International Journal of Early Childhood Special Education (INT-JECSE)
DOI: 10.48047/INTJECSE/V14I6.352 ISSN: 1308-5581 Vol 14, Issue 06 2022

ANALYZING THE CONVENTIONAL AND REMOTE SENSING DATA ON AREAS OF WATER HARVESTING FOR AGRICULTURE

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ABSTRACT

Little reservoirs are a common way for farmers to deal with the semiarid climate's short rainy season and extended dry spells. Certain areas, like the villages of South India, small tanks for storing rainwater have been used for this purpose from ancient times. Monitoring the water volume changes on a regular basis is essential for the effectiveness of the revitalization activities and tank management. This paper presents a New method for measuring water storage capacity in reservoirs ranging from 5 to 80 hectares in the Gundar river basin in the southern Indian state of Tamil Nadu. Because of this uncertainty, the use of effective agricultural practices is crucial to the success of farmers in securing their food supply, income, and standard of living. Water harvesting, a method of agricultural water conservation, is being used to boost crop yields in sub-Saharan Africa. In addition to improving water productivity, these methods have also been demonstrated to enhance nitrogen levels and organic matter in the soil. In this study, we utilize satellite images with a high enough resolution to distinguish between farms that use traditional farming and those that employ water collecting techniques.

KEYWORDS Water Harvesting, Remote Sensing, agriculture, Remote sensing Data

INTRODUCTION

Instead of letting rainwater run off, "rainwater harvesting" (RWH) captures and stores it for later use. A percolating reservoir, aquifer, or deep pit (well, shaft, or borehole) collects rainwater from a roof or similar surface and allows it to seep underground to replenish aquifers or the ground water. You may use nets or other instruments to gather dew and fog as well. The difference between rainwater collecting and stormwater harvesting lies in the source of the gathered water. The water may be used for a variety of purposes, such as gardening, watering cattle, irrigating crops, and even heating homes after adequate treatment. In a dry region with an average annual precipitation of 150 millimeters, for instance, a 4-hectare plot of land would not be able to sustainably grow a crop. There will be a total of 300 millimeters of precipitation if the two hectares that make up one half of the region provide their part of 150 millimeters to the other half. Perhaps enough to sustain drought-tolerant plant life. Even more so, With the help of the other three hectares, the fourth hectare might get an additional 300 millimetres of rain, bringing the total quantity of precipitation to 600 millimetres (450 mm).The right distribution of this might be enough to grow a broad variety of crops. Of fact, in practice, it may only be possible to divert a small fraction of this water with little difficulty or expense.

The collected water may potentially be used to replenish aquifers or for other long-term storage projects. Rainwater collection helps mitigate the destructive effects of storm water and floods on urban farms. Building temperatures may be reduced by more than 1.3 degrees Celsius when urban "green" roofs are combined with rainwater catchments. The United Nations' Sustainable Development Goals for better air quality, better health, and more reliable food and water supplies might all be advanced by the combination of rainwater gathering and urban gardening (Sustainable Development Goal 6). While the technology exists, it must be adapted before it can be used effectively to reduce water waste in metropolitan areas.

LITERATURE REVIEW

Shaho Noori et.al (2022) Long-term drought, water shortages, and certain random flood episodes have all resulted from the combined consequences of human-caused shifts in water consumption and climate change. The northern part of Iraq has been hit hard by these in recent decades. Especially in dry and semiarid regions, water resource management has emerged as a crucial component in finding a solution to this problem. The collected water might be used for human, household, and animal consumption and needs. And it's a precious commodity for irrigating farmland. The purpose of this research is to locate promising areas in the Sulaimaniyah province of Iraqi Kurdistan for the collection of rainwater for later use. Remote sensing, GIS methods, and multi-criterion decision making have all been used in these procedures (MCDM). The AHP model has been used to identify optimal water collecting sites. Runoff, slope, soil type, land cover, and drainage density were all taken into account. The relative importance of each consideration is calculated. According to the data, about 32% of the landmass is in a prime location for water collecting and is considered exceptional. Important and helpful for future water resource management is the model used here.

Yalembrhan Debebe et.al (2022) Tigray, in northern Ethiopia, is home to many small holder farmers who face severe difficulties due to water shortages and soil degradation. In semi-arid places like Tigray, both excessive and insufficient precipitation may be detrimental to agricultural production. Short but severe downpours not only generate runoff, which washes away vital soil nutrients, but also fail to provide enough water to sustain crop development, leading to crop failure. Micro- and macro-catchment rainwater collecting systems, if well planned in advance, may solve the problems of water shortages and soil erosion. The goal of this study was to use weighted overlay analysis as a means of locating promising areas for rainwater harvesting (rwh). In addition, the Kilte Awlaelo district in eastern Tigray uses Ahp (analytical hierarchy process) as an efficient multi-criterion decision-making method across an area of 1001 km2. This approach was selected because it meets our needs perfectly: it is easy to use, cheap, adaptable, and widely used. The selection criteria took into consideration physical, hydrological, climatic, and socioeconomic factors. According to the study's results, 8.74% of the land was found to be optimal (85.25 km2), while 56.1% was deemed acceptable (550.75 km2), 30.8% was deemed fairly optimal (303.2 km2), and 4.56 percent was deemed less optimal (43.87 km2). Finally, several strategies for water collection from both small and large catchments are suggested, with the importance and relative size of each criterion and sub-criterion being tailored to the specific set of suitable sites that have been identified. Rwh experts, local and international groups working on soil water conservation projects, and policymakers may all utilise this method as a decision-making tool in the early stages of planning.

Tanha Talaviya et.al (2020) Agriculture is a vital part of the economy. The widespread use of agricultural automation is a topic of increasing interest and urgency. There has been a dramatic rise in the number of people in the world, and with that has come a rise in the need for both food and people to work. Farmers' time-tested practices weren't cutting it anymore when it came to meeting these standards. Because of this, modern automated techniques have emerged. These innovative practices not only supplied the food needs, but also gave billions of people a chance to work. The use of AI has sparked a revolution in the farming industry. This innovation has mitigated the effects of climate change, population increase, labor market instability, and food insecurity on agricultural output. The major objective of this research is to undertake a comprehensive inventory of AI applications in farming, including but not limited to the use of sensors and other technologies embedded in robots and drones for irrigation, weeding, and spraying. As a result of these advancements, less water, pesticides, and herbicides are needed, the soil's fertility is preserved, labor is used more effectively, and output and quality are both raised. This publication synthesizes the findings of several studies to provide a high-level overview of the state of automated weeding systems using robots and drones in modern agriculture. It discusses two automated weeding approaches and the different soil water sensing techniques. Drones and the several methods used by drones for spraying and monitoring crops are discussed.

P. Shanmugapriya et.al (2019) The use of remote sensing for agronomic research has several benefits. Evaluation of crop canopies in agriculture has led to key discoveries about agronomic factors. Classifying crops, keeping an eye on them, and estimating their production are all made much easier with the help of remote sensing. Because of the frequent shifts in soil, climate, and other physico-chemical parameters, remote sensing is crucial in agronomic research. Strong seasonal trends are seen in the monitoring of agricultural production systems in connection to the biological life cycle of crops. All of these characteristics exhibit a significant degree of spatial and temporal variability. In addition, the agricultural output might shift rapidly due to unfavorable growth circumstances. Timely monitoring is essential for agricultural systems. A strong tool for timely monitoring and delivering a detailed image of the agricultural industry is high-revisit frequency, high-accuracy remote sensing. All the elements impacting the agricultural sector need to be analyzed on a spatial and temporal basis for sustainable agricultural management. Remote sensing, along with other cutting-edge technologies like GPS and GIS, is having a significant impact on the evaluation and management of farming operations worldwide. For the sake of keeping agricultural systems sustainable and boosting national economic growth, These tools have many potential applications in agriculture, such as: yield estimation; weather forecasting; crop monitoring; soil moisture estimation; evaluation of soil fertility; detection of crop stress; detection of diseases and pest infestation; monitoring of drought and flood conditions; and detection of crop stress.

Bhau Gavit et.al (2018) Having access to clean water is crucial for the well-being of all forms of life. In hydrogeology, a watershed is a hydrogeological unit defined by ridge lines that drain into a single body of water. A digital elevation model (DEM) is any three-dimensional (3D) depiction of the topographic relief of an area. The geographical resolution and number of DEM providers are also up for grabs. The ASTER DEM is one of the public domain DEMs. Taking use of rainwater is crucial in this day and age of increasing water shortage. Rainfall patterns, terrain, LULC, and soil type all play a role in determining the best method of water collection. Bundling, pitting, rainfall harvesting, water harvesting, floodwater recharging, and recharging the groundwater all fall under the umbrella of water harvesting conditions. This research demonstrates the usefulness of GIS and remote sensing in determining the viability of rainwater collection systems. The area being studied is the Punad watershed in the district of Nashik

(India). ASTER Digital Elevation Model, LISS-III image, SOI toposheet, soil, precipitation, and other data are utilized. Around 290 square kilometers are included in the investigation. There are two toposheets, 46 H/14 and 46 L/2, that include the watershed. The Kalwan tahsil typically receives about 780 millimeters of precipitation each year. ASTER DEM was used to create maps of the drainage system and slope, while toposheet data was used to create maps of land use and land cover change, transportation networks, and human settlements. There are three levels of slope intensity: steep, intermediate, and gentle. These maps were then used in a geographic information system (GIS) to identify prospective rainwater gathering locations. It was determined where in the research area to place a percolation tank and a check dam by following the recommendations set out by the IMSD.

METHODS

Remote sensing analysis

Throughout each research location, Quickbird (QB) pictures were used to scan both water-harvesting and conventional farms. This research compared typical farms to those that also incorporated water gathering techniques. Past footage from Google Earth was utilized to confirm agricultural activity throughout the growing season. Zai pits, furrow bands, contour stone-bunds, and catchment ponds were used to identify farms that use water gathering. To distinguish conventional farms, we looked for obvious water collection systems (Fig. 1). In this research, 500 farms were categorized as either traditional or water harvesting. Farms that were digitized were transformed to centroid points so that further data could be extracted from the data. Without on-the-ground observations, farm types may have been misidentified; however, thanks to the utilization of high-resolution images (1 m), this was not the case.

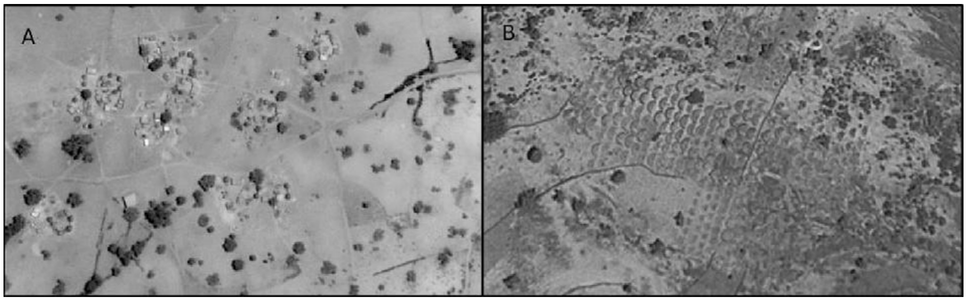


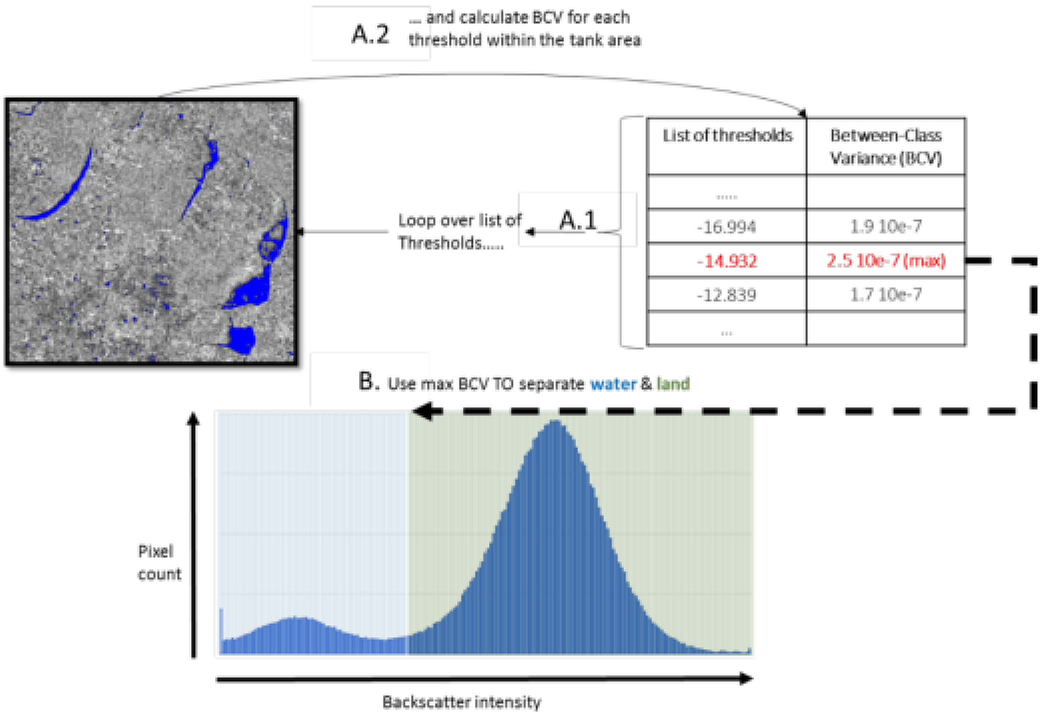
Fig. 1. Quick Bird image subsets displaying farming methods

lets the image analyzer see water collecting structures, increasing the likelihood that the classification of each farm type is accurate. The images from Landsat 8 OLI was collected between May and November of 2013. Each farm had an NDVI overlay applied to it, calculated using data from the OLI photos. Each farm with no overgrown bushes or trees had its NDVI measured. To provide a fair comparison between conventional and water-harvesting farms, NDVI readings were collected at the beginning of May. Maximum NDVI for plant growth in farms was calculated using the highest NDVI reading taken throughout the growing season.

Surface water estimation

Using SAR data for SW retrieval has been the focus of certain studies. SAR data is useful for SW monitoring in cloudy monsoon circumstances because to its all-weather capability and moderate-high spatial resolution. Simple threshold-based processes based on images of histograms are extensively used for SW estimates in operations. Automatically determining a threshold value is a crucial part of the thresholding procedure. Since it can be easily adapted to the GEE setting, the Otsu (1979) approach was chosen. Iterating through all potential threshold values for a histogram, the algorithm divides the data set into n classes (per scene).

The SAR data was processed to create a tank mask buffer of 200 m around each tank for SW retrievals. Each masked SAR picture has its own threshold (VV and VH polarization) generated by running the Otsu algorithm. To reduce the impact of the incidence angle on the threshold selection procedure, a unique local threshold was chosen for each tank in each satellite image. Pixels below the Otsu-defined threshold were masked, and water was assigned to them, while pixels above the threshold were given land. After transforming each picture into a vector file, the SW area of each resulting vector was determined.



List of thresholds	Between-Class Variance (BCV)
.....	
-16.994	1.9 10e-7
-14.932	2.5 10e-7 (max)
-12.839	1.7 10e-7
...	

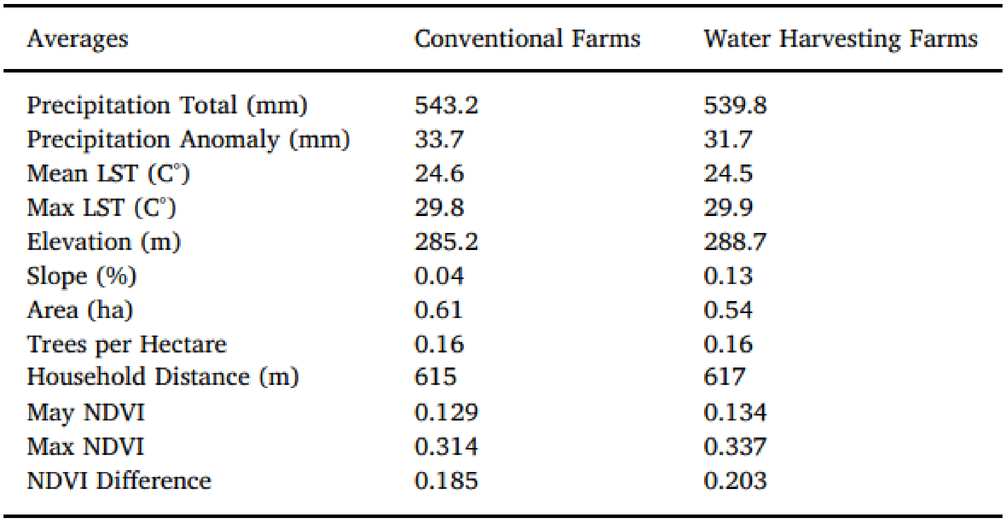
Figure 2: Concept of the implemented Otsu method to separate water from land in tanks.

DATA ANALYSIS

There are a total of 1,000 farms shown here; 500 are conventional and 500 are water-harvesting. The maximum NDVI for farms using any water collection technology is greater than the average for farms using traditional methods. In this research, the usage of stone strips for water gathering was most common. Combining several water collecting methods into a single system was typical practice. Table 1 displays the mean values for a variety of environmental parameters on conventional and water-harvesting farms. Maximum LST, mean LST, height, slope, tree density, and average home distance were all about the same for conventional and water collecting farms. Farms that used water collection techniques saw a decrease in rainfall and shrank marginally in size compared to their traditional counterparts. Differential NDVI values between May and the peak of the growing season were greater in water-harvesting farms than in those of conventional farms.

There was no statistically significant difference in NDVI values between the two farming practises, as determined by a control matched paired t-test performed at the start of the growing season. Maximum NDVI for farms using water collection techniques in 2013 was considerably (p 0.005) higher. Farms that used water harvesting had an average maximum NDVI that was 0.023 points higher than farms that didn't. This is in line with earlier on-the-ground production assessments comparing water and traditional farming techniques, however the difference is rather tiny compared to the seasonal variation in NDVI.

Table 1 Numerical environmental averages for conventional and water harvesting farms.



Averages	Conventional Farms	Water Harvesting Farms
Precipitation Total (mm)	543.2	539.8
Precipitation Anomaly (mm)	33.7	31.7
Mean LST (C°)	24.6	24.5
Max LST (C°)	29.8	29.9
Elevation (m)	285.2	288.7
Slope (%)	0.04	0.13
Area (ha)	0.61	0.54
Trees per Hectare	0.16	0.16
Household Distance (m)	615	617
May NDVI	0.129	0.134
Max NDVI	0.314	0.337
NDVI Difference	0.185	0.203

Validation of bathymetry and SW area

In Table 2, we can see a summary of the differences between the TanDEM-X DEM and the four tanks that were physically examined. TanDEM-digital X's elevation model (DEM) and field heights had a mean absolute error (MAE) and root mean square error (RMSE) of 0.67 to 0.86 and 0.98 to 1.47 metres, respectively, for the four tanks.

Table 2: Comparing the TanDEM-X DEM to topographic field measurements

Site	Mean Absolute Error (m)	Standard Deviation (m)	RMSE (m)	Area Storage Relationship	
				$V = a \times A^b$ from field (F) & TanDEM-X (T) data	R^2
Tank 1	0.67	1.22	0.98	(F) $V = 0.00061 \times A^{1.660}$ (T) $V = 0.00042 \times A^{1.693}$	97.35 97.34
Tank 2	0.86	1.72	1.47	(F) $V = 0.00107 \times A^{1.651}$ (T) $V = 0.00156 \times A^{1.542}$	90.32 95.83
Tank 3	0.76	1.12	0.89	(F) $V = 0.00021 \times A^{1.601}$ (T) $V = 0.00035 \times A^{1.590}$	93.78 91.89
Tank 4	0.80	1.50	1.26	(F) $V = 0.00861 \times A^{1.212}$ (T) $V = 0.00876 \times A^{1.251}$	96.42 95.33

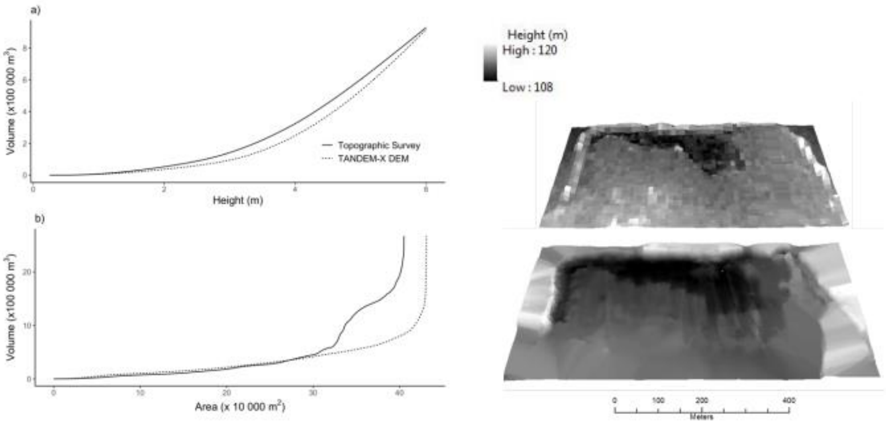


Figure 2: TanDEM-X DEM compared to the field DEM for tank 1.

Classifications based on VV polarized images were more highly correlated with the reference water mask than those based on VH polarized images were (96% vs. 91%), showing the greater sensitivity of the VV polarization to the presence of SW in tanks, as part of the SW area extraction process. In addition, for a set of SW-based pixels, we discovered no statistically significant relationship between the backscatter incidence angle and the backscatter coefficient (see Appendix F, Figure F2).

Table 3 presents 2017 estimates for the SW region (8.55 km2) based on photos from both the PS and S1-A satellites and 111 tanks. These containers were chosen because they would have water in them throughout the times of observation. S1-A was determined to be a 27% (2.28 km2) underestimate of overall SW coverage (Table 3). The MAPE differed greatly across the 111 tanks when comparing SW estimations at the tank level. Diagram 3. An RMSE of 30,540 m2 was found for S1-A SW calculations, This is equivalent to a volume of 27,741 m3 (Table 3). The MAPE for the Southwest's landmass was between 37% and 84%, and for its volume, it was between 47% and 71%. The high MAPE for the SW region is troublesome since this inaccuracy will translate to an even larger percentage volume mistake due to the power connection between reservoir area and volume.

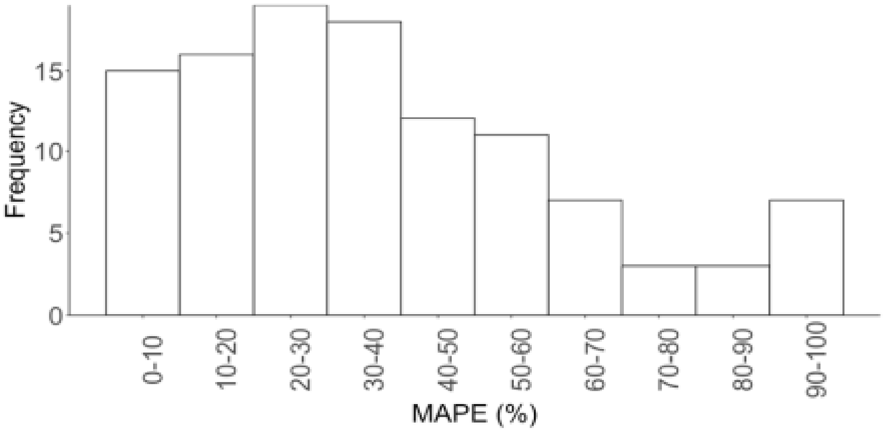
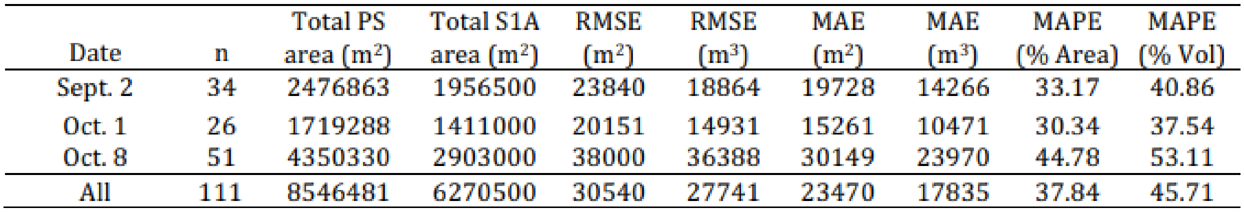


Figure 3: Histogram of MAPE for SW areas in 111 tanks

Table 3: Accuracy of 111 tank SW extents and volume equivalents from S1-A and PS data.



Date	n	Total PS area (m²)	Total S1A area (m²)	RMSE (m²)	RMSE (m³)	MAE (m²)	MAE (m³)	MAPE (% Area)	MAPE (% Vol)
Sept. 2	34	2476863	1956500	23840	18864	19728	14266	33.17	40.86
Oct. 1	26	1719288	1411000	20151	14931	15261	10471	30.34	37.54
Oct. 8	51	4350330	2903000	38000	36388	30149	23970	44.78	53.11
All	111	8546481	6270500	30540	27741	23470	17835	37.84	45.71

CONCLUSION

Understanding water availability across scales was greatly aided by spatial data on SW distribution in the Gundar Basin. The first use of radar data with a high-resolution global DEM for tank monitoring gives proof of concept in this area, but with significant limitations. Combining tank bathymetry with S1-A SAR data and a power model, the findings show that time-series volume estimations may be computed. This research compared water-harvesting farms to conventional farms in terms of their maximum NDVI as a function of environmental factors. High-resolution images were important in this study's ability to distinguish between the various water-harvesting strategies used. Farmers in rural areas of Burkina Faso have benefited from the increased production potential made possible by water collection practices. Better crop yields from using modern farming methods will help alleviate poverty in rural areas, and farmers will be less likely to be affected by weather extremes like drought and floods.

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