Original Research Article

Assessment of Water Spread Area in Cheyyar Sub Basin using Sentinel 1A data

Abstract

A research study was conducted for estimating the water spread area in Cheyyar sub basin for the year 2022. Mapping and regular monitoring of tanks plays an important role in water resource planning. Sentinel-1A SAR data has high potential in estimating water spread area as it is unaffected by cloud cover, light or weather conditions. After processing the obtained satellite data using SNAP software, the water spread area was obtained by threshold approach. The backscattering (dB) value ranged between -30.641 and 22.898 during the course of study. The total water spread area was noticed maximum and minimum during the month of January and July with 5728.20 ha and 1123.44 ha (21.88% and 4.29 % of total tank area) respectively. The water spread area seems to be proportional to the rainfall of previous and current months.

Key words: *Remote sensing, SAR, Sentinel-1A, Tanks, Water spread area.*

Introduction

Water, being the critical input in crop production, plays a key role in food security. As a non-renewable resource, the availability of freshwater is decreasing day by day owing to more usage by domestic and industrial sectors. Hence, water resource planning is necessary for framing of effective cropping system to achieve more water productivity. Tanks (small reservoirs) are source of irrigation since Vedic period as they are important to thousands of marginal and small-scale farmers and are less capital expensive and have a greater geographical dispersion than large projects. There are 41,123 tanks in Tamil Nadu and along with canals, tanks contribute to 37.34 % of net irrigated area [1]. Mapping and monitoring of water bodies in river basin/sub-basin can help in assessing water spread area.

Conventional methods of finding water spread area involve more investments and are time-consuming. With an advent of remote sensing techniques, analysis of water spread area has become much easier with help of satellite data sets. Mapping of surface water is one of the important applications of remote sensing in estimating the availability of water, measuring its change in time, and predicting droughts and floods [2]. Optical and microwave sensors can be used for monitoring changes in water bodies but the problem with optical data is that they are affected by light and cloud cover.

Synthetic Aperture Radar (SAR) sensors generates its own energy and then measures how much of that energy is reflected back after interacting with the [3]. SAR data is commonly utilized for surface water monitoring [4]. SAR wavelengths are unaffected by cloud cover, illumination, weather conditions and vegetation. Sentinel-1A SAR Ground Range Detected (GRD) in VV polarization has high resolution (10m) and greater accuracy in surface water monitoring [5]. SAR microwave sensor was suitable for flood and surface water mapping [6]. Comprehensive use of SAR data helps in water resource management and accurate flood assessment [7]. So, SAR data is widely used in water spread dynamic assessments.

Materials and Methods

Study Area

Cheyyar sub basin is the largest sub basin of Palar basin covering an area of 4362.69 sq.km, spread over the districts of Kanchipuram, Thiruvannamalai, Vellore and Ranipet. The Cheyyar sub basin is surrounded by Agaramaru sub basin in the North and Pennaiyar basin in the South and West and Kiliyar sub basin in the East. The basin is located between 12°14' N to 12°55' N and 78°39' E to 79°52' E. Cheyyar river originates from the Jawadu Hills in Chengam taluk runs for about 186 km to join Palar River at Thirumakkudal village. The basin with 535 tanks has a total command area of 43626.08 ha. The study area map is given in Fig.1

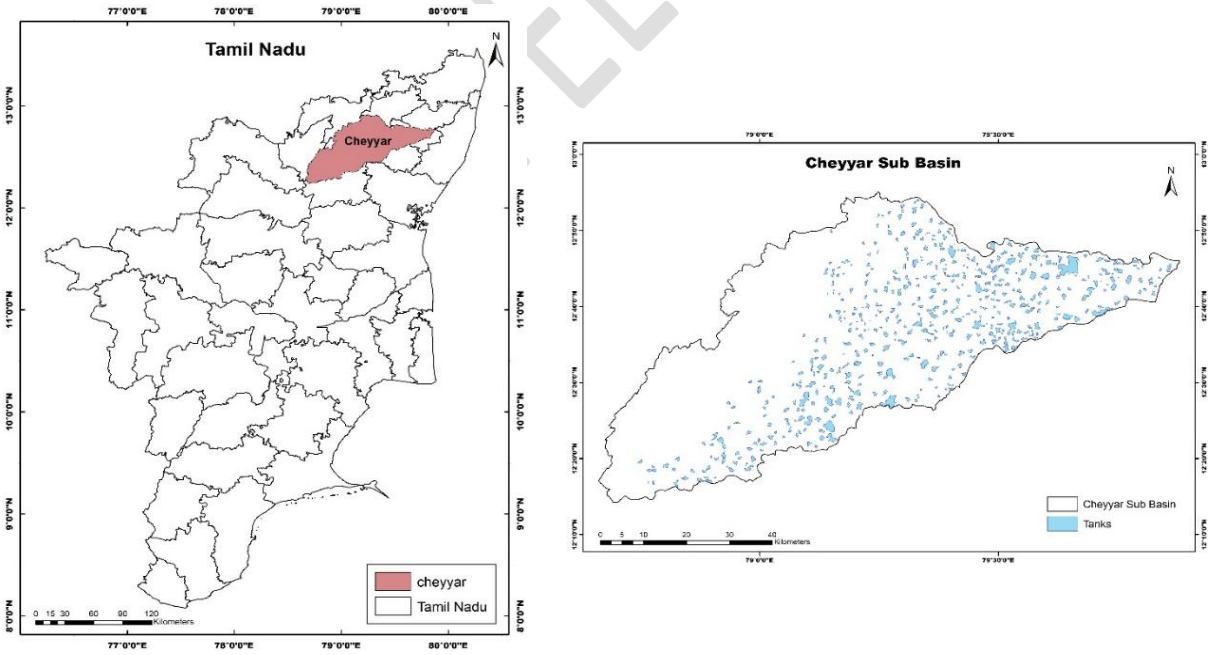

Fig.1 Study area map

Satellite data

Sentinel-1 is an imaging radar mission giving continuous all-weather, day-and-night imagery at C-band. Synthetic Aperture Radar (SAR) data from Sentinel-1A C-band GRD was obtained from European Space Agency's Sentinel Scientific Data Hub

(https://scihub.copernicus.eu/dhus/). Interferometric Wide swath (IW) mode is the primary operational mode of Sentinel-1A over land. Sentinel-1 is a dual polarization SAR system that preserves phase. It is capable of transmitting and receiving signals in both H and V polarizations. VV Polarization amplifies the effect of water surface roughness [8], VV polarization was effective in detecting surface water than VH polarization [9], Hence, VV polarization is used in this study. The methodology of water spread area estimation is depicted in Fig.2

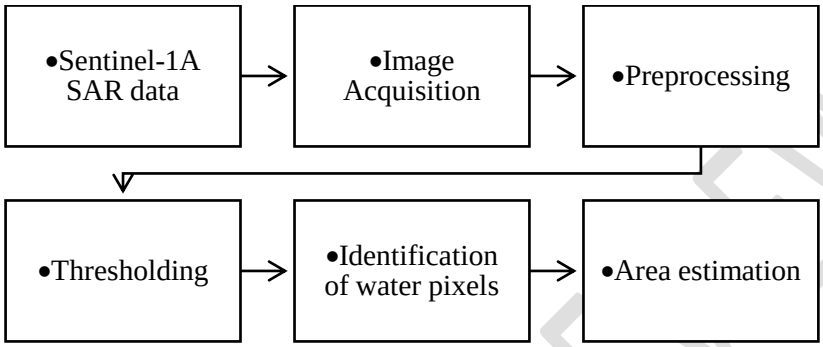

Fig.2 methodology

Image Acquisition

Datasets were acquired at 12 days interval with spatial resolution of 20m and swath of 250 km for a period of 12 months (2022) from Copernicus Open Access Hub (Fig. 3)

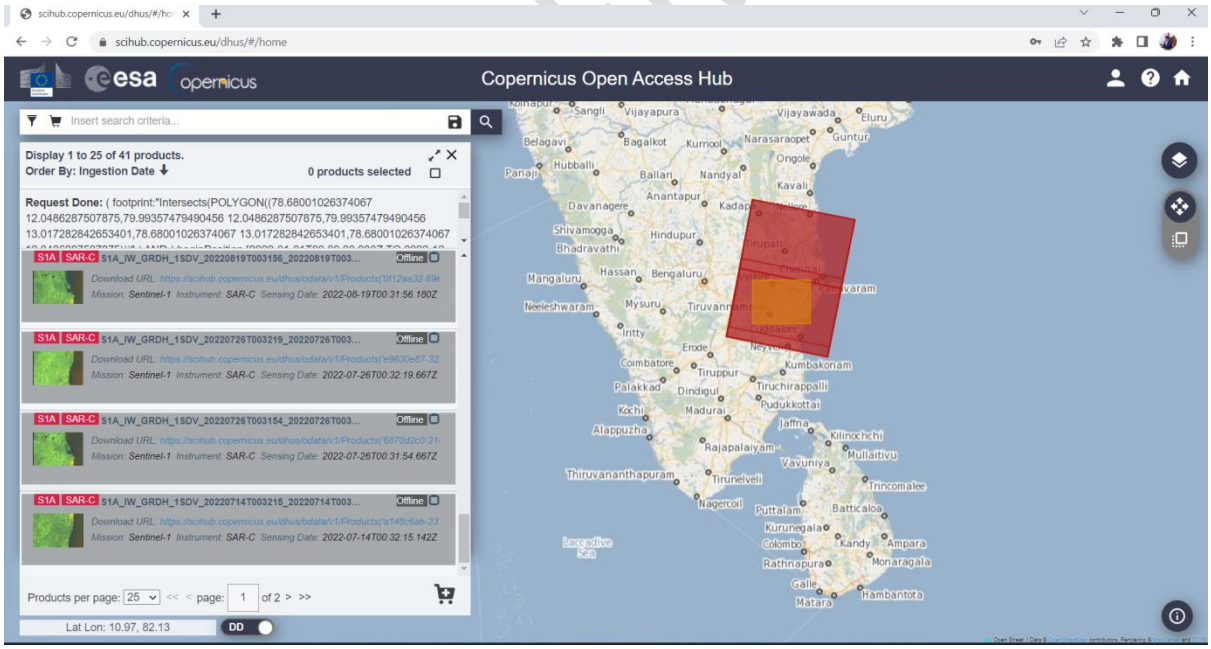

Fig.3 Image Acquisition for ESA Copernicus website

Preprocessing of SAR data

SAR data acquired by radar sensors require preprocessing to improve the quality of images. SNAP software from ESA was used for preprocessing which was carried out in steps [10] (Fig.4). Accurate position of SAR metadata is attained with the application of orbit

file. Thermal noise affects the image quality and its removal helps in normalization [11], By removing border noise, invalid data is removed. Calibration helps in converting digital pixel values to SAR backscatter. Speckle (granular noise) filtering reduces thermal noise error [12,13] and radiometric correction is done to obtain quantitative data in dB (decibel) [14].

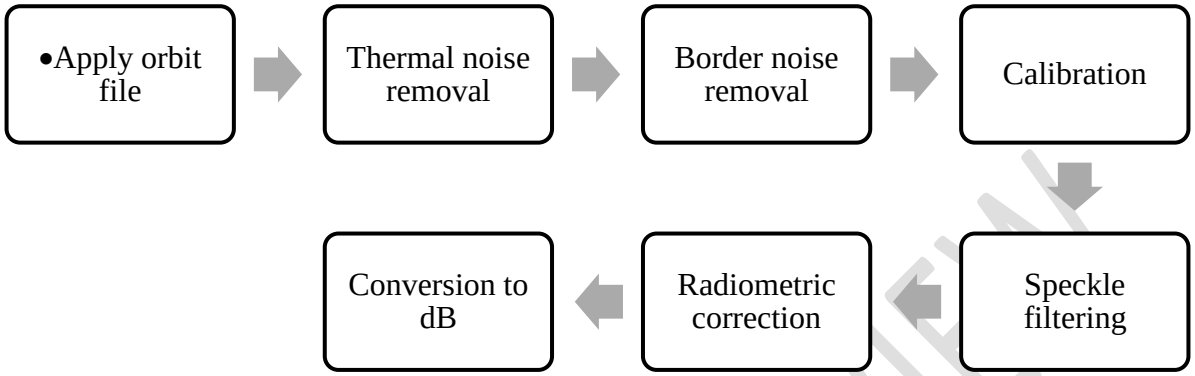

Fig.4 Preprocessing of SAR data

Thresholding

Water and non-water area need to be identified for estimating water spread area. Thresholding is an important step in the histogram-based approach, processing of images and image pattern recognition [15]. Thresholding algorithms on SAR images are widely utilized since they are effective and take up little processing effort. Histogram thresholding is the most widely used technique for converting image values with single band to water and non-water pixels [16,17]. Hence, thresholding with a dB value of -21 is used for estimating the dynamics of water spread [18].

Rainfall data

Rainfall has a direct impact on the water spread area and filling of tanks. IMD provides daily high spatial resolution (0.25 x 0.25 degree) grid data. The rainfall data from IMD is downloaded, processed and monthly rainfall is calculated for discussion. Monthly rainfall of 2022 is given in Fig.5

Results and discussion

SAR data downloaded from Sentinel-1A satellite is preprocessed with SNAP software and the backscattering values obtained after preprocessing are presented in table 1.

Table1. Backscattering values

Month	Backscattering (dB) Value
January, 2022	-29.201 to 20.618
February, 2022	-30.641 to 19.233
March, 2022	-29.456 to 17.150
April, 2022	-28.979 to 16.226
May, 2022	-28.298 to 19.386
June, 2022	-27.611 to 18.532
July, 2022	-27.155 to 17.301
August, 2022	-29.641 to 18.954
September, 2022	-29.188 to 16.708
October, 2022	-29.487 to 17.013
November, 2022	-27.940 to 22.898
December, 2022	-29.843 to 17.708

Higher (brighter tone) backscattering values correspond to constructions and cities, while lower (darker tone) backscattering values correlate to water pixels. The values of the intermediate backscatter are associated with vegetation, barren land and dry soils.

Tank area estimation

Water spread area in tanks was estimated using thresholding, a quicker method to generate binary pixels. The water spread area of tanks in Cheyyar basin during the months of 2022 is given in Fig.4

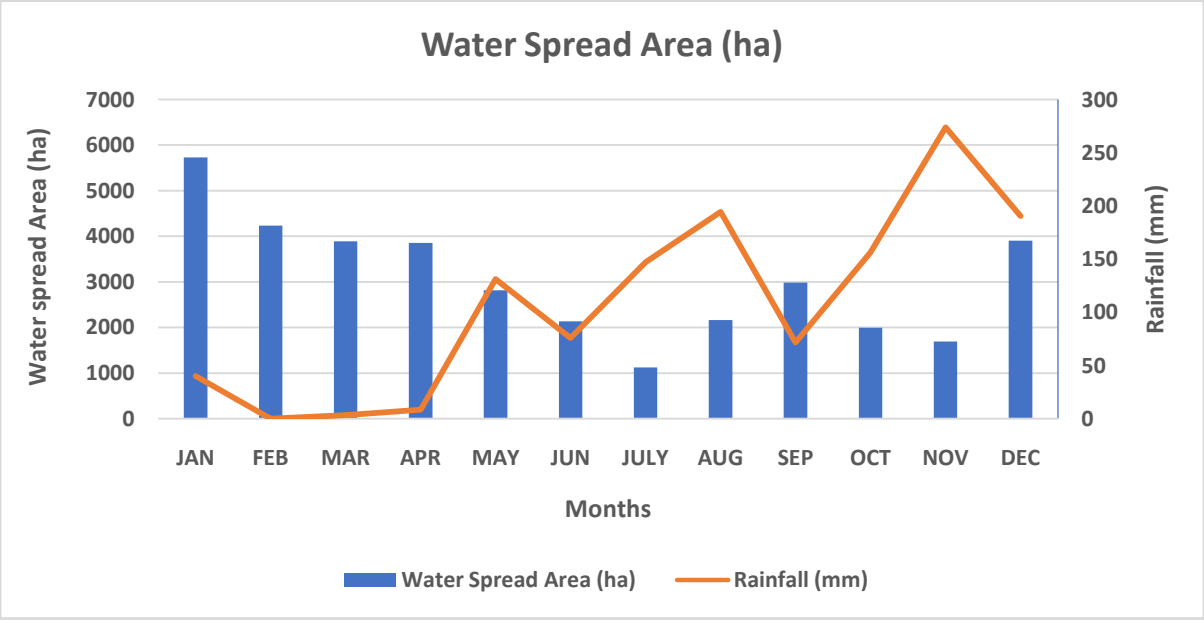

Fig.5 Water spread area(ha) and Rainfall for Cheyyar sub basin in 2022

The estimated average water spread area in tanks was 3042.61 ha in the year 2022. The highest water spread area was recorded in the month of January (5728.20 ha) while the lowest water spread area was in July (1123.44 ha).

The water spread area of tanks was grouped with the percentage interval of 0% (no water spread), 0 to 25% filled, 25 to 50% filled, 50 to 75% filled, and above 75% (75-100%) filled tank capacity. On average out of 535 tanks, 193 tanks remain unfilled throughout the year and the maximum of 282 tanks comes under the range of 0-25%, 50 tanks come under the category of 25-50% and the remaining 10 tanks observed 50- 75% filling. Month-wise water spread area range is depicted in Fig.6

Rainfall being the major source of water for tanks, it plays an inevitable role in water spread area. The total rainfall received during 2022 in Cheyyar sub basin was about 1290 mm [19]. In November and December, 2021 about 690 mm of rainfall was recorded in Cheyyar sub basin resulting in the filling of tanks and the water spread area reached a peak in January. Cheyyar received only about 50 mm in Jan-Apr 2022 and this resulted in gradual decrease in water spread area. Though May month received about 150 mm, due to peak summer water consumption was more resulting in further decline. Crop cultivation needs water and tank water being the important recharge source for wells and borewells, Water spread area in tanks reached as low as 1123.44 ha in July. Rainfall from South West monsoon resulted in filling up of tanks and system tanks receiving water from Cheyyar river, filled quickly so that water spread area increased and also reduction in rainfall in September affected water spread in October and November. North East monsoon rainfall increased the water spread area in December, 2022.

With regard to water spread area in hectare on average 193 tanks (36.12%) have no water spread area and 271 tanks (50.69%) have a water spread area of 0-10 ha. Also, 42 tanks (7.93%) have water spread of 10-25 ha and 29 tanks (5.26%) showed water spread area more than 25 ha. Month wise water spread area is given in Fig.7

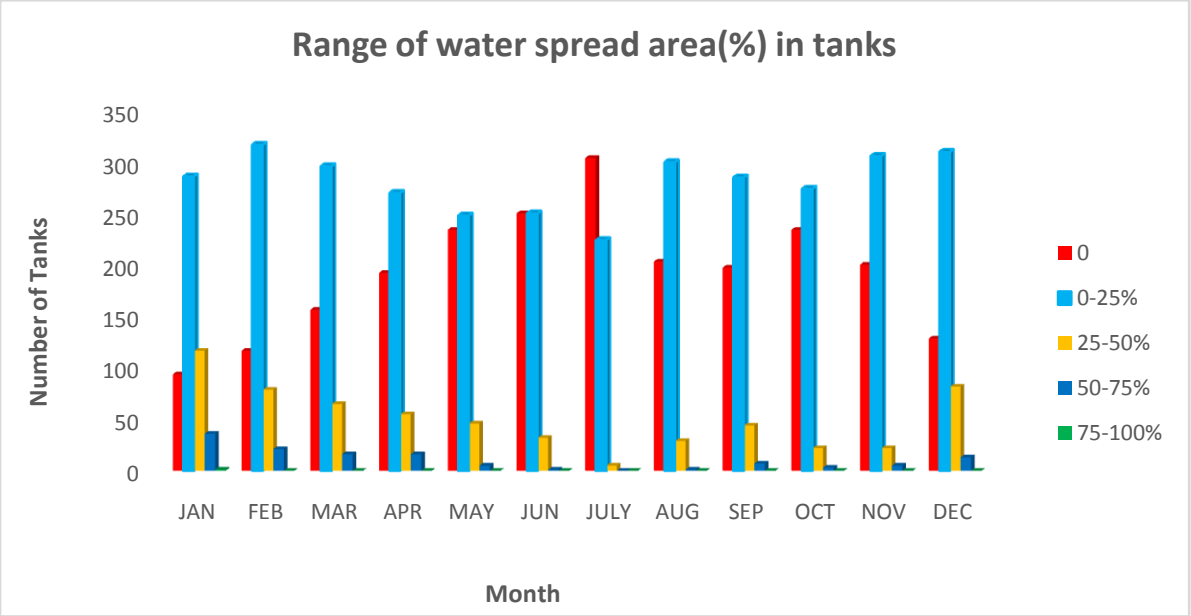

Fig.6 Range of Water spread area (%) month wise (2022) in Cheyyar sub basin

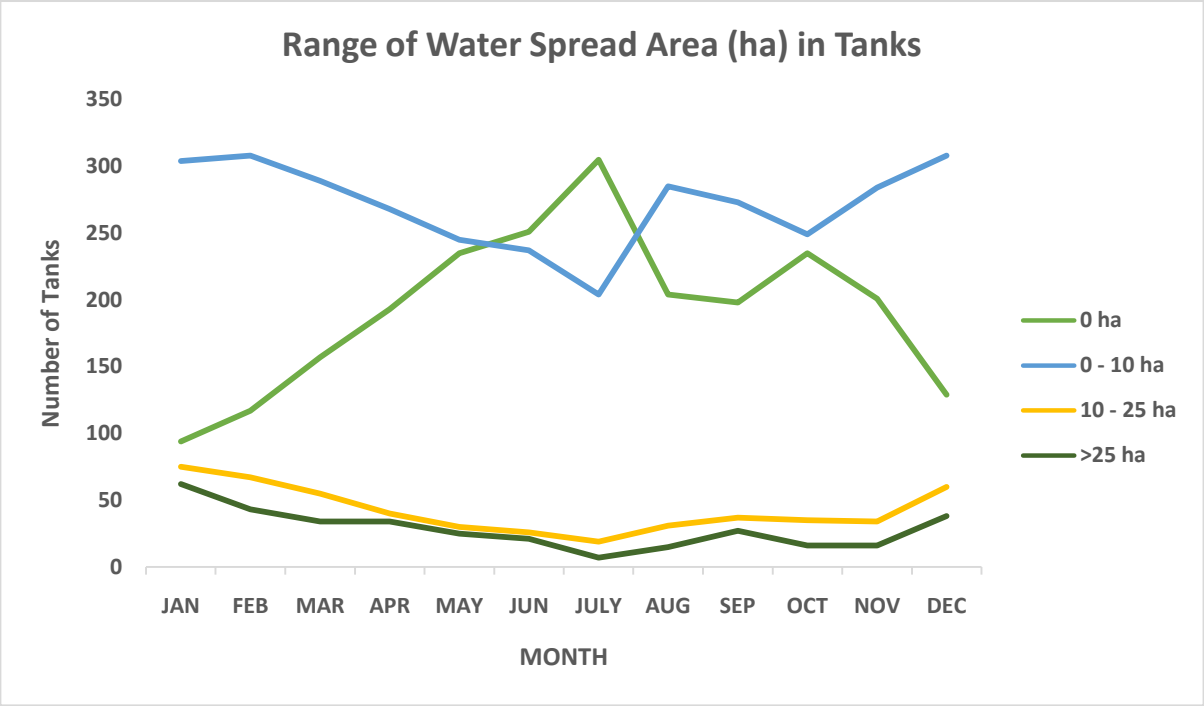

Fig.7 Water spread area (ha) month wise (2022) in Cheyyar sub basin

Conclusion

The SAR data obtained from Sentinel-1A after preprocessing and thresholding is highly useful in estimating the water spread area and dynamics of water spread. The average water spread area of tanks in Cheyyar basin during 2022 was 3043.02 ha while July month with 305 unfilled tanks recorded the lowest water spread area. From the correlation between rainfall and tank water spread, it is evident that rainfall is the key factor in determining the water spread area of tanks in Cheyyar sub basin.

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