Assessment of Domestic Rainwater Harvesting Potential in Tropical Monsoonal Climate of South Asia Using Remote Sensing

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Introduction:

Domestic rainwater harvesting could be the sustainable and cost effective solution for supplying safe drinking water in the rural areas due to its social acceptability, environmental friendliness, lower capital and maintenance cost. Estimating rainfall variability is the key to successful design of rainwater harvesting system. Traditional gauged measurement provides the magnitude of rainfall at a point location and stations are even sparsely located in the developing countries. Plethora of high resolution satellite rainfall data are available that give the spatial coverage of entire world. So rainfall estimation using remote sensing is more appropriate for hydrological applications in developing countries.

Objective:

To investigate the feasibility of Domestic Rainwater Harvesting (DRH) in rural areas of South-Asia by hydro-metrological analysis.

Study Area:

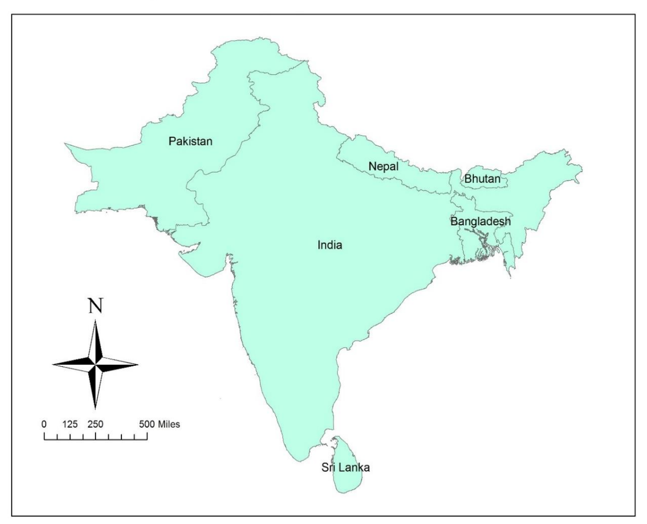

Figure 1. Countries in South Asia

South Asia is a densely populated land mostly with low income people living in the rural areas. Almost 134 million people in south Asia do not have access to improved water sources (UNICEF and WHO,2015). Ground water depletion, Salinity and Arsenic contamination have exacerbated the condition.

DATA:

Precipitation Data : Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) Version 2.0

Spatial Resolution : 0.05° Time Period : January 1981- April 2016

Satellite Images: Google Earth (www.earth.google.com)

Source: DigitalGlobe, AeroWest, GeoContent, Cnes/Spot Image.

Table 1. Potable Water Demand and Domestic Water Demand

	Application	Amount (per capita per day)
Potable water demand	Drinking and Cooking	7.5 liter (WHO,2005)
Domestic water demand	Drinking + Cooking+ Basic hygiene needs+ Basic food hygiene	20 liter (WHO,2016)

Reference:

1. UNICEF and WHO (2015), Progress on sanitation and drinking water – 2015 update and MDG assessment. ISBN 978 92 4 150914 5.
2. WHO (2005), Minimum water quantity needed for domestic uses.
3. WHO (2016), What is the minimum quantity of water needed?
4. Mahmood, A., and F. Hossain (2016) Feasibility of Managed Domestic Rainwater Harvesting in Rural areas of South-Asia using Remote Sensing, Resources, Conservation and Recycling, (In review)

Methodology:

Average Monthly Rainfall Estimation
↓
Trend Analysis
↓
Roof Area Approximation from Satellite Images
↓
Estimation of Monthly Harvestable Rainwater Using Minimum Monthly Precipitation
↓
Storage at the End of Each Month Using Concept of Dynamic Programming for Different Reservoir Sizes and Demands
↓
Percent of Time of Each Month Water Demand Fulfilled
↓
Percent of Time of the Year Water Demand Fulfilled
↓
Feasible Location for Domestic Rainwater Harvesting

Figure 2. Sequence of analytical steps used in the study to explore feasibility of domestic rainwater harvesting

Roof Area Estimation:

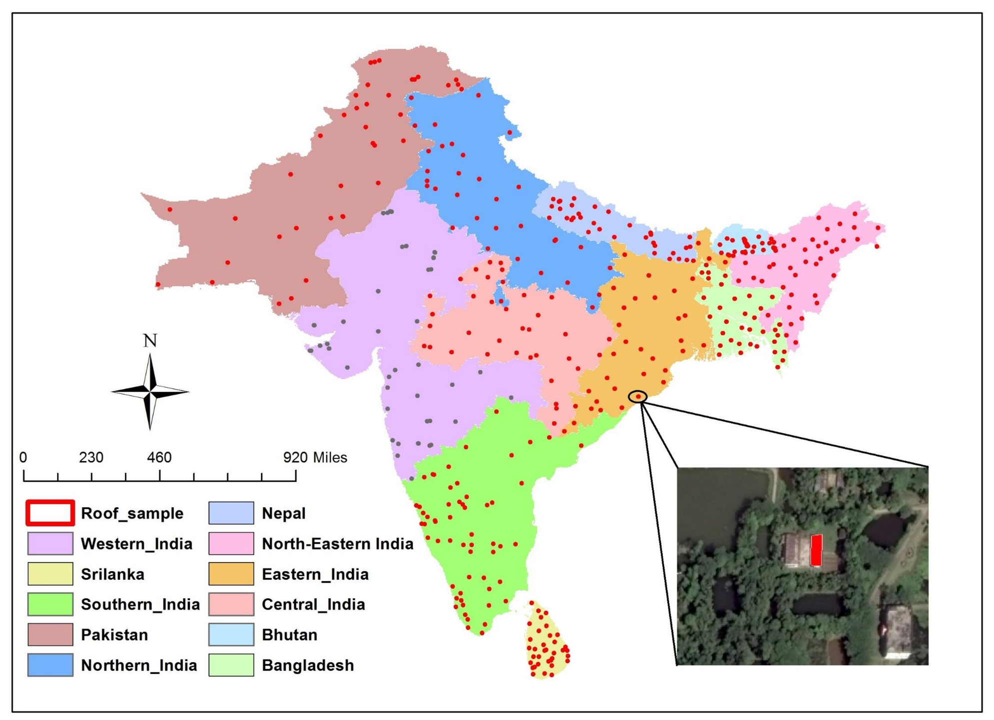

Figure 3. Roof area samples in different regions of South Asia derived from visible satellite imagery via Google Earth

Spatial and Temporal Distribution of Rainfall:

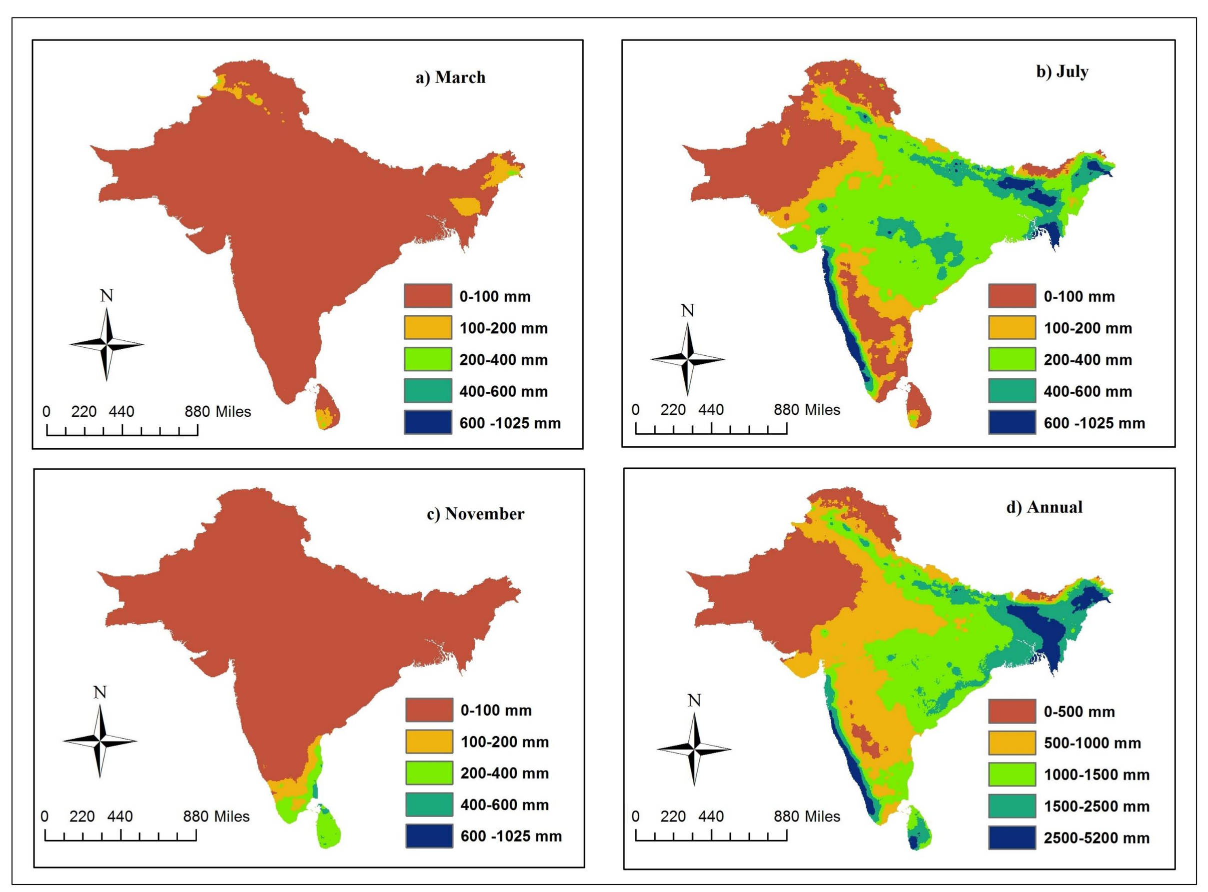

Figure 4. a) Average Monthly Precipitation of March b) Average Monthly Precipitation of July c) Average Monthly Precipitation of November d) Annual Average Precipitation

Long Term Trend in Precipitation :

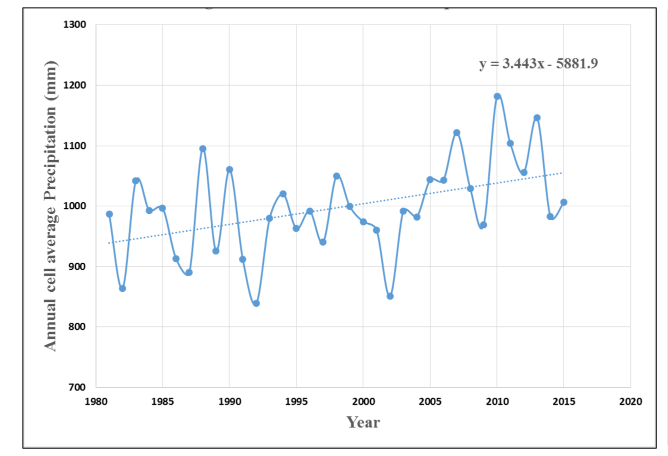

Figure 5. Long term trend in annual cell average precipitation

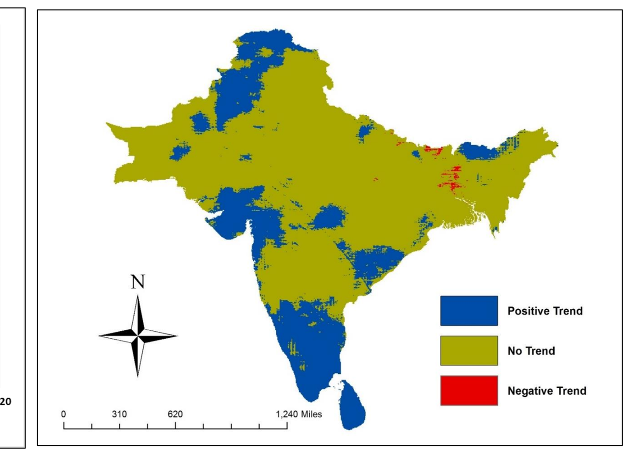

Figure 6. Spatial distribution of long term trend in annual precipitation

Potential Amount of Harvestable Rainwater :

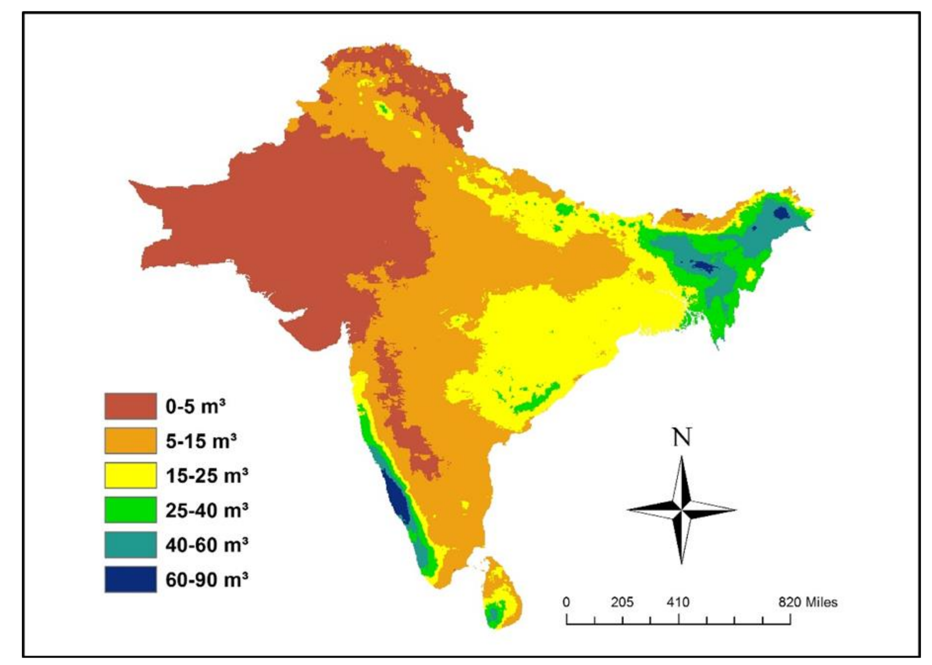

Figure 7. Potential amount of rainwater that can be harvested annually per rural household assuming no storage limitation.

Water Demand Fulfilled without Storage Limitation :

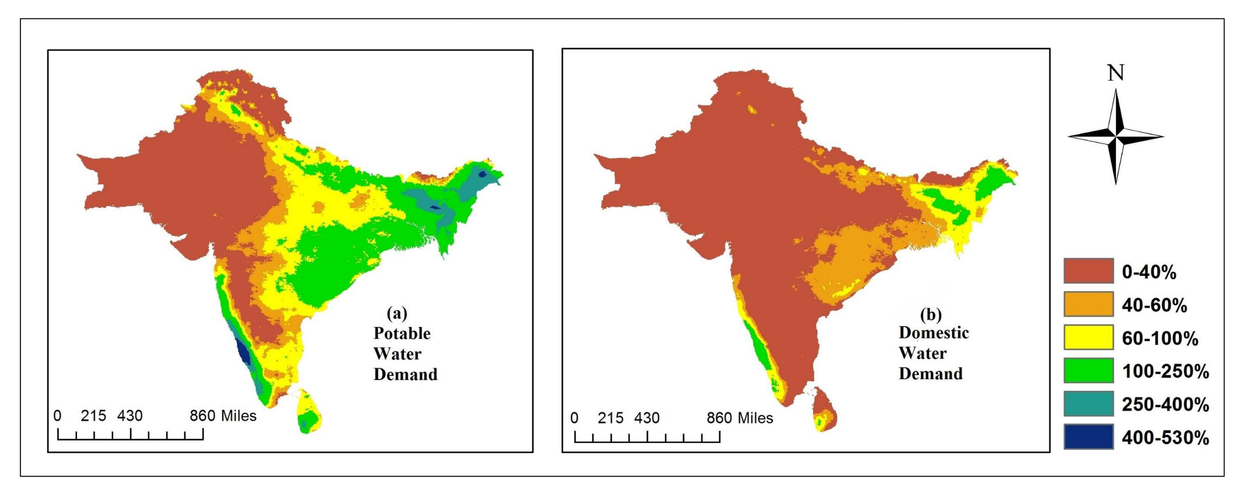

Figure 8. Percent of time of the year a) Potable water demand b) Domestic water demand is fulfilled without storage limitation

Potable Water Demand Fulfilled with Storage Limitation :

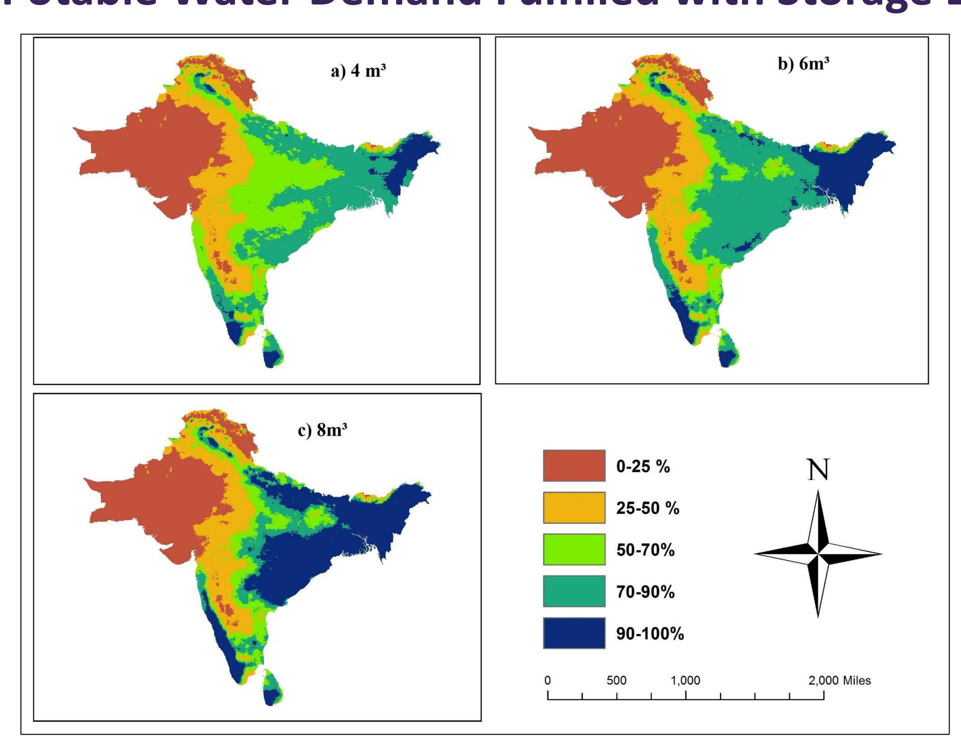

Figure 9: Percent of time of the year potable water demand fulfilled with a) 4m³ b) 6m³ and c) 8m³ reservoir size

Domestic Water Demand Fulfilled with Storage Limitation :

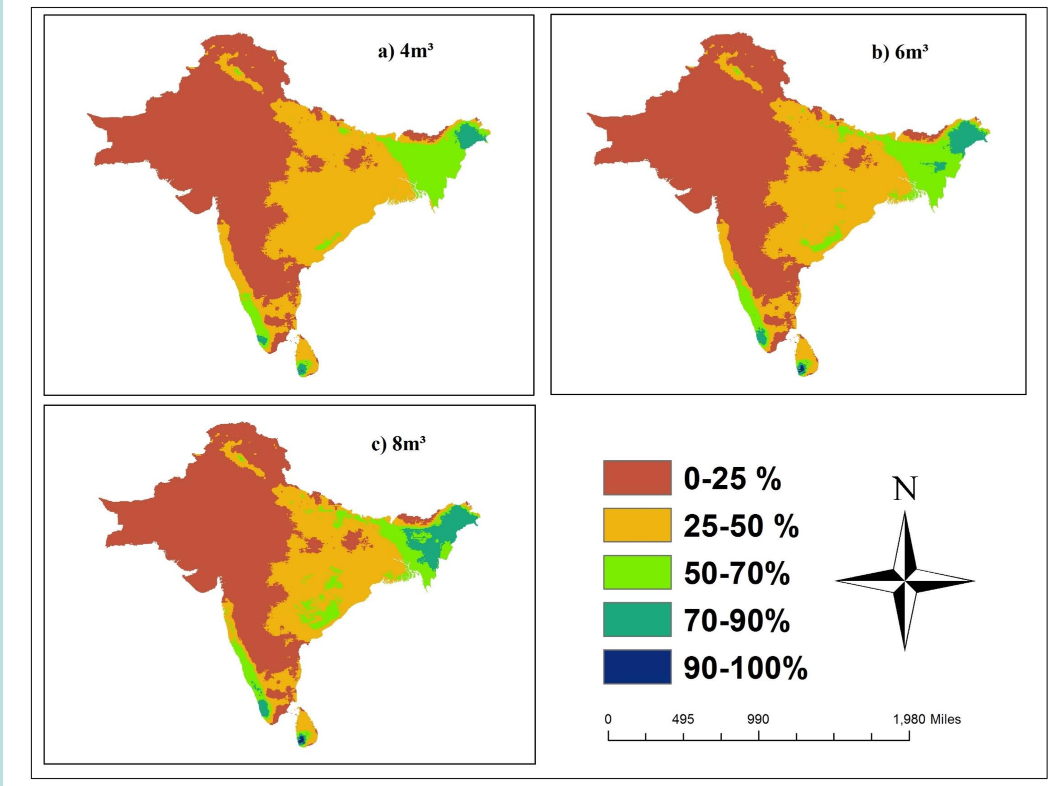

Figure 10. Percent of time of the year Domestic water demand fulfilled with a) 4m³ b) 6m³ and c) 8m³ reservoir size

Effect of storage size on geographic feasibility

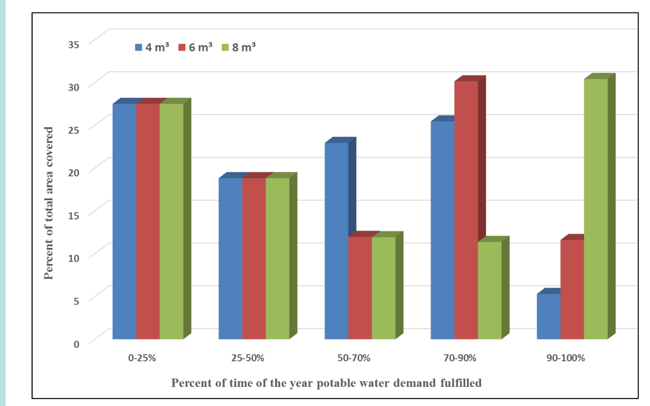

Figure 11. Variation in area coverage of potable water demand with respect to different reservoir size

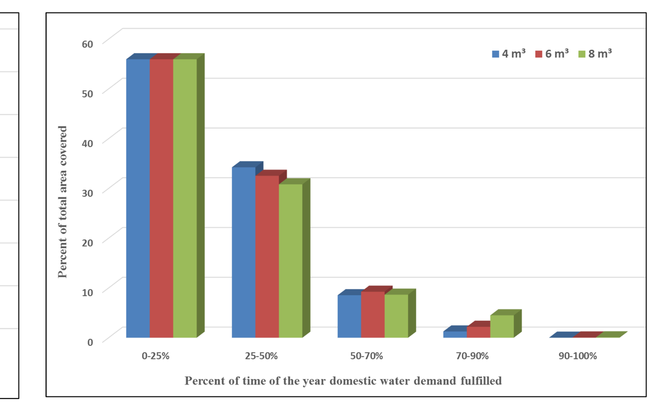

Figure 12. Variation in area coverage of Domestic water demand with respect to different reservoir size

Major Findings:

- DRH is not feasible in most regions of Pakistan, Northern and Western parts of India.
- A 4m³ reservoir can fulfill the potable water demand of a household in North-east India.
- A 8m³ reservoir can satisfy the potable water demand of a household in many parts of South-Asia

Limitations & Future Work:

- This study does not represent the feasibility of DRH in urban area due to high population density.
- Socio-economic factors and demographic information were not considered in this study.
- Fixed per capita water demand was assumed in the study for the simplification of the analysis.
- This study represents the feasibility of DRH for “now” climate. How this will change in context of climate change or land use/land cover change in the future should be explored for better policy management.

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