

Utility of GPS in classification accuracy assessment

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Global positioning system (GPS) has become a versatile tool for georeferencing, classification and accuracy assessment of earth system data. GPS acquired geo-co-ordinates in S/A mode are used in this study to assess the classification accuracy of a vegetation-type map prepared by knowledge-based hybrid classification technique. The validation of different forest types provided 55.91, 74.19, 83.87, 89.25 and 92.47% correspondence within one, two, three and four pixel(s) buffer ranges, respectively, between GPS-based information and map data. About 93 GPS points were used for this purpose. The procedure has also been automated for accuracy estimation from the GPS field points through software in the GIS domain. The study area falls under the Eastern Himalaya, which happens to be one of the 18 biodiversity hot spots of the world. This study supports the use of GPS in evaluating the classification accuracy.

CLASSIFICATION accuracy obtained from remote sensing satellite data has been traditionally evaluated using reference data obtained either through photo-interpretation or field verification. At present, global positioning technology is being used for on-ground collection of feature information^{1,2}. This is applicable to both traditional survey as well as modern photogrammetric methods, viz. in geo-referencing, classification³ and accuracy assessment⁴. Image classification encompasses all procedures of assigning a pixel to an information class⁵. Establishment of the link between 'classification results' and 'true information classes' calls for subsets of precisely located pixels, which represent these classes in the real world. An assessment of the usefulness of remote sensing products can only be as good as the reference data against which an imagery is evaluated. It follows that verification information, commonly called ground truth, must guarantee thematic as well as positional accuracy. The acquisition of positional information from Global Positioning System (GPS) is sensitive to procedural variations and environmental factors. Different results can be expected not only due to this, but also because of the receiver quality.

Accuracy assessment quantifies data quality so that a map user may evaluate the utility of a thematic map for

its intended applications. It begins with the definition of the target population, which is the area or region represented by the land use/cover map. The individual elements or units of this population are defined as pixels or polygons, depending on the map representation⁶. A sample of units is selected from this population for accuracy assessment. The work was done with funding from the Department of Biotechnology and Department of Space, Government of India in the form of a nationwide project on 'Biodiversity characterization at landscape level using remote sensing and GIS'.

A GPS is a satellite-based positioning system operated by the U.S. Department of Defense (DoD). GPS allows the collection of information about the geographical position of any location using a network of satellites. The system consists of 24 NAVSTAR (Navigation Satellite Time And Ranging) satellites, each in a 12 h orbit at an altitude of 20,200 km. The GPS system works on the basis of satellite trilateration, i.e. by measuring the distances of a site from at least four satellites at any given instant of time, from knowledge of the satellite positions at that instant in space and travel times of signals corrected for ionospheric and partially tropospheric delays. The accuracy depends upon the equipment and processing methods used. The quality of a position determination is indicated by the DOP (dilution of precision) value that appears on the receiver. GPS has great potential in landscape ecology, as well as in many other related disciplines requiring geographic locations to locate objects in the landscape⁷. Coupled with GIS, it is a powerful tool to describe the spatial characteristics of ecological systems.

A handheld ProMARK X-CP, 10-channel SPS code and carrier phase code receiver designed to collect pseudorange and carrier phase data was used for this purpose⁸. The ProMARK X displays altitude as either height above the ellipsoid or as orthometric height (height above sea level). In general, a SPS receiver can provide position information with ± 25 m error and velocity information with an error of less than 5 m/s. The US government normally activates Selective Availability (SA) to maintain optimum military effectiveness. SA inserts random errors into the ephemeris information broadcast by satellites, which reduce the SPS accuracy to about 100 m. It has been observed that the accuracy varies between 100 and 200 m, depending upon the site.

The study area lies in the Subansiri district of Arunachal Pradesh in north-eastern India, the latter happens to be one of the 12 mega-biodiversity regions of the world. The Subansiri district lies between the 26°55'N and 28°42'N latitudes and 92°41' E and 94°37' E longitudes (Figure 1). The 28°N latitude crosses the district in its broadest part and the 93°30'E longitude runs through its longest part. The district occupies an area of approx. 20,032 km², inhabited by a population of

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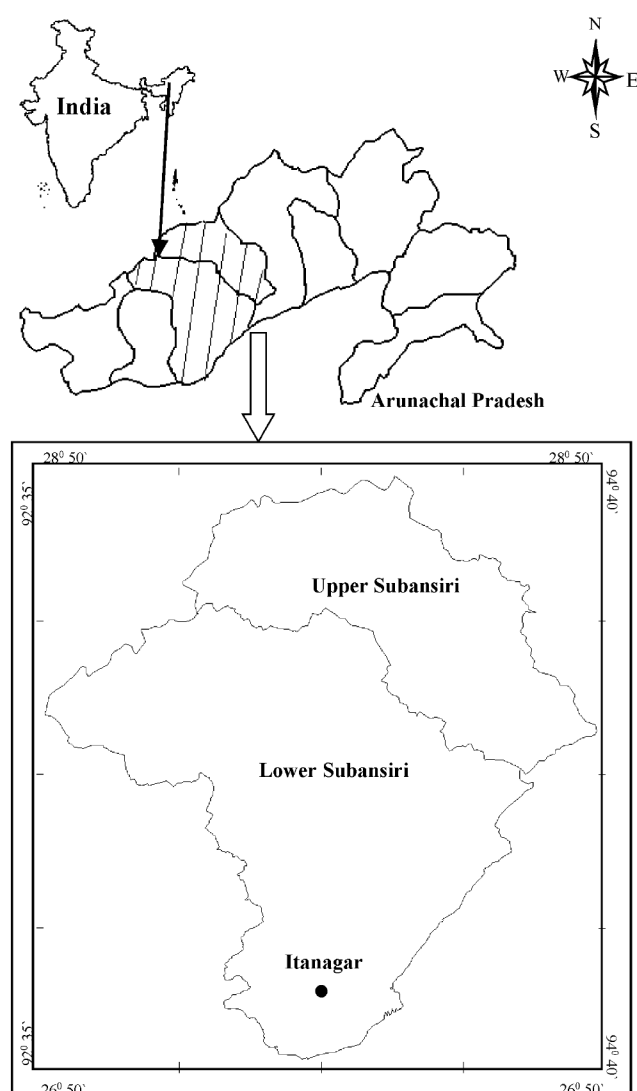


Figure 1. Location map of the study area.

2,06,064 (1991 census)⁹. The district of Subansiri, which falls in the Eastern Himalaya biogeographic zone, owes its high floral and faunal diversity to its strategic location—at the confluence of three biogeographic zones, viz. the Palaeoartic, the Indo-Malayan and the Indo-Chinese¹⁰. Numerous streams and rivers dissecting the complex topography of the area maintain the natural drainage system. Traditionally, people practice a kind of ‘slash and burn’ agriculture, locally called as ‘jhum’¹¹.

For the present study, we used IRS 1C LISS-III digital data¹². The study area is covered by four scenes comprising paths/rows, viz. 111/51, 111/52, 112/51 and 112/52. During the reconnaissance survey, the major vegetation types were covered along the traverses laid across roads, drainages, ridges, valleys and other access points.

For constancy, it is imperative that images are geometrically rectified, so that a given pixel of one scene overlaps on the same pixel of another scene. Image to map registration was followed by image to image registration using the nearest neighbour resampling algorithm with pixel size of 62.5 m. All the four scenes were thus co-registered using proper identification of GCPs with a RMS error of 0.0002 to 0.0012 pixels. Each image was taken separately for classification. After an initial trial, a knowledge-based hybrid classification approach was adopted. This approach is a mixture of extracts from unsupervised and supervised classification and knowledge-based weight from field experience. All images were classified using this method. The final colour-coded thematic output was filtered using a 3×3 majority filter to eliminate salt and pepper effect¹³.

Having the requirements to deal with satellite data and GPS points, it was imperative to consider the spatial dimension for the evaluation of accuracy assessment. The spatial domain was dealt in detail under the software ‘Bio_CAP’ developed under the Department of Space, Govt. of India for the biodiversity characterization project¹⁴. This software provided a user-friendly option to directly import the GPS point in a ‘dbase’ format. It was assumed that the input points were in geographic co-ordinates. Further options were therefore provided to project the GPS points onto either the ‘Lambert’ or ‘Polyconic’ projections. This helped the user to check the accuracy in terms of ground unit, i.e. metres. This software has delivered the accuracy corresponding to distance as well as with respect to other classes, by checking with the user-specified vegetation type in the map.

The vegetation type map prepared from digital classification is shown in Figure 2 (ref. 15). The mapping scale was 1:250 000. It was necessary to accommodate small geometric mis-registrations of the map and the check data. For example, there were known residual errors of about 20 m on the map. Further, all GPS signals intentionally incorporate a randomly introduced error (to hinder strategic military use). In addition, the spherical model of the earth, used for the Lambert projection-based mapping of the district, compared with the modern geodetic referencing of the GPS, induces possible placement differences which fall within the range of ± 100 m. To compensate for these spatial differences between map and locations, the scoring of the map cover was done within various buffer ranges (multiples of 62.5 m) drawn around each point. The scoring procedure recorded presence/absence of the forest class mapped within 187.5 and 250 m (Tables 1 and 2) of the GPS registered points corresponding to three and four pixels buffer, respectively.

Comparisons gave 89% and 92% correspondence for 187.5 m and 250 m buffer ranges, respectively, between field and map data (Figures 3 and 4). It was clear that

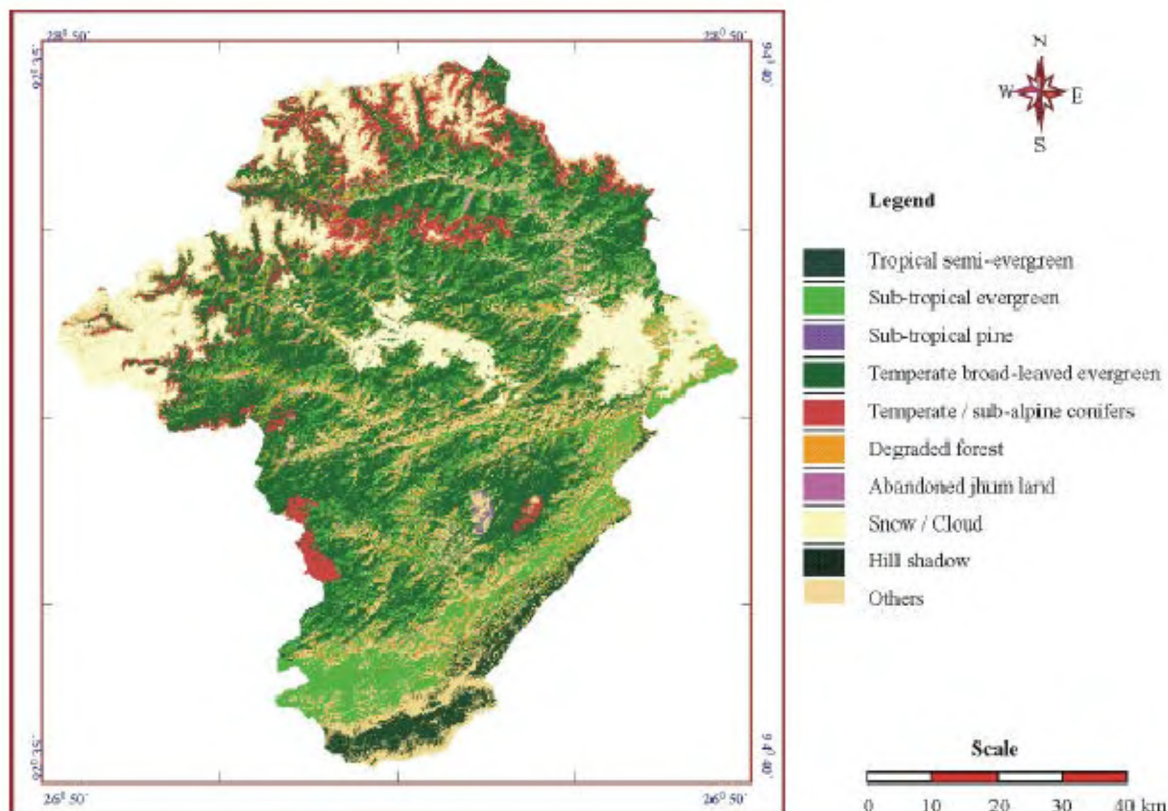


Figure 2. Vegetation cover map of Subansiri district.

Table 1. Correspondence among true vegetation cover at 93 validation points and the land cover map of Subansiri prepared using remotely sensed data. The score of correspondence allowed a maximum of 187.5 m buffer zone around the map sample point

Cover type	TSE	STE	TMP	STP	CON	DEG	JHM	SND	BRN	BMB	Total	% Agreement
TSE	25							1	4		30	83.33
STE		32									32	100
TMP			7						1		8	87.5
STP				3							3	100
CON			1		8						9	88.88
DEG						7					7	100
JHM							1		1	2	4	25
SND								—			0	
BRN									—		0	
BMB										—	0	
Total	25	32	8	3	8	7	1	1	6	2		
% Agree-ment	83.3	100	87.5	100	88.9	100	25	0	0	0		89.25

TSE, Tropical semi-evergreen forest; STE, Sub-tropical evergreen forest; TMP, Temperate broad-leaved evergreen; STP, Sub-tropical pine forest; CON, Sub-alpine/alpine conifers; DEG, Degraded forest; JHM, Abandoned jhum land; SND, Sand/dry river bed; BRN, Barren/fallow land; BMB, Bamboo mixed forest.

Table 2. Correspondence among true vegetation cover at 93 validation points and the land cover map of Subansiri prepared using remotely sensed data. The score of correspondence allowed a maximum of 250 m buffer zone around the map sample point

Cover type	TSE	STE	TMP	STP	CON	DEG	JHM	SND	BRN	BMB	Total	% Agreement
TSE	26								4		30	87.00
STE		32									32	100
TMP			8								8	100
STP				3							3	100
CON			1		8						9	88.88
DEG						7					7	100
JHM							2		1	1	4	50
SND								—			0	
BRN									—		0	
BMB										—	0	
Total	26	32	9	3	8	7	2	1	1	1		
% Agreement	83.3	100	88	100	88.9	100	25	0	0	0		92.47

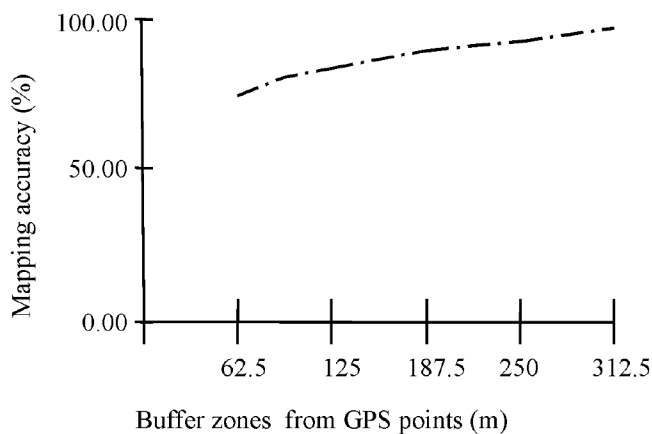


Figure 3. Overall mapping accuracy of the vegetation cover type map.

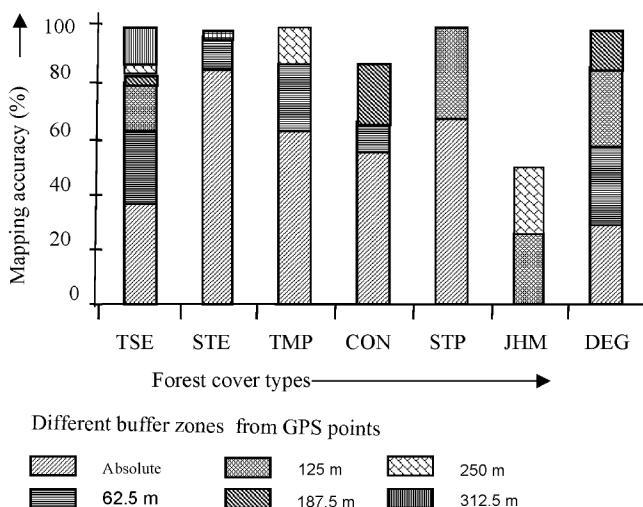


Figure 4. Mapping accuracy of various forest types around various buffer zones.

the vegetation cover type misclassification was not very well spread. Problems usually involved confusion between similar and clearly undefined adjacent classes. Since the area is well drained, deep gorges alternate with tall mountains. Four of the GPS measurements of tropical semi-evergreen forest have gone to barren/fallow land class which could be attributed to the high degree of fragmentation. Due to fast land use changes, some fallow or barren land classes might have been converted to abandoned jhum or bamboo mixed forest. Most of the core forests were highly inaccessible owing to high degree of terrain complexity. Hence, most of the GPS measurements fall near the transition zones. This on the other hand, precisely defines the classification accuracy. This could be due to the two-year difference in the date of satellite data and date of field survey.

The overall agreement among GPS points and digitally classified data meant that the vegetation type map of Subansiri district provides an accurate map of the area. The 89 and 92% overall mapping accuracy is well within the expectations from an operational product for a variety of applications¹⁶. The advent of GPS has added a new dimension in earth surface charting, especially in finding out the point-specific details and area mapping. GPS provides information on geographical coordinates – latitude, longitude and elevation from mean sea level. GPS application in classification accuracy assessment is rather new. GPS could be employed to gather point location information in terms of geo-coordinates and forest cover types and the data are useful not only in image classification but also in classification accuracy assessment, as demonstrated in this study.

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Photodegradation of azadirachtin-A: A neem-based pesticide

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Azadirachtin-A when exposed to UV light (254 nm), as a solid thin film on a glass surface, furnished only a single photoproduct. The photoproduct was isolated by repeated column chromatography and identified by NMR and mass spectroscopy. NMR data indicated that the (E)-2-methylbut-2-enoate ester group of azadirachtin-A has been converted into (Z)-2-methylbut-2-enoate ester. Half-life of azadirachtin-A as thin film under UV light was found to be 48 min.

NEEM plants, like all plants, have several different active chemical compounds. One group of compounds

called limonoids, are of special interest. More specifically, one of these limonoids, which is unique to the neem plant, is called azadirachtin and is found in abundance in neem extracts. Most of the research that has been done on neem plant has focused intensely on this compound because, it is the principal active ingredient of a unique insecticide which is thought to be the most useful and most fascinating by-product of the neem tree. It is thought to be so peculiar because of its properties as a bio-pesticide: it does not immediately kill the insect like most pesticides do. Instead, when an insect eats azadirachtin, it actively attacks the insect's reproductive cycle, its feeding pattern, its bodily development, as well as acting as a direct toxin. Thus, when azadirachtin is sprayed on the plant and the insect takes a bite – if it can stand the bitter taste – the insect will no longer be able to reproduce, eat or grow. This unique compound only affects the insects that consume it, other 'friendly' insects which may help pollination and other plant functions are not harmed; it is a 'narrow spectrum pesticide'. Tests have shown azadirachtin to be effective on at least 200 different insect species¹. Limonoid compounds are found in almost all parts of the neem plant. The active ingredients in neem extracts are very low in toxicity and thus are not toxic to mammals and also quickly biodegrade from the sun's light.

Azadirachtin-A, a powerful insect antifeedant and growth-regulating substance with exceptional environmental characteristics, has been isolated from the seed kernels of the neem tree (*Azadirachta indica* A. Juss.). However, the use of azadirachtin-based neem pesticides may be limited by the acid and base sensitivity of the compound and its susceptibility to photodegradation due to presence of light-absorbing moieties^{2,3}. The (E)-2-methylbut-2-enoate ether group of azadirachtin-A has been converted into (Z)-2-methylbut-2-enoate⁴ in the photoreaction of azadirachtin-A in benzene solution, under both nitrogen and oxygen atmosphere. An alcohol adduct across the double bond was obtained when azadirachtin-A was exposed to UV light in alcohol⁵. There are no reports on the isolation of photoproduct on irradiation of azadirachtin-A as thin film on glass surface. Therefore, in this paper we report the isolation and identification of a photoproduct on irradiation of azadirachtin-A as a thin film on glass surface.

Azadirachtin-A was isolated and purified from neem (*A. indica*) seeds using a previously published method⁶. It was further purified by crystallization from carbon tetrachloride to a melting point of 149–150°C. The purity was checked by high-pressure liquid chromatography. A sample of analytical azadirachtin-A was supplied by SPIC Foundation.

For studies on glass surface as a thin film, a solution of azadirachtin-A in acetone (1 mg ml⁻¹) was applied uniformly with a pipette to petri plates (5 × 5 cm dia.). Acetone was evaporated at room temperature, leaving

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