CURRENT APPROACHES FOR SMART AGRICULTURE

Editors

Dr. Satybhan Singh

Dr. Himanshu Trivedi

Dr. Virendra Singh

AkiNik Publications

New Delhi

Published By: *AkiNik Publications*

AkiNik Publications
169, C-11, Sector - 3,
Rohini, Delhi-110085, India
Toll Free (India) – 18001234070

Editors: *Dr. Satybhan Singh, Dr. Himanshu Trivedi and Dr. Virendra Singh*

The author/publisher has attempted to trace and acknowledge the materials reproduced in this publication and apologize if permission and acknowledgements to publish in this form have not been given. If any material has not been acknowledged please write and let us know so that we may rectify it.

© ***AkiNik Publications***

Edition: *1st*

Publication Year: *2022*

Pages: *528*

ISBN: *978-93-5570-290-6*

Book DOI: *https://doi.org/10.22271/ed.book.1833*

Price: *₹ 1795/-*

Chapter - 10
Application of Remote Sensing for Precision Water Management

<u>Authors</u>

Richa Khanna
School of Agricultural Sciences & Engineering, IFTM University, Moradabad, Uttar Pradesh, India

Anil Nath
Department of Agronomy, College of Agriculture, GBPUA&T, Pantnagar, Uttarakhand, India

Anurag Bera
Department of Agronomy, DRPCAU, Pusa, Bihar, India

Krishan Pal
School of Agricultural Sciences & Engineering, IFTM University, Moradabad, Uttar Pradesh, India

Virendra Singh
School of Agricultural Sciences & Engineering, IFTM University, Moradabad, Uttar Pradesh, India

Ananya Singh
School of Agricultural Sciences & Engineering, IFTM University, Moradabad, Uttar Pradesh, India

Abhay Saini
School of Agricultural Sciences & Engineering, IFTM University, Moradabad, Uttar Pradesh, India

Chapter - 10

Application of Remote Sensing for Precision Water Management

Richa Khanna, Anil Nath, Anurag Bera, Krishan Pal, Virendra Singh, Ananya Singh and Abhay Saini

In the words of Leonardo da Vinci “Water is the driving force of all nature”. There is no doubt water is the most precious gift of nature to mankind, but due to unwise use of water, in present time we are facing the scarcity of water. One third of our planet earth is covered with water but all of that water is not available for our use. Only 2.7 percent of total water on earth is fresh water and that can be used by us. Water is required by all forms of life on earth, including plants. At present the gap between availability and supply of water is continuously widening and agriculture sector is not an exception. Agriculture consumes a major portion of the fresh water available on earth and this sector also accounts for most un précised use of water. Generally, farmers lack knowledge on irrigation aspects that when to apply water, how to apply and how much to apply, due to these factors there is massive loss of water. Further, due to liberalization in Government policies a huge number of farmers have installed submersible and pump sets in their fields which is providing them water with less efforts and they are using it unwisely. In agriculture the most optimum way to save water is by improving water use efficiency which can be attained by better crop management practices. Therefore, it becomes essential to apply water to crops in a précised and calculated manner so that wastage can be avoided and this can be made possible by use of advanced techniques like micro irrigation and remote sensing.

Among these remote sensing is an innovative technique that can manage water precisely and helps in avoiding wastage. Several sensor-based devices like drones, satellite images, GPS, GIS etc. are used which ensure the optimum utilization of water.

What is Remote Sensing?

The science of deriving information about an object from measurements of electromagnetic radiation reflected or emitted from that object is known as remote sensing (Lillesand and Kiefer, 1994). In simple way, “Remote sensing may be defined as sensing of an object from a far place without being in contact with it”. Remote sensing is a potentially important tool in agriculture because the sensors are able to store analyze and display the sensed data.

The process of remote sensing can be understood simply by following elements

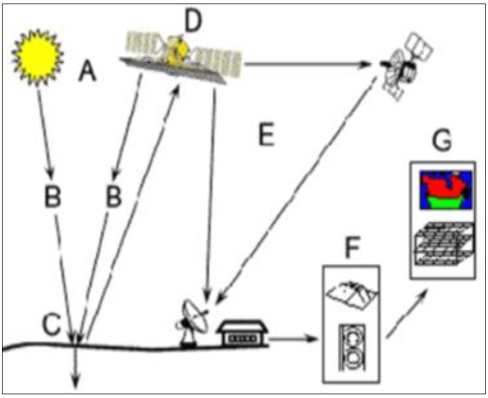


Fig 1: Elements of Remote Sensing

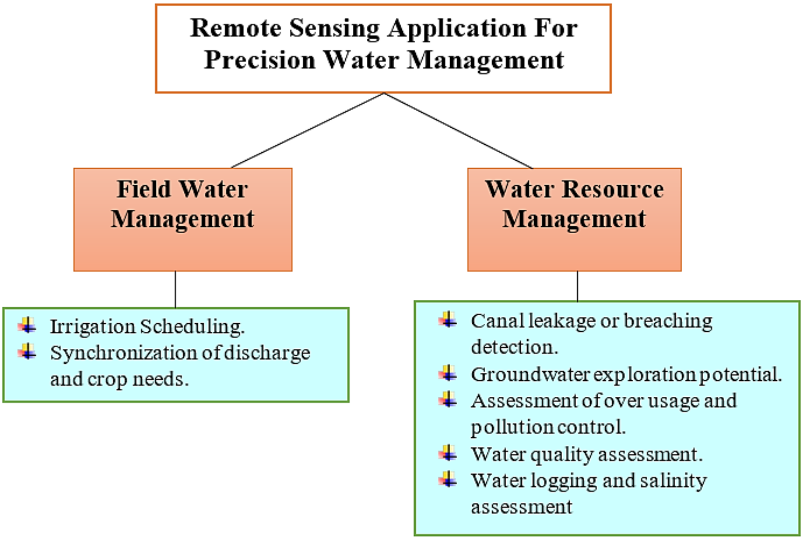
1. Energy source or illumination (A)
2. Radiation and the atmosphere (B)
3. Interaction with the target (C)
4. Recording of energy by the sensor(D)
5. Transmission, reception and processing (E)
6. Interpretation and Analysis (F)
7. Application (G)

Why to go for remote sensing for precision water management?

- It provides synoptic coverage.
- Large and inaccessible areas can be covered effectively.
- It provides information in spatial domain.
- The data obtained by remote sensing is quantifiable and the software can process it quickly.
- It can serve as a store house of large amount of data.
- Remote sensing process doesn’t disturb any living being and environment.

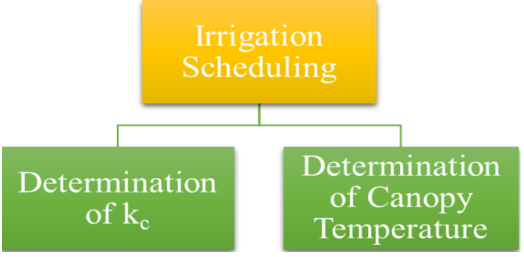
Application of remote sensing for precision water management

Remotely sensed images have a variety of use in agriculture from identifying nutrient deficiencies, disease diagnosis, sensing water deficiency or surplus, weed infestations, insect damage, hail damage, wind damage, herbicide damage, and plant populations. The images taken through satellites and aircrafts provides a means to assess the existing field conditions without being in physically contact with the place. Using these images and data analyzed by different softwares farmers can easily get information on when to irrigate and how much to irrigate.



Remote sensing for irrigation scheduling

Irrigation scheduling is one of the most important criteria that determines the efficient utilization of irrigation water. It includes aspects like when to irrigate and how much to irrigate. Remote sensing can be effectively used for irrigation scheduling either through determination of crop coefficient or by determination of canopy temperature by infrared or thermal regime images.



A. Determination of crop coefficient (K_c)

Crop coefficient (K_C) is the ratio between evapotranspiration of crop (ET_C) and potential evapotranspiration (ET_0). Crop coefficient (Kc) based estimation of crop evapotranspiration (ETc) is one of the most commonly used methods for irrigation water management (Singh and Irmak, 2009). This method is often used for irrigation scheduling but the most limiting factor in this method is difficulty faced in reliably estimating the values of crop coefficients. For most of the crops constant K_C values are used for irrigation scheduling and crop coefficients are commonly estimated based on days since planting or (occasionally) growing degree days (Allen *et al.* 1998). A wide variety of irrigated crops are grown under a wide range of conditions, and dependable crop coefficients are not available for many of the crops and growing conditions. This is especially true for horticultural and other specialty crops that are increasingly important in irrigated areas. The figure 2 shown below is representing how crop coefficient values are changed according to different environmental parameters (Aghdasi *et al*., 2011). Therefore, in such cases remote sensing technique is an efficient, economic and strong tool for monitoring K_C values. The crop coefficient values obtained by remote sensing were found to be 30 percent more précised as compared to visual or local methods of detection (Trout, 2009).

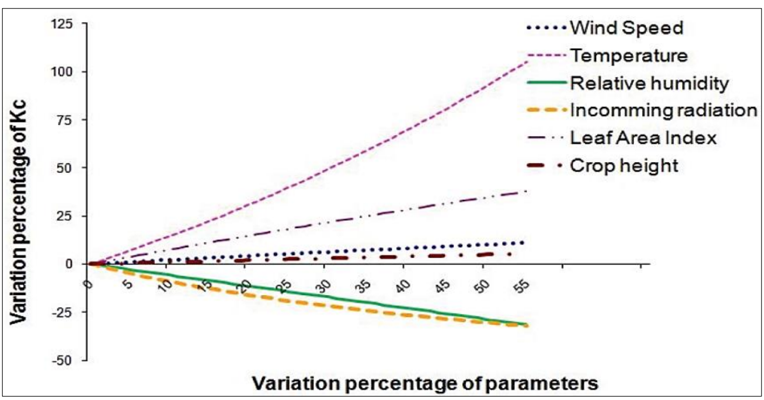


Fig 2: Variation of K_C with different environmental factors

B. Canopy temperature concept

Plant water stress is a very good method to determine time and quantity of irrigation to be applied to a crop. Thermal images obtained through remote sensing is a very efficient technique to detect water stress faced by plant. Based on thermal sensing "Crop Water Stress Index" is calculated and it helps in optimizing irrigation to be applied to a crop (Jones *et al.*, 2009).

$$CWSI = \frac{T_{\text{canopy}} - T_{\text{wet}}}{T_{\text{dry}} - T_{\text{wet}}}$$

Where, T_{canopy} = Actual canopy temperature obtained with thermal image sensing.

T_{wet} = Temperature of a transpiring leaf with open stomata.

T_{dry} = Temperature of non-transpiring leaf with closed stomata.

The images 1 and 2 shows canopy temperature based thermal images in rice crop at IRRI, Manila and in grape wine yards, South America where well irrigated portions are shown in blue color and drought affected ones are shown in red color (Jones *et al*., 2009).

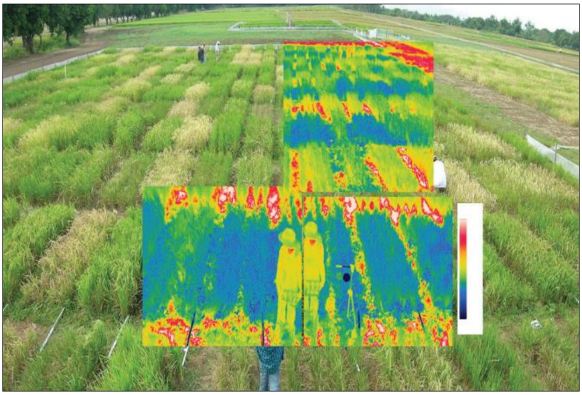


Image 1: Canopy temperature based thermal images in rice indicating well irrigated and drought affected areas.

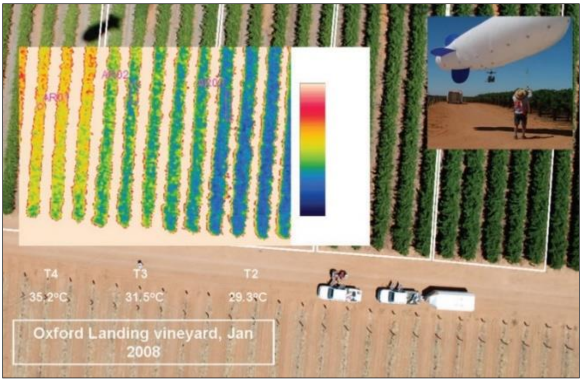


Image 2: Canopy temperature based thermal images in grape vineyards indicating well irrigated and drought affected areas

Remote sensing for water resource management

Water occurs on earth in three forms: solid, liquid and gases. About 97 percent of water present on earth is confined to oceans, which is not useful for irrigation purpose. Out of total water available on earth, 2.60 percent is fresh water and out of this 77.23 percent is found in polar ice caps, ice bergs and glaciers. Only a small fraction of water resources of earth is present in ground, lakes, rivers and atmosphere and can be harvested for irrigation of crops (Reddy and Reddy, 2020). Therefore, it becomes very important to utilize these resources and wastage in any form should be avoided.

A. Canal breaching or leakage detection

Canals are one of the main sources of irrigation in India. Water from the rivers is directed towards agricultural fields through canals. However, the conveyance efficiency of canals in not up to the mark and major loss occurs through seepage through breaks present in canals. These breaks go unnoticed for a longer period of time and results in wastage of precious water resources. The most common ways to locate break in a canal system is either through visual observations or through flow monitoring equipments which are very costly. Remote sensing based imaging system has lots of potential in identifying these cracks and seepage loss in almost no time and a lot of water resources can be saved by that way (Huang *et al.*, 2010; Arshad, 2008). Image 3 is showing how remotely sensed thermal images can easily detect damage in a canal and its rectification can save gallons of water from being wasted (Huang and Fipps, 2002).

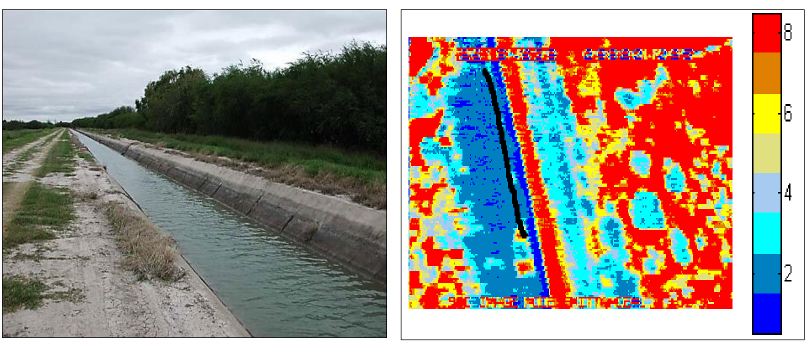


Image 3: Detection of seepage in canal caused by cracks through thermal imaging.

B. Remote sensing for groundwater exploration

Groundwater removal for human consumption is a practice since time immemorial. Since surface water resources are not sufficient and they tend to dry up in non-monsoon season people remove the groundwater for various usages. As a result of this most of the groundwater resources are getting over exploited. Remote sensing helps us to identify potential exploitation zones and thus prevents over and under utilization of resources and helps in précised water management. Table 1 is showing hydro geomorphological analysis of Sohna block of Haryana to identify potential sites for groundwater exploitation (Chaudhary *et al*., 1996). The table clearly indicates that alluvial plains and low-lying depression areas have excellent potential to exploit groundwater whereas, low structural hills and pediment areas have very poor potential for groundwater removal. This data obtained through remote sensing could be very beneficial in identifying potential sites and exploitation of resources can be reduces.

Table 1: Hydro geomorphological analysis of Sohna block of Haryana

Area Under Study	Water Level	Exploitation Potential
Low structural hills	-	Very poor
Valley fills	6-12 m (bgl)	Good
Pediment	25-30 m (bgl)	Poor
Piedmont plain	16-21 m (bgl)	Moderate to fair
Aeolian plains	17-27 m (bgl)	Moderate to good
Alluvial plains	4-9 m (bgl)	Excellent
Low lying depressing areas	6-9 m (bgl)	Excellent

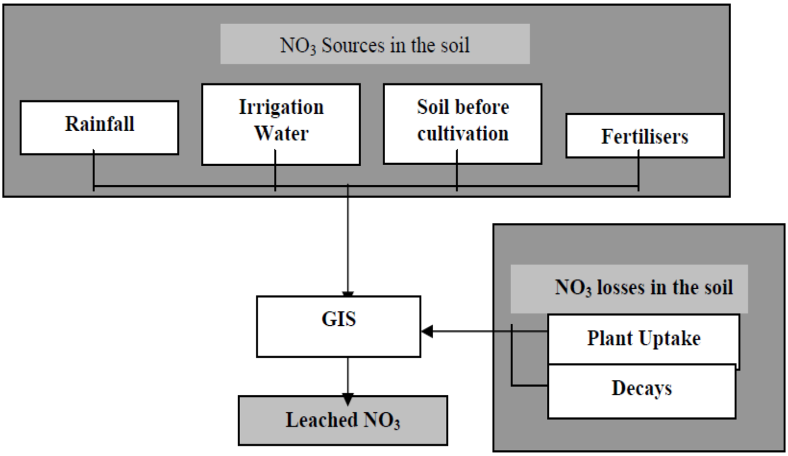


Image 4: Assessment of nitrate pollution through remote sensing

C. Assessment of over usage of water and pollution control

Remote sensing can be successfully used for assessment of water and soil pollution levels. Image 4 is showing GIS based sensing of leached nitrates from the soil. This data can be successfully used to identify potential polluted sites and measures can be adopted for reclamation and amelioration of soil pollution (Rida A Al Adamat *et al*., 2006). Lei *et al*. (2009) used the technique of remote sensing to assess the amount of nitrate N leached due to excess usage of irrigation water and also assessed the nitrogen hazard classes by the use of remote sensing (Image 5). In terms of amount of nitrate leached maximum amount is reported from agricultural fields where nitrogenous fertilizers are being used and least leaching was reported from urban areas. Such assessment through remote sensing could be highly beneficial for the society.

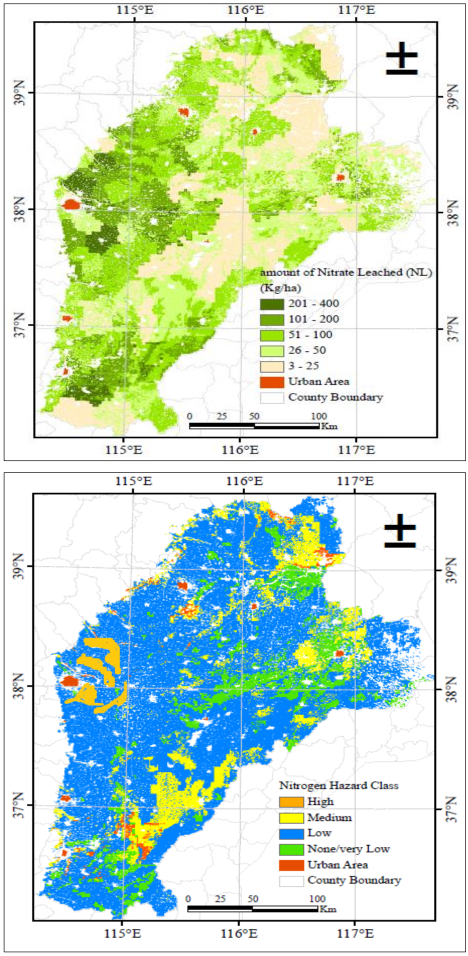
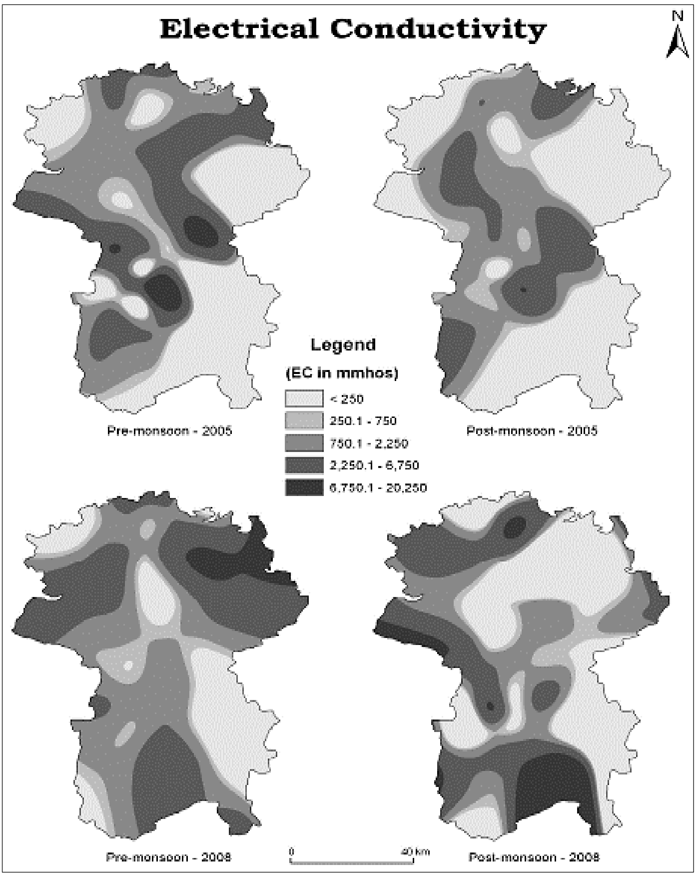


Image 5: Amount of nitrate N leached due to excess irrigation water and nitrogen hazard classes.

D. Remote sensing for water quality assessment

Remote sensing based spatial images can be used for assessment of water quality. Parameters such as electrical conductivity, TDS, sodium absorption ratio and total hardness were assessed by Balachandar *et al*., 2010 in Coimbatore (Image 6 and 7). The study revealed that The EC values ranged from 430-5500 m mhos during 2008, indicating moderate to high values. 95 % of total samples falls under good and excellent category of SAR and 5 % under permissible category. About 59 % of samples during pre-monsoon and 63 % of samples during post monsoon period falls under good quality irrigation water suitable for irrigation. With the easy availability of this kind of data water quality can be assessed in a much more précised way and provision for safe irrigation water can be ensured for farmers.



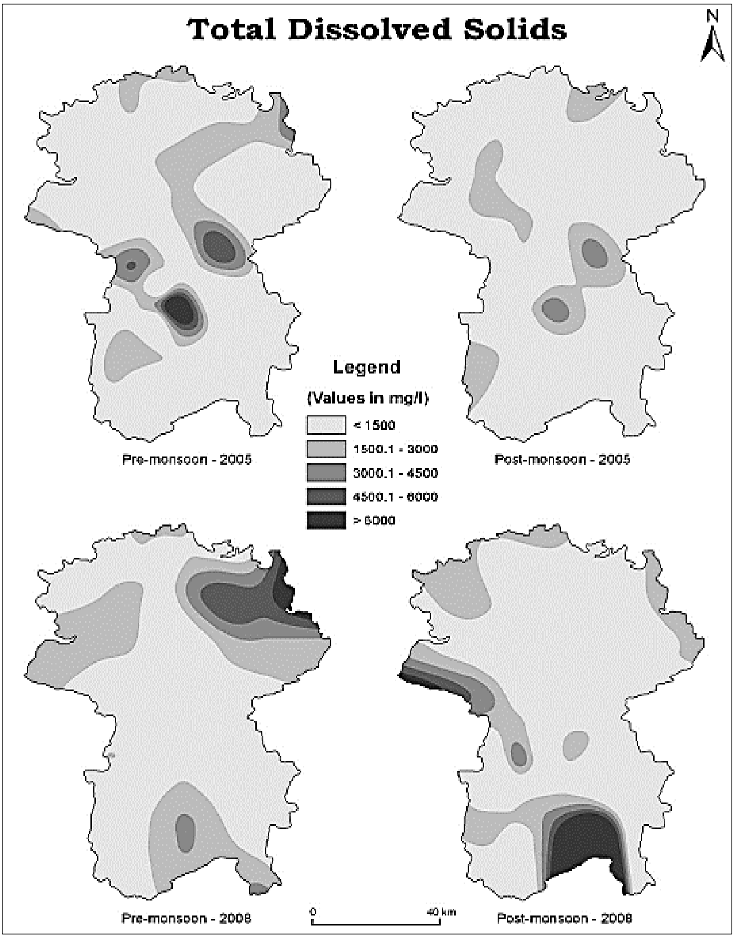


Image 6: Remote sensing based electrical conductivity and TDS map of groundwater of Coimbatore.

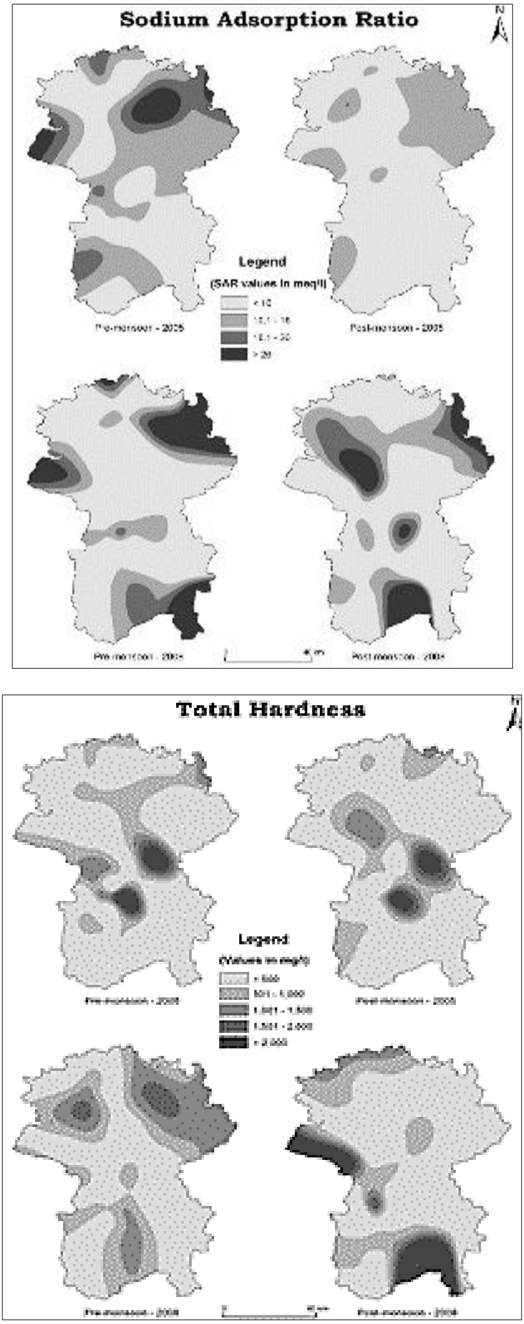
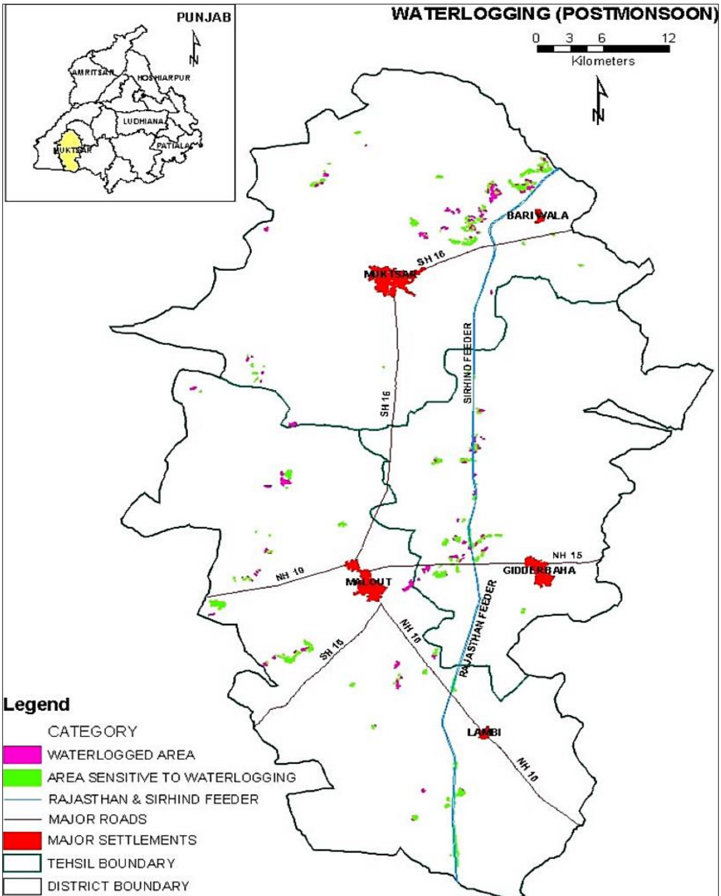


Image 7: Remote sensing-based sodium absorption ratio and total hardness map of groundwater of Coimbatore.



Source:IRS ID LISS III Satelite Data of September, 2001.

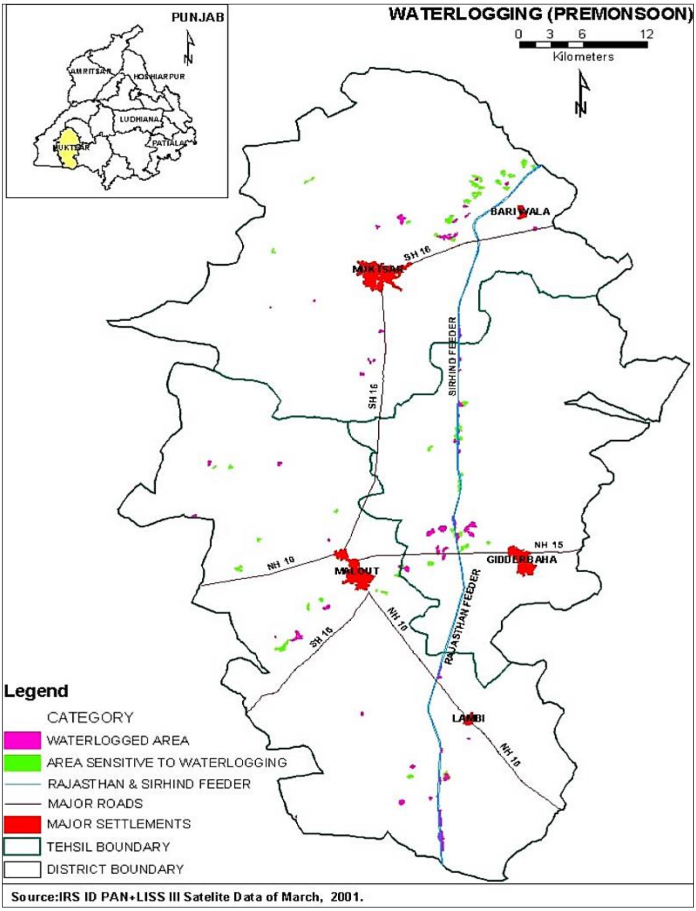


Image 8: Remote sensing based assessment of pre and post monsoon water logged areas in Punjab.

E. Remote sensing for water logging assessment:

Water logging is considered to be one of the major threats to agricultural production. Remote sensing through its synoptic viewing and multi spectral capability makes the task of precise mapping of water logging much easier. Bhatt *et al*. (2001) compared the pre and post monsoon season water logging in Punjab. The remotely sensed images helped in identification of areas affected with water logging in pre monsoon period and then in post monsoon period.

This data could be potentially used for determining the types of crops to be taken and measures to be adopted for overcoming water logging problems (Image 8).

Conclusion

- Remotely sensed vegetation indices helps in over coming within field variability and can be used towards upgradation of crop coefficients.
- Remote sensing can be used to pinpoint the location of breaks in the canals in addition to merely detect its presence.
- Integrated assessment of surface features is a suitable method for predicting groundwater potential and water storage structures.
- It can be successfully used in assessment of risks associated with over usage of water like nitrate pollution and water logging.

On the basis of above discussed points, we can say that remote sensing is a very efficient technique in précised management of water in agriculture.

Major Gaps

- No agency has overall responsibility for regularly updating and maintaining remote sensing data.
- At present remote sensing and GIS data are only generated in a project mode in specific segments.
- User departments are attempting to address on their own GIS requirements and rather than integrating it with other related aspects.
- Data duplication and state-level data inconsistency is an unresolved matter.

Future line of work

- Integrated approach of remote sensing involving various aspects of agriculture and allied fields need to be studied.
- Need to broaden the horizons of remote sensing rather than considering it as a project and making it more farmer's friendly.

References

1. Aghdasi F, Sharifi MA and Van Der Tols C. (2011). Assessing crop water requirement methods using remotely sensed data for annual planning of water allocation in irrigated agriculture. International commission on irrigation and drainage, ICID 21st International Congress on Irrigation and Drainage, 15-23, October, 2011, pp. 345-353.
2. Allen RG, Pereira LS, Raes D and Smith M. (1998). Crop Evapotranspiration: guidelines for computing crop water requirements. FAO Irrigation and Drainage paper - 56. FAO, Rome.

3. Arshad, M. (2008). Improving the accuracy of canal seepage detection through geospatial techniques. Ph.D. dissertation, George Mason University, pp. 164.

4. Balachandar, D., Sundararaj, P., Rutharvel Murthy, K. and Kumaraswamy, K. (2010). An Investigation of Groundwater Quality and Its Suitabilityto Irrigated Agriculture in Coimbatore District, Tamil Nadu, India - A GIS Approach. International Journal of Environmental Science, 1(2): 176-190.

5. Bhatt, C.M., Singh, R., Litoria, P. and Sharma, P.K. (2004). Use of remotely sensed data and GIS techniques for assessment of waterlogged and salt-affected area tehsil wise in Muktsar district of Punjab. 7th Global Spatial Data Infrastructure (January 30 - February 6, 2004) At: Bangalore (India).

6. Chaudhary, B.S., Kumar, M., Roy, A.K. and Ruhal, D.S. (1996). Application of remote sensing and geographic information system in ground water investigations in Sohna block, Gurgaon District, Haryana (India). International archives of photogrammetry and remote sensing, 31(B6): 18-23.

7. Huang, Y., & Fipps, G. (2002). Thermal Imaging of Canals for Remote Detection of Leaks: Evaluation in the United Irrigation District 1.

8. Huang, Y., Fipps, G., Mass, S.J., Fletcher, R.S. (2010). Airborne remote sensing for detection of irrigation canal leakage. Irrigation and Drainage, 59(5): 524-534.

9. Jones, H.G., Serraj, R., Loveys, B.R., Xiong, L., Wheaton, A. and Price, A.H. (2009). Thermal infrared imaging of crop canopies for the remote diagnosis and quantification of plant responses to water stress in the field. Functional Plant Biology, 36: 978-989.

10. Lei, Y., Wang, Z., Li., H., Zheng, Li. And Zheng, S. (2009). Assessment of nitrate leaching on agriculture region using remote sensing and model. Proceedings of SPIE 7472, Remote Sensing for Agriculture, Ecosystems, and Hydrology XI, 74722A, doi: 10.1117/12.831342.

11. Reddy, T.Y. and Reddy, G.H.S. (2020). Principles of Agronomy. Kalyani Publishers, New Delhi, 110 002.

12. Rida A Al Adamat, Baban, S.MJ. and Foster, I. (2006). Modelling Nitrate Leaching in the Azraq Basin/ Jordan Using GIS. The 2nd International Conf. on Water Resources & Arid Environment, pp. 1-28.

13. Singh, R. and Irmak, A. (2009). Estimation of crop coefficients using satellite remote sensing. Journal of irrigation and drainage engineering, 135(5): 597-608.

14. Trout, T. (2009). New Developments in irrigation scheduling. In Proceedings of the 2008 Central Plains irrigation conference, Greeley, Colorado, February 19-20. Colorado State University. Libraries.