normal germination of pollen which occurs on the stigmatic surface only, in *Artemisia maritima* some pollen grains were seen germinating at the point of nectary and the pollen tubes thus emanating were seen entering the ovary (Figure 1 *e* and *f*). The species thus represents pollen germination at two points, while the pollen from other florets/plants germinates on the stigma, some self-pollen germinates on the top of the ovary also. While pollen germination inside anthers[2] and some other floral parts or on ovary wall[3,4] has been reported in some plants, there has been no report of nectar acting as a stimulus of pollen germination and of pollen germinating at the point of the nectar disc. *A. maritima* thus represents a unique case of dual pollen germination, on nectary capping the ovary and on the stigmatic surface. That pollen germination on the nectary is responsible for some amount of seed set in the species was confirmed by a simple experiment in which florets were bagged initially. The bags were opened daily to locate the emerging non-receptive, closed stigmas, which were regularly clipped-off so that no pollen could land on them. The seed set on these florets averaged $\bar{x} = 21.09 \pm 2.18\%$.

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Land use around Maithon reservoir: a study from high-resolution ASTER data

The study of land-use pattern using remote sensing is a popular tool for researchers after the advent of high-resolution multispectral imagery. While most of the study deals with monitoring of vegetation, soil moisture and bare lands using visible, SWIR and TIR bands, little effort has been given to integrated study of change in vegetation, soil moisture and its effect on land–water mega-system. Here, we present simple band-ratio images that can be used to perceive the effect of unplanned growth and land use around a multipurpose reservoir, located on the River Barakar at Maithon, eastern India.

The primary objective of the Damodar Valley Corporation (DVC) was to utilize the water resources of the most problematic river 'Damodar' – the sorrow of eastern India – by flood control, irrigation and navigation benefits and power generation[1]. A series of dams have been constructed on the river Damodar and its tributary, the Barakar. However, repeated devastating floods in the lower Bengal basin during the recent years have led to the question of usefulness of these dams. There is a steady growth of population in the vicinity of the reservoir since its construction. The human activities greatly reduce the vegetation cover and the top soil consequently. These are the areas of interest of our study[2]. Apparently, the situation is an inevitable outcome of population explosion, and a detailed examination of land use indicates that the reservoir is under serious threat of pollution and increased sedimentation.

The Barakar is the major tributary of the Damodar. The DVC constructed the Maithon reservoir on Barakar during the post-independence period. The Maithon reservoir and its adjoining areas (lat. 23°46′–23°56′N, long. 86°45′–86°54′E; Figure 1) were selected for the present study. The area is situated at the border of West Bengal and Jharkhand.

The study area is covered by the deformed and metamorphosed 'Chhotonagpur Granite Granulite Complex'[3] in the eastern, western and northern parts, and coal-bearing sandy and silty rocks of Talchir and Barakar formations of Gondwana Supergroup in the southern part. The geomorphological units are residual hills, pediments and dissected valleys. Small-scale landslides are common at the NE–SW trending hillocks bordering the reservoir. Action of running water is the major agent of geomorphic processes. Fluvial systems show two types of drainage pattern (structurally controlled and dendritic).

ASTER LIB data have been used for the present study. ASTER is a collection of sensors that can record radiations ranging from visible to thermal infrared wavelengths. The detailed data structure, spatial and spectral resolution and processing techniques have been discussed by Nasipuri *et al.*[4]. The present LIB dataset has been downloaded from LPDAAC, NASA. ENVI 3.5 software was used to process the data.

The formula for different band-ratio images given below was originally developed for LANDSAT data. The equivalent representative bands of ASTER data are used here to obtain the same band images. Normalized Difference Vegetation Index (NDVI) image is used widely to monitor the quality and distribution of vegetation. NDVI is computed using the formula:

$$\left[\frac{d(\text{Band 3}) - d(\text{Band 2})}{d(\text{Band 3}) + d(\text{Band 2})}\right],$$

where d(Band 3) and d(Band 2) represent the NIR and red band reflectance of ASTER respectively. In Figure 2, the margin of the reservoir is characterized

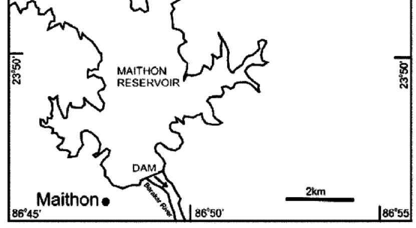

Figure 1. Location map of the study area.

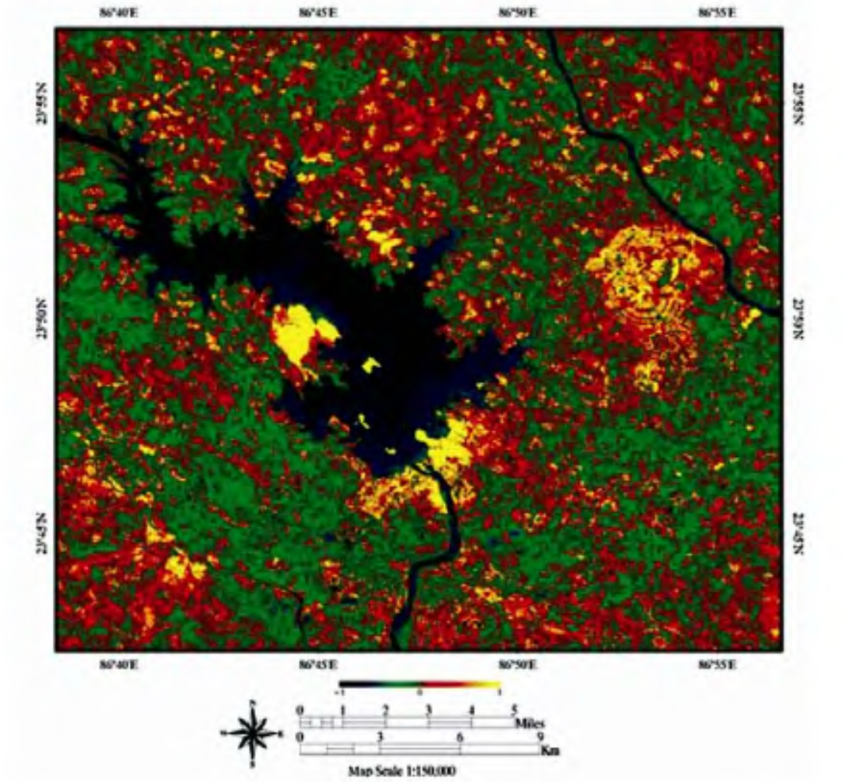

Figure 2. Normalized Difference Vegetation Index (NDVI) image of the study area. The residual hillocks and private orchard show high NDVI values compared to the surrounding reservoir which shows a low NDVI value.

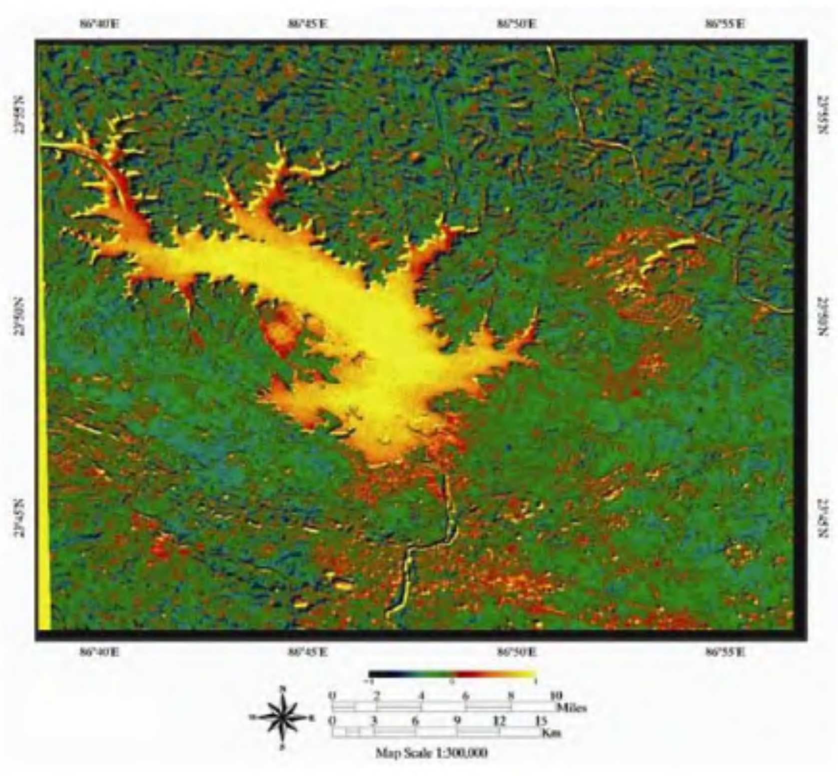

Figure 3. Normalized Difference Water Index image of the study area. The large water body can be demarcated easily. Note the overall scanty of free water in the reservoir surroundings.

by low NDVI values ranging from –0.1 to +0.3. NDVI values greater than 0.5 are localized to hill ranges and zones of afforestation.

It is well known that the SWIR is absorbed by water. To assess water content in a normalized way, Gao[5] introduced the NDWI (Normalized Difference Water Index). This index increases from dry soil to free water. NDWI is calculated using the formula:

$$\left[\frac{d(\text{Band }3) - d(\text{Band }4)}{d(\text{Band }3) + d(\text{Band }4)}\right].$$

The Maithon reservoir is characterized by high NDWI values (0.2–0.4) in contrast to the granitic–gneiss country rock, where the value is extremely low (–0.2 to –0.01). The NDWI image (Figure 3) reflects inhomogeneous distribution of water in the study area.

Distribution and change of bare land play an important role in the land–water mega-system. Zhao and Chen[6] used LANDSAT ETM+ images to calculate Normalized Difference Bareness Index,

$$\text{NDBI} = \left[\frac{d(\text{Band }5) - d(\text{Band }6)}{d(\text{Band }5) + d(\text{Band }6)}\right],$$

where d is the digital number value (DN) of the corresponding bands; Band 6 represents DN of ETM+/Band 6 or TM/Band 6. We have extrapolated the formula proposed by Zhao and Chen[6] to generate NDBI image using ASTER data. We have used temperature image instead of Band 6 of LANDSAT ETM+, as temperature reflects the effects of maximum emissivity. In bare land index image (Figure 4), the reservoir margin is characterized by lands with high bareness index ranging from +0.3 to +0.1, with occasional patches of human settlement and the DVC township.

In the scattered-plot diagram, NDVI and NDWI show positive correlation (Figure 5 *a*), which implies the influence of water (and probably basement lithology) on vegetation growth. However, poor correlation of vegetation (and water) with bare land (Figure 5 *b*) is the result of significant soil erosion near the reservoir margin. From the BI image, it is clear that soil erosion is expected due to faulty land-management practice near the reservoir margin. Anthropogenic activities thus have a direct and adverse bearing on the functionality of the reservoir.

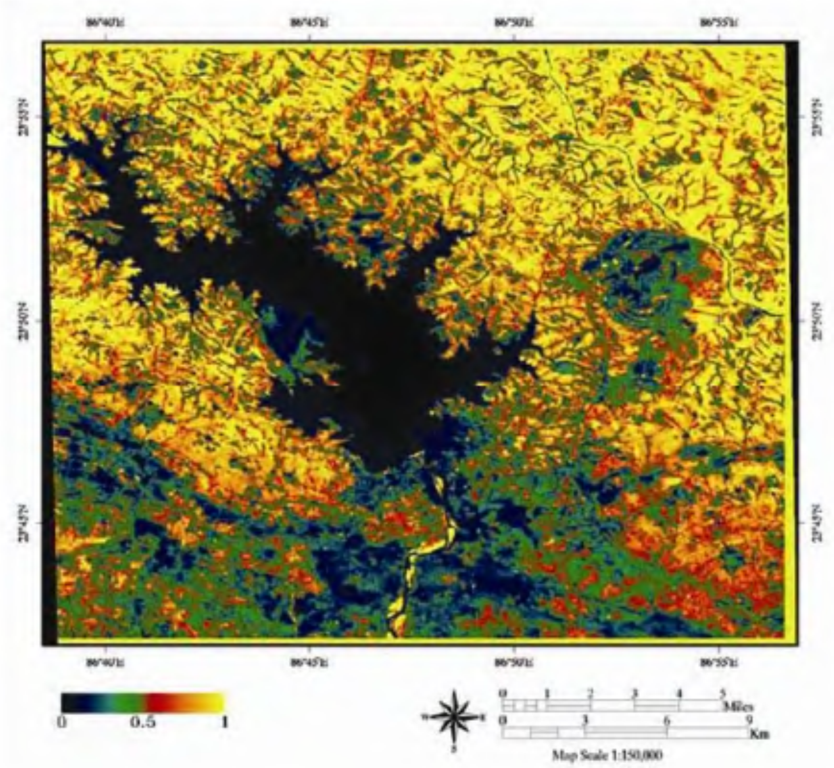

Figure 4. Normalized Difference Bareness Index image of the study area. The water body shows low values due to high content of suspended materials. Barring, the DVC colony and zones of high NDVI, the area has a high bareness index.

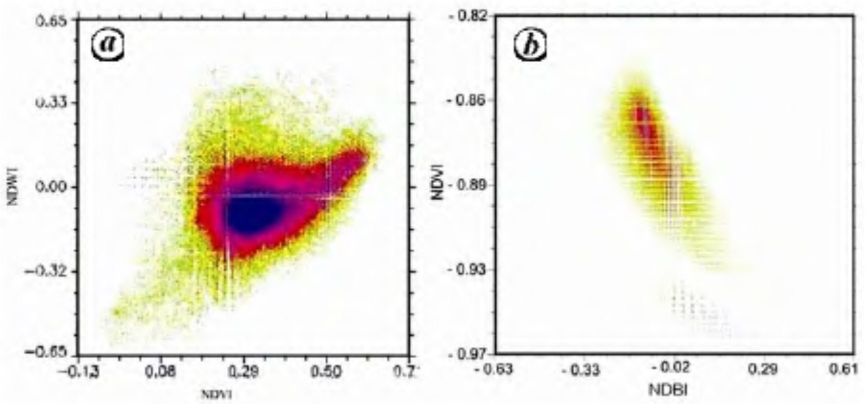

Figure 5. Scattered plot of (***a***) NDVI vs NDWI and (***b***) NDVI vs NDBI images. NDVI and NDWI show positive correlation that indicates availability of water and vegetation. However, poor to negative correlation of NDVI and NDBI indicates that soil erosion is prominent in the zones of low NDVI, i.e. barren land.

In a developing country like India, social development is unavoidable. However, if socio-economic development is to be achieved at the expense of our natural resources, we have to rethink about its utility; else we have to pay the price for destroying our natural resources.

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