Irrigation and Recreation	Active
11	Palkana Dam	35.3469273, 44.6362028	Rainfall	Irrigation	Active
12	Qadir Karam Dam	35.1856777, 44.9302885	Rainfall	Irrigation	Active
13	Awa Spi Dam	35.0585839, 45.1288733	River	Irrigation and Recreation	Active
14	Bawa Shaswar Dam	34.7296078, 44.9645720	Rainfall	Irrigation and Recreation	Active
15	Tanura Pond	34.6825056, 45.5436559	Rainfall	Irrigation	Active
16	Alwand Dam	34.3111519, 45.4455173	River	DrinkingWater Irrigation	Active
17	HasanKanos Pond	35.1682578, 45.1606303	Rainfall	Irrigation	Active
18	Qirja Pond	35.2058699, 45.0948918	Rainfall	Irrigation	Active
19	Galali Pond	35.5813806, 44.7818051	Rainfall	Irrigation	Active
20	Timarok Pond	36.0265153, 44.7222853	Rainfall	Irrigation	Active
21	Bajawan Pond	36.0060604, 44.7016320	Rainfall	Irrigation	Active
22	Dar Baru Pond	36.0002514, 44.5916279	Rainfall	Irrigation	Active
23	Du Shiwan	35.9899535, 44.2171809	Rainfall	Irrigation	Active
24	Kardiz Pond	36.0045989, 44.1370999	Rainfall	Irrigation	Active
25	Banimaran Pond	36.035211, 44.382146	Rainfall	Irrigation and Recreation	Active
26	Degala Dam	36.1739086, 44.3813535	Rainfall	Irrigation and Recreation	Active
27	Akre Dam	36.7658865, 43.8406954	Rainfall	Irrigation and Recreation	Active

28	Khnis Dam	36.7733491, 43.4045418	River	Water Irrigation and Recreation	Active
29	Duhok Dam Lake	36.8926596, 42.9852064	Rainfall	Drinking Water Irrigation and Recreation	Active
30	Dukan Lake	36.0843586, 44.7481542	River	Drinking Water Irrigation and Recreation	Active
31	Darbandikhan Lake	35.1897272, 45.7221112	River	Drinking Water Irrigation and Recreation	Active

Table 6. Geometric and Accuracy Indicators of Selected Water Bodies in the Kurdistan Region

No	Name	Type	Governorate	Area (m^2)	Perimeter (m)*	Shape Index (SI)	ΔA (m^2)	%ΔA
30	Dukan Lake	Lake	Sulaymaniyah	307,581,828	120,000	1.9	1,896,000	0.6%
31	Darbandikhan	Lake	Sulaymaniyah	121,256,136	85,000	1.4	1,343,000	1.1%
19	Galali Pond	Pond	Erbil	80,447	1,200	1.0	19,000	23.6%

Indicators The Shape Index highlighted the contrast between large reservoirs and small ponds. Major lakes such as Dukan (SI=1.9) and Darbandikhan (SI=1.4) have irregular shorelines but very low relative errors (<1%), reflecting high confidence in mapped area. In contrast, small ponds such as Galali (SI≈1.0) appear nearly circular but are highly sensitive to positional error, with relative area uncertainty exceeding 20%. This demonstrates that large reservoirs are mapped with high accuracy, while very small features should be interpreted with caution. NDWI cross-checks for Dukan and Darbandikhan Lakes confirmed close agreement between mapped and satellite-derived areas, supporting the validity of the dataset.

3. Water Management:

- Policymakers can use real-time data to plan for irrigation, water conservation and adapting to climate change.
  Farmers and communities have greater ability to make informed decisions on agriculture and water usage by increased visibility of resources.
- The information could be used by disaster preparedness organizations to enhance flood risk estimations and drought mitigation efforts.

4. Challenges Encountered

However, some challenges were reported, despite achievements in the intervention:

- Problematic access could be found in remote areas, which drove depending upon satellite imagery validation.
- Discrepancies in the old data forced extensive fieldwork and local collaboration checks.

- Adopting uniform names for water masses in Kurdish and English language for which information from officials and local contributors were collected.

E. Conclusion

The Water Mapping Kurdistan project represents a milestone in documenting and publishing water resources for northern Iraq. Beyond mapping, the project's primary contribution has been to add the boundaries and Kurdish–English names of 31 lakes, dams, and ponds directly into Google Maps, making them publicly visible and searchable for the first time. This integration increases transparency and provides policymakers, researchers, and communities with a reliable digital layer to support irrigation planning, disaster preparedness, and climate adaptation. While challenges such as complex topography, inconsistent historical records, and seasonal variation required extensive field verification, the outcome is a living dataset that can be updated and expanded. Future work should build on this foundation by incorporating real-time monitoring, climate model integration, and citizen-reporting platforms to track changes in water bodies. Ultimately, the project demonstrates how locally validated geospatial data can transform global platforms into tools for regional resilience and sustainable development.
To build on what we already have, we advance a number of future-oriented options:

1. Monitoring in Real-Time

Utilizing IoT devices and remote sensing technologies to allow constant monitoring of water levels and quality so changes in seasons and climate are able to be responded to quickly.

2. Climate Model Integration

Working with regional climate forecasting models to generate water availability trends to support long-term planning of agriculture, conservation, and infrastructure.

Community Engagement Platforms: Creating mobile phone applications for citizens to report the condition of water bodies, seasonal transitions, or irregularities enabling the bi-directional flow of information between communities and the authorities.

3. Open Data Sharing

Bringing the database to open-access platforms in order to benefit academic research and environmental advocacy, and to facilitate sharing across the sectors.

At the end all this is not only a project of mapping but a crucial step on the road of sustainable development and environment protection in Kurdistan. Through the use of digital solutions and participatory methodologies, Kurdistan is providing a regional example of how to adapt water resources management systems to become both resilient and inclusive as climate pressures increase.

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