Assessing the Potential of Satellite-Retrieved and Global Land Data Assimilation System-Simulated Soil Moisture Datasets for Soil Moisture Mapping in Bangladesh

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January 17, 2023

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November 24, 2022

Abstract

Soil moisture plays an essential role in the complex eco-hydrologic processes, such as infiltration, rainfall-evapotranspiration-runoff circulation, photosynthesis, and groundwater recharge. However, the accurate estimation of soil moisture (SM) at regional or larger scale is difficult because SM varies highly over space and time due to heterogeneous land cover and soil properties, and ground measurements are often time-consuming and expensive. Currently, Bangladesh Meteorological Department (BMD) measures SM only at twelve stations which is quite inadequate for assessing large-scale spatial and temporal variation of SM. Thus, satellite-derived soil moisture data products or Global Land Data Assimilation System simulated (GLDAS-2.2) soil moisture dataset with the Gravity Recovery and Climate Experiment Data Assimilation (GRACE-DA) can be promising alternatives to the in-situ measurement for this data-scarce region. In this study, the spatial and temporal variations of SM from GLDAS and Soil Moisture Active Passive (SMAP) satellite were compared against the in-situ measurements from seven agrometeorological stations of Bangladesh. The GLDAS and SMAP products overpredicted the in-situ SM for most of the stations and could capture the temporal dynamics of observed SM with correlation coefficient (R) of 0.36 and 0.17, respectively. Later an Artificial Neural Network model was developed based on soil moisture from both sources (SMAP and GLDAS) and terrestrial water storage from GLDAS to obtain more accurate estimation of SM for this data-scarce region. The ANN model shows an improvement in estimation and predicted SM with R = 0.63 (considering all stations). The results were more promising when separate model is developed for each study site. Incorporating additional climate data (such as precipitation with different lag times) as input improved the accuracy marginally. This study suggests that the release of daily GRACE gravity field solutions in near-real-time may provide a reasonable and continuous estimate of soil moisture in this data-scarce region.

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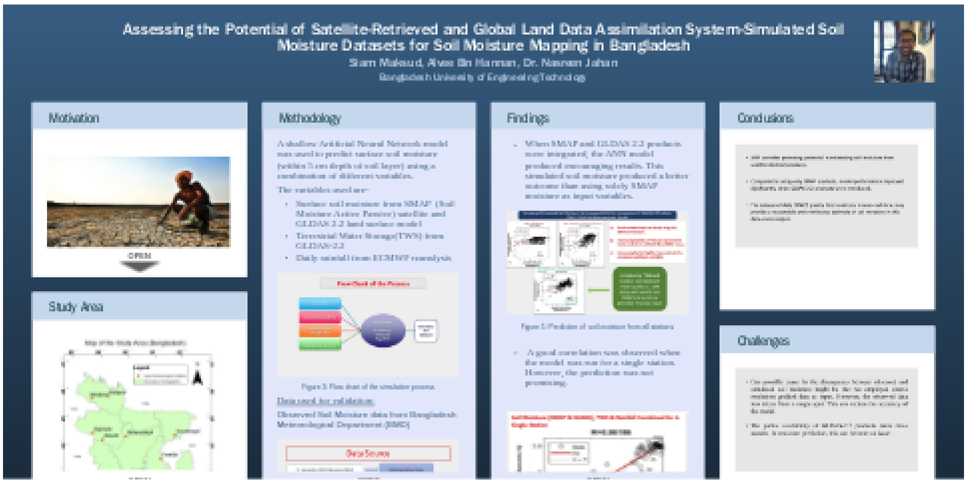

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PRESENTED AT:

MOTIVATION

Figure 1: Effect of Climate Change on Agricultural Lands of Bangladesh

- Bangladesh is a South Asian country located in a region vulnerable to climate change. The country is witnessing irregular weather patterns, as well as a consistent rise in temperature and precipitation.
- ·Soil Moisture is an important climate variable to understand and predict extreme events which can provide early warnings of these events and help the country mitigate the effect of climate change.
- In Bangladesh, the measurement of soil moisture is limited to only a few climate stations. The field measurement of the data is also done weekly.
- To avoid these problems, satellite-derived products can be cheap and useful alternatives to the field measurements
- In this study, we accessed the use of satellite-derived products to predict soil moisture in the real field.

STUDY AREA

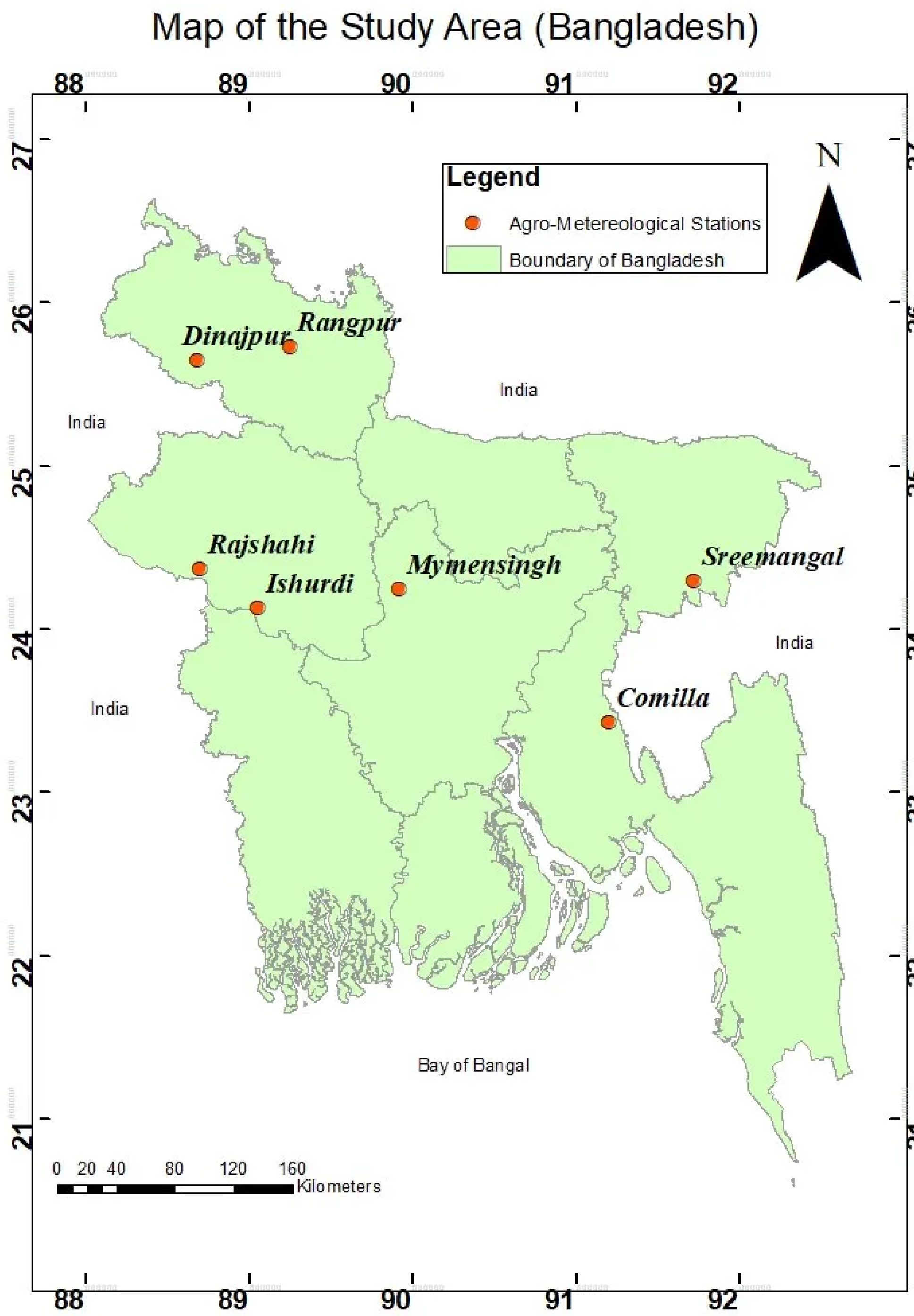

Figure 2: Locations of the study sites.

- The study was conducted in seven different Meteorological stations all over Bangladesh.
- Within the seven stations, five are situated in the northwest region. This region is arider compared to the other areas of the country.

METHODOLOGY

A shallow Artificial Neural Network model was used to predict surface soil moisture (within 5 cm depth of soil layer) using a combination of different variables.

The variables used are-

- Surface soil moisture from SMAP (Soil Moisture Active Passive) satellite and GLDAS 2.2 land surface model
- Terrestrial Water Storage(TWS) from GLDAS-2.2
- Daily rainfall from ECMWF reanalysis

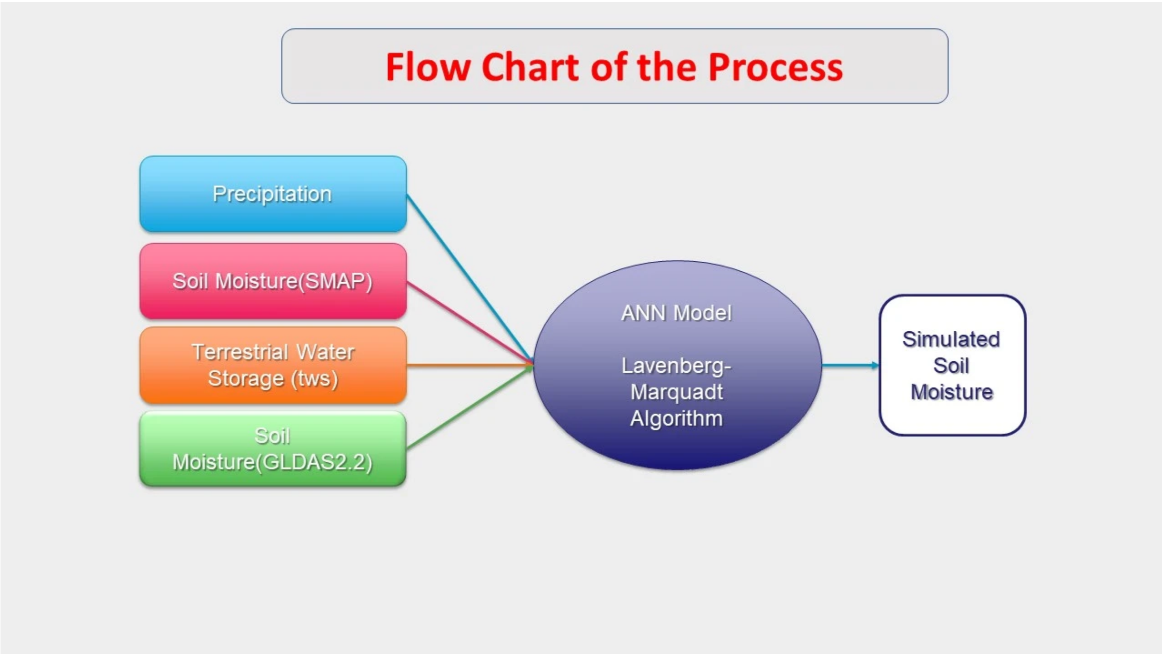

Figure 3: Flow chart of the simulation process

<u>Data used for validation:</u>

Observed Soil Moisture data from Bangladesh Meteorological Department (BMD)

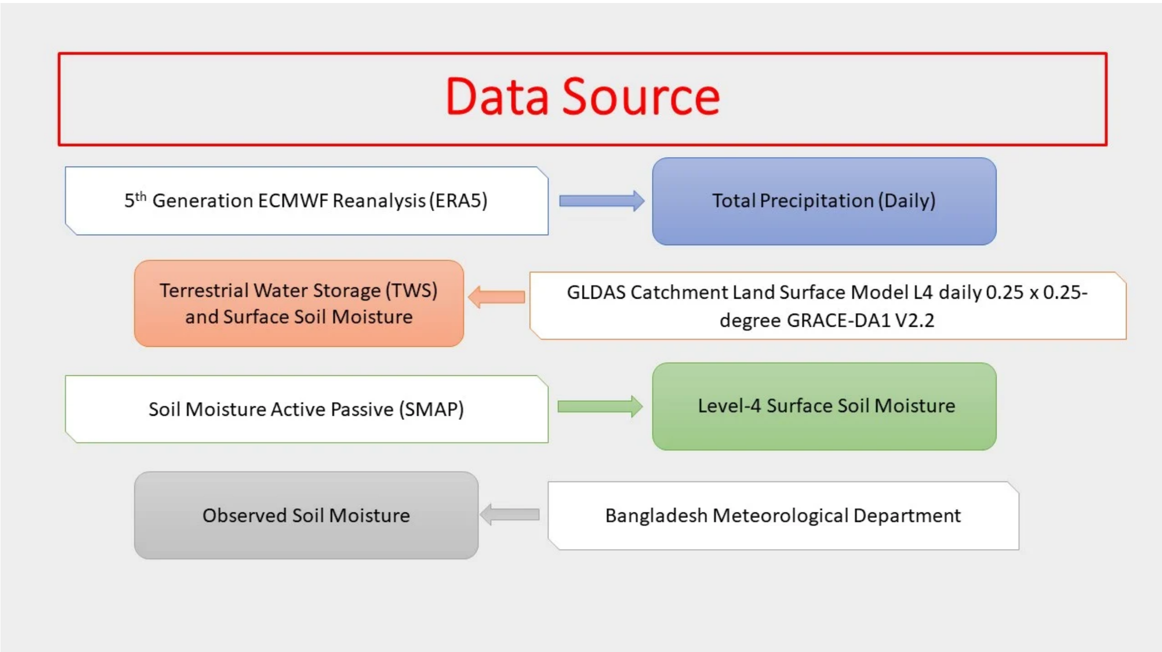

Figure 4: Source of the used data

FINDINGS

- When SMAP and GLDAS 2.2 products were integrated, the ANN model produced encouraging results. This simulated soil moisture produced a better outcome than using solely SMAP moisture as input variables.

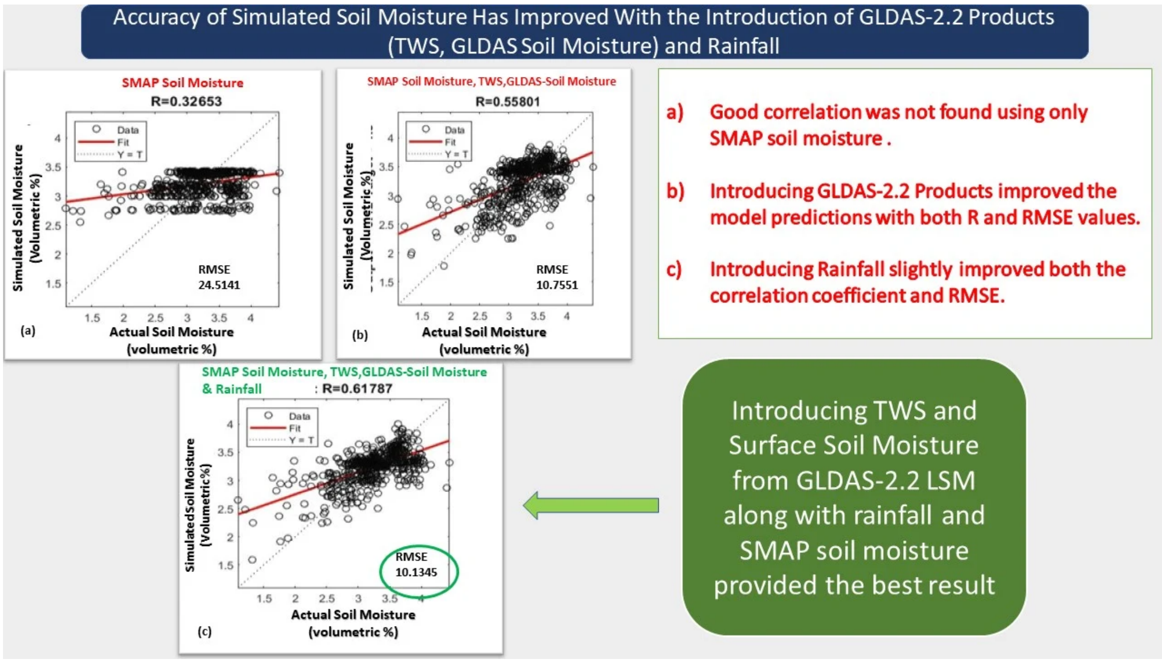

Figure 5: Prediction of soil moisture from all stations

- A good correlation was observed when the model was run for a single station. However, the prediction was not promising.

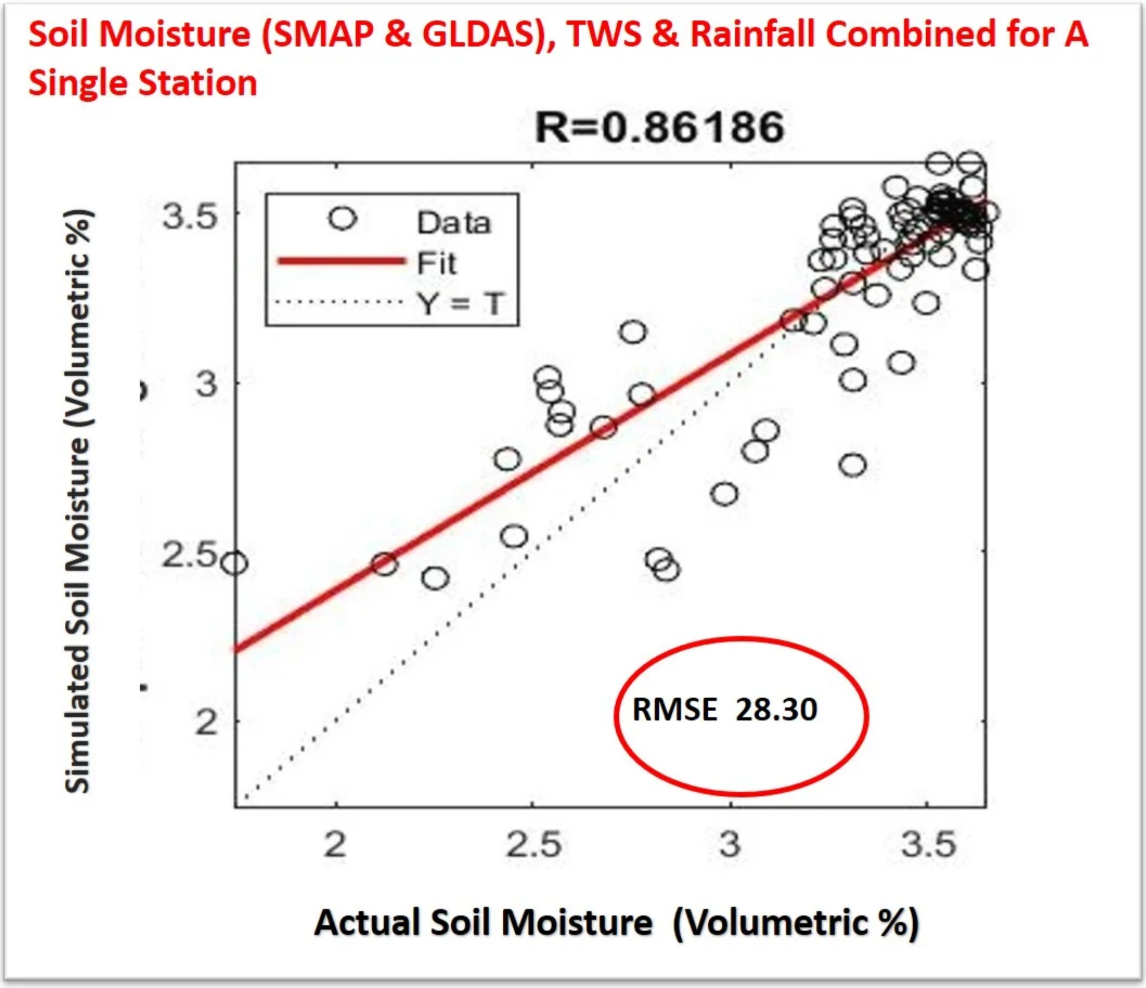

Figure 6: Prediction of soil moisture from a single station

- Linear regression with a single variable (SMAP soil moisture and GLDAS surface soil moisture) resulted in R^2 values of 0.36 and 0.19 respectively.

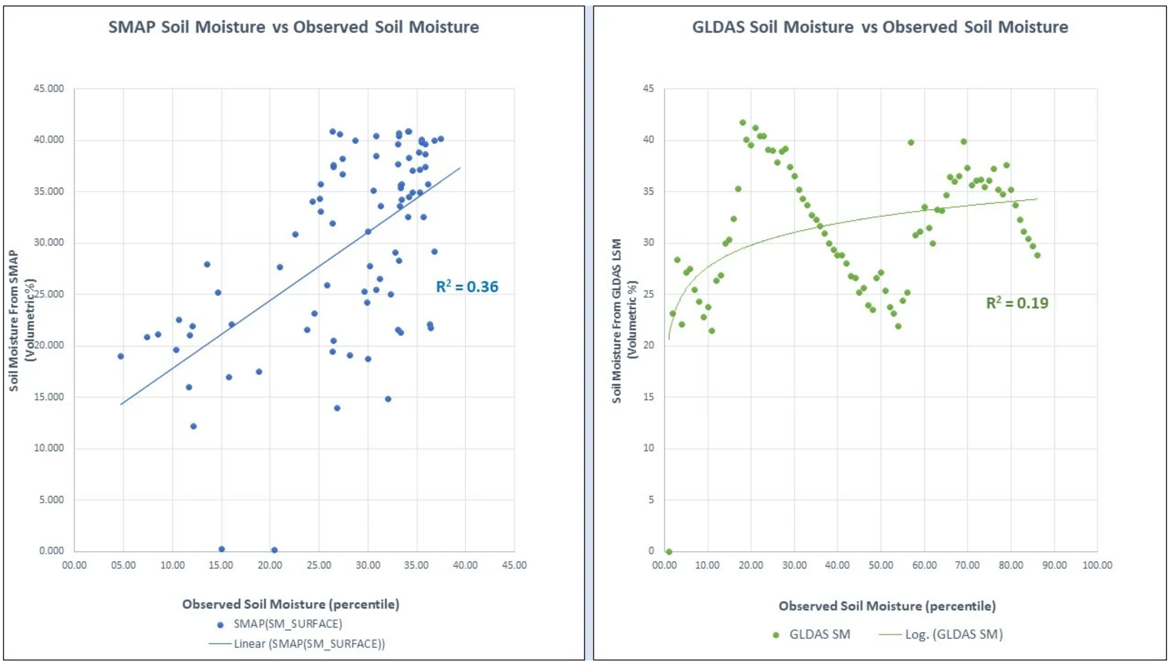

Figure 7: Single variable regression with SMA{ and GLDAS-2.2 soil moisture

CONCLUSIONS

- ANN provides promising potential in estimating soil moisture from satellite-derived products.
- Compared to using only SMAP products, model performance improved significantly when GLDAS-2.2 products were introduced.
- The release of daily GRACE gravity field solutions in near-real-time may provide a reasonable and continuous estimate of soil moisture in this data-scarce region.

CHALLENGES

- One possible cause for the discrepancy between observed and simulated soil moisture might be that we employed coarse resolution gridded data as input. However, the observed data was taken from a single spot. This can reduce the accuracy of the model.
- The public availability of GLDAS-2.2 products takes three months. In real-time prediction, this can become an issue.

AUTHOR INFORMATION

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ABSTRACT

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