CURRENT SCIENCE

Volume 61 Number 6 25 September 1991

Remote sensing in India — an addendum

The article 'Those who made it possible' in the special issue on 'Remote Sensing for National Development' (*Curr. Sci.*, **61**, 117) had to be written in a hurry and there was no time to dig up all the archival material on the growth of remote sensing in India. My attention has been drawn to some serious omissions in this article.

(1) M. G. K. Menon, former chairman of the Electronics Commission, director-general, CSIR, and secretary, DST, who took charge of ISRO immediately after Vikram Sarabhai died, was responsible for the smooth transition of NRSA from DST to ISRO.

(2) Yash Pal, former chairman, UGC, played an important role when he came from TIFR to shape the scattered effort in Ahmedabad into the Space Applications Centre (SAC). He too played (along with Brahm Prakash) a vital role in the formation of the NNRMS. Yash Pal also did the first application of remote sensing to archaeology—Saraswathi river.

(3) Y. S. Rajan, Adviser, DST, should have been mentioned for his important role in the development of the multi-agency nationwide NNRMS system. He was the first chairman of Earth Observation Systems at ISRO Headquarters.

(4) Vasanth Rajyadhyaksha, Chief Consultant to the Planning Commission, suggested in the late seventies that resource management should receive higher support in the space effort. He persuaded the Planning Commission and the Ministry of Finance to support a fully Indian effort in this area (cf. INSAT-1 and other bought-out systems followed by INSAT-2 Indian systems).

(5) D. S. Kamath produced the first software for Indian machine processing of space imagery.

(6) When DST decided to establish the National Remote Sensing Agency (NRSA) at Hyderabad, they could find no suitable scientist to head it. K. R. Rao from SAC went over to establish the new agency.

(7) While it is a fact that the Indian remote sensing programme stands on a firm foundation that is definitely Indian, the vital cooperation and contributions of NASA, CNES and the USSR Academy of Sciences must not be underestimated.

(8) S. Dhawan was not a student of von Karman. He worked with Hans Liepmann at Caltech.

S. Ramaseshan

SCIENTIFIC CORRESPONDENCE

Remote sensing of water-logged areas

With reference to K. P. Singh's paper 'Insensitivity of remote sensing to water-logging in low-capillarity soils' (*Curr. Sci.*, **59**, 464–465): Field work is not only necessary for making essential checks but is fundamental and even prelusive to photogeological and remote-sensing studies. It is a fundamental fact taught to students of photogeology. Therefore a full paper rhetoric of this aspect alone perhaps carries no new significant contribution. LANDSAT imagery and Thematic Mapper (TM) data, along with aerial photographs, only help in covering larger areas in a shorter time and give a perspective view of the area, but can never be a substitute for active field work.

Secondly, since LANDSAT and TM are of a very small scale and because they record from a long distance from the earth, one is bound to miss the smaller, imperceptible objects while interpreting the imagery/data. That is why, even when areas are water-logged, LANDSAT images may not perceptibly register signatures of the smaller water-logged areas. If, however, the water bodies are large but are not picked up by LANDSAT, then the lithology must be different. This aspect has not been discussed clearly by the author though he mentions low capillary action.

It is not clear whether the author implies that all the water-logged areas that could not be picked up by

LANDSAT (where the capillary rise is low) are underlain by a uniform lithology and if this lithology is different from the lithology of the areas where water-logging was picked up (high capillary rise). This part, which should in fact be the basis of the paper, has not been clearly discussed. With all other parameters being the same, could the author tell the difference in lithology/soil type in the two areas differentiated, which may both be part of Older Alluvium? Such indirect information (on the basis of water-logging in such areas) could be helpful in delineating and mapping the variation of lithology within the Older Alluvium, which otherwise is not perceptible and cannot be mapped by ground-survey methods since the area is under extensive cultivation. In the absence of such an observation and discussion it is superfluous to conclude that 'such observations when interpreted without the aid of field data lead to deceptive results, wrong planning and execution of schemes in the field for reclamation of water-logged areas'.

We know that capillary action is more effective in the finer sediments, i.e. silty clays, and nil in the coarser or sandy soils. It is quite likely that the areas where water-logging is identified (and where capillary action is high as reported by the author) are underlain by Older Alluvium and the areas where water-logging is not picked up (owing to low capillary action as reported by the author) are underlain by sandy soils, which may be of aeolian nature. Such an observation has not been made by the author.

As a matter of fact study of LANDSAT imagery should be followed by a study of aerial photographs of moderate scale, say 1:63,360 or 1:40,000, to get the correct extent and shape of the bodies on the ground.

I have had the opportunity of working in the southern parts of Punjab and have also studied the LANDSAT imagery. My experience has been that water-logged bodies delineated from remote-sensed data correspond well with ground data.

I support and confirm the view of the author that the water-logged areas in south-west Punjab continue to increase, in contrast to the observations of R. P. S. Chopra, cited in the paper, that they are decreasing.

It would have been better if the author had given maps of the areas based on remote sensing and field mapping separately. In fact, the paper has no map, and even the figure it has does not give an index of symbols used for soil types.

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The paper by K. P. Singh does not include the necessary information concerning the work carried out. For example, the name (MSS/TM), scale and date of the product have not been given. The choice of season, scale and data product plays an important role in delineation of water-logging by remote sensing. It is very true that unsaturated topsoil will not be registered in the imagery. So one must select a date when one can find maximum saturated topsoil to bring down the error. Moreover one must take into consideration the resolution of MSS/TM/LISS data. When using MSS with a resolution of 76 m, one cannot expect a sensitivity that allows identification of water-logged patches less than the dimension $152 \times 152\ m^2$; and so with TM, $60 \times 60\ m^2$. Above all this, statistical analysis of accuracy testing is very important. This has been omitted in the paper. Every method must be used with precision, at the same time taking into consideration the negative points. The paper of K. P. Singh leads to a very hasty conclusion without proving the degree of insensitivity of remote sensing in a prescribed area using proper statistical analysis.

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K. P. Singh replies:

1. Comments of Gurdev Singh

In the present case, a typical environmental problem of hydrology has been studied and the significance of detailed field work in investigating such an environmental problem, which is dynamic in nature, has been highlighted. Field checks are essential but at times insufficient field work is done in checking the results obtained from remotely sensed data. In such cases wrong interpretations are made, as also pointed out by Kalubarme *et al.*[1] The work of Johnson and Kamprad[2] also emphasizes the need of sufficient field checking of each scene while using multidate data for mapping temporal features, supporting the conclusions drawn by me.

Regarding the point that a study of LANDSAT images should be followed by aerial photography on a moderate scale of 1:40,000 to get the correct extent and shape of the water-logged bodies, as far as large-scale investigations are concerned, it is true that LANDSAT images give a larger view of the area and aerial photographs are of help in identification of correct extent and shape of any surface feature that may be small in size. My own studies[3] using LANDSAT data and aerial photographs for mapping hydromorphological units at macro and micro levels show that aerial photographs are extremely useful in mapping small-scale hydromorphological units. However, I emphasize that, in studying such a problem, which is dynamic/temporal in nature, aerial photographs are of little use. Moreover, repeat aerial photography is expensive and normally not practised.

It is true that when resolution of LANDSAT and TM products is 80 m and 30 m respectively the smaller bodies may not be picked up. But in the present case a large tract (173,000 ha) is water-logged. Where such large tracts are not completely picked up in the satellite imagery, subsurface lithology may be important, and this has been demonstrated. As already pointed out, variation in the subsurface lithology has caused the variation in capillary rise, resulting in differences in spectral signatures. In the figure in my paper, two types of models are shown. In the first case aquifer materials and soils are fine-grained (fine sand mixed with silt) and have high capillary rise while in the other case the aquifer material and soils are coarse-grained (coarse sand) and capillary rise is less. In both cases the area forms a part of Older Alluvium.

Soils in both cases belong to Typic Camborthids and Typic Calciorthids. It will be too immature at this stage to map variations in the subsurface lithology of aquifers on the basis of LANDSAT data using appearance of water-logging as a single parameter. Mendel and Shultz[4] have also correctly pointed out that only in exceptional cases, and only indirectly, can groundwater be identified from satellite data. Therefore mapping variation in subsurface lithology of Older Alluvium on the basis of remotely sensed data seems to be difficult at this stage. However, indirectly some indications may be obtained from surface features that may reflect the nature of local subsurface lithology. Such interpretations of subsurface lithology from satellite data are still at the experimental stage[5].

It is true that incorrect identification of water-logged areas leads to wrong planning and execution of works in the field. In fact, such a situation had arisen when it was presumed that water-logging had been controlled and remedial measures were stopped, whereas the situation in the field was entirely different.

Regarding preparation of maps on the basis of remotely sensed and field data, I must point out that such maps have already been prepared and are being published separately in a detailed paper elsewhere.

2. Comments of K. A. Bhagwat

A number of data products were used. LANDSAT black-and-white images of MSS bands 5 and 7 for 18 May 1981 on 1:250,000 and 1:1,000,000 scale were used. False-colour composites of MSS bands 4, 5, 7 for 10 November 1975 on 1:250,000 scale and of bands 1, 2, 4 for 9 November 1983 on 1:250,000 scale were used. False-colour composites of MSS bands 2, 3, 4 for 19 May 1984 and for 17 March 1987 on 1:250,000 scale were also used.

TM data products used include TM band 4 imagery for 16 October 1989 on 1:250,000 scale, TM imagery of band 3 for 24 April 1988 and 21 June 1988 on 1:1,000,000 scale, TM imagery of band 5 for 28 November 1987 on 1:1,000,000 scale, and TM false-colour composite generated from bands 2, 3, 4 for 3 May 1987 blown up to 1:50,000 scale. It may be mentioned here that *during all these times* the area remained water-logged, as revealed by field data.

It is true that the time when one can find maximum saturated topsoils must be kept in view to map water-logged areas correctly. Certain areas may not be water-logged during the pre-monsoon period (May/June) but may become water-logged after the monsoon recharge in October/November when the depth to water is shallow. This is known as seasonal water-logging pattern. I have studied[6] seasonal water-logging patterns. The results of these investigations support the views of Bhagwat. However, *in the present case, large tracts are water-logged* and water-logging is *permanent* and prevalent during the entire year. Therefore data relating to specific dates were not required.

It is also true that water-logged areas of smaller dimensions and some other features may not be picked up if data on different resolution are used. This fact was also pointed out in the work of Kalubarme *et al.*[1], where it has been demonstrated that LANDSAT-MSS picks up water-logged and saline areas if such areas are at least 4–5 ha. But in the present case large tracts are water-logged (173,000 ha). Keeping in view the areal extent of the water-logged area correct data based on sufficient resolution were used.

It is wrong to say that the conclusion is hasty because the conclusions are drawn on the basis of study of data from 1975 to 1988 along with field observations concerning a critically water-logged area of 173,000 ha. As I mentioned in the paper, visual interpretation techniques were used, and statistical analysis was not possible. However, computer-compatible tapes are being procured for pixelwise statistical analysis of the area.

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