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RESEARCH NOTES

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Assessing the extent and causes of degradation in India's arid rangelands

Key points

- Land use pressures are increasing degradation in India's arid zone grazing lands.
- Research supported by ACIAR is developing ways to assess the extent and causes of degradation in the Thar Desert region of Rajasthan.
- Remote sensing provides a way of monitoring vegetation cover over large areas.
- Environmental, animal production and socio-economic data are combined in a GIS to help interpret and display the information.
- The purpose is not just to quantify degradation – once the extent of the problem is known, action to improve grazing management is needed.

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The problem

Desertification of the Indian arid zone is occurring at an alarming rate, as a consequence of overgrazing in landscapes which naturally have low rainfall and recurring droughts. Removal of vegetation makes soils susceptible to wind and water erosion. Subsistence farmers carry out grazing, cropping and vegetation cutting. They have little capacity to plan for the future when the present is so precarious.

More than 200,000 sq km of western Rajasthan is arid, representing almost two-thirds of the entire Indian arid zone. Annual rainfall ranges from 100 to 350 mm and is predominantly monsoonal and highly variable. Grazing is the major land use. Meat, wool and milk underpin the economy, while crop production is opportunistic and for subsistence only. About half the livestock are sheep and goats, and the remainder are cattle, camels and donkeys. The human population is increasing by about 30% every decade and is currently about 20 million, of whom 80% are rural dwellers. Livestock numbers are also growing. According to ground-based estimates, nearly two-thirds of India's arid grazing lands are in poor or extremely poor condition. Consequently, the rural landscape is being pressured directly by a population increase in both people and livestock locally and, indirectly, by expanding urban populations which depend on rural areas for supply of animal products.

There is little quantitative information about the extent of the problem, nor is there capacity to give people quantitative information about the impacts they are having or the effects that management changes might have. Due to the lack of appropriate tools for land management decision making, effective contingency planning has not evolved. Since 1999 ACIAR has supported collaboration between Indian and Australian scientists to develop ways of assessing the extent and causes of degradation in the Thar Desert region of Rajasthan.

Potential of remote sensing for monitoring

The factors and processes causing desertification in India are reasonably well understood but intensive on-ground assessment is expensive and difficult across broad areas of low production. Remotely-sensed information provides a way of extending ground-based knowledge to whole regions. Remote sensing methods can rapidly monitor vegetation cover over large areas and, in some cases, provide an objective way to separate land use impacts from natural variation. This allows managers to target specific areas and monitor trends in landscape health.

When remotely-sensed information is coupled with on-ground knowledge of land use and impacts, the causes and extent of degradation or recovery can be quantified over wide areas. This gives rapid feedback on the impact of land administration and management initiatives and contributes to better policy. It may also provide a means of feeding back information to farmers if it is combined with suitable explanations from advisers.

Integrating information about land use impacts with a GIS

To obtain information about degradation from a combination of remotely-sensed and ground-based data, first of all, a suitable measure of landscape resilience is derived from remotely sensed data. The capacity of natural vegetation to respond to significant wet-season rainfall is a simple measure of resilience, which can be determined by analysing images from dry and wet seasons. Secondly, environmental, animal production and socio-economic data are required to interpret and verify the analyses made from satellite data. Finally, this data is combined into a GIS to help interpret and display the information.

Remote sensing and vegetation attributes

Remote sensing techniques produce an index of vegetation cover from satellite data and then search for systematic patterns in cover change related to land use. In grazing lands, cover tends to be higher where grazing and tree cutting activities are less intensive. Cover levels also increase after rainfall and so, after heavy rain, land use impacts should substantially disappear where the landscape is resilient to grazing and other uses. Where impacts persist, the landscape has been damaged by past use.

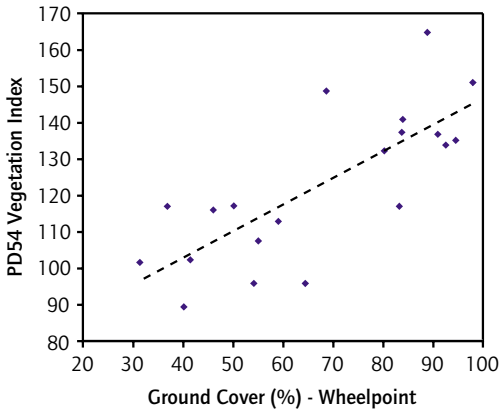
Women collect domestic water from wells in the Thar desert of Rajasthan. The rural landscape is being pressured by a population increase in both people and livestock.

These photos taken at a site immediately north east of Shergarh village illustrate the growth response on a resilient landscape, following monsoon rains.

Sometimes land use gradients centred around watering points or villages are detectable. The wet period vegetative cover response remote from the centre of activity represents the maximum potential response and all other responses are scaled against it. When gradients are not evident, researchers can assess the response of vegetation cover at discrete locations (satellite pixels) following heavy rain. Here, areas with responses above and below the average response for a landscape are identified and the patterns are related to land use effects. The latter approach was recommended for the Shergarh region of the Thar desert.

To establish a suitable index of vegetation cover, satellite images (Landsat TM, IRS 1C/1D/P6 with LISS 3 sensor) are acquired prior to, and following, a minimum of three contrasting wet seasons. All images are geometrically registered and radiometrically calibrated before calculating an index of vegetation cover – PD54 in this instance. This is a perpendicular vegetation index based on the green and red spectral bandwidths.

The index is verified by collecting the spectral reflectances of different soil and vegetation features in the visible and near-infrared wavelengths using a spectrometer. Having confirmed that the PD54 data space satisfactorily describes the measured reflectances of dominant land-surface features of the region, ground-based measures of vegetation cover obtained with the wheelpoint apparatus are compared with the PD54 index values of corresponding pixels. The PD54 index estimates vegetation cover reasonably well on the generally bright sandy soils of the Shergarh region of the Thar Desert. It would need verifying again in different vegetation cover and soil types.



Relationship between the PD54 index of vegetation cover and the cover measured on the ground with the wheelpoint.

The magnitude of vegetation response to wet-season rainfall for pairs of image dates is used to estimate vegetation resilience. Spatial patterns in the sequence of resilience images over time are then related to land use and apparent (or perceived) degradation on the ground.

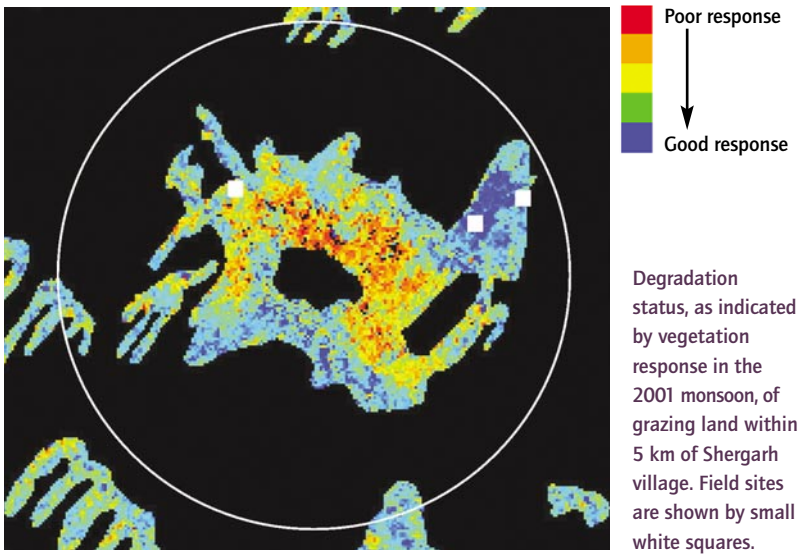
Ground validation

Ground data enable us to verify that degradation detected by satellite data exists, and to identify the causes. Social, economic and livestock information are collated from census data and collected directly from sample villages within a satellite image. It is important to establish credibility and trust with villagers beforehand to enable entry into their communities. Entry into villages can be achieved initially through existing relationships. Subsequently, assistance can be provided, for example through veterinary advice, prescriptions or medicines, and gifts of saplings of forage species. Making cash payments to collaborators can be counterproductive if it alienates people who don't receive them.

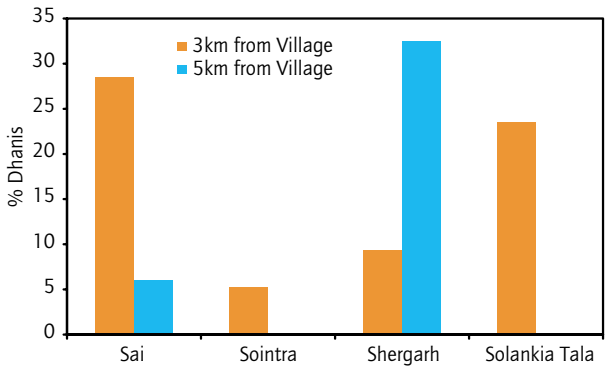
Social data which may help to explain land use impacts include human population size and structure, growth rates, castes, literacy levels, occupations, family size, size and aggregation of land holdings, and number and composition of livestock. Economic data may include the last two and, additionally, size of landholding versus herd size, value of livestock products, contribution of livestock products to total income, income level of household and consumption patterns. Livestock data may include, in addition, feed and fodder availability, average grazing distances travelled and nutritional impacts on reproduction, morbidity and mortality rates.

GIS

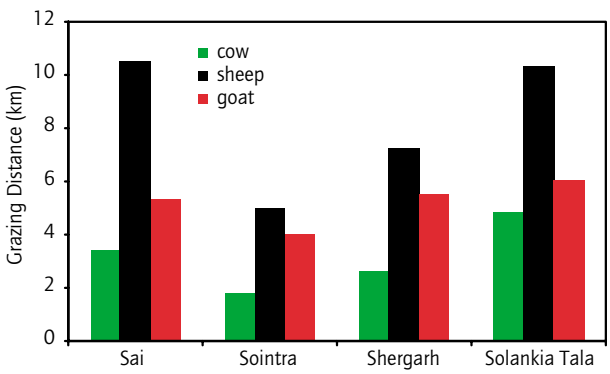
A GIS can be used to display and analyse spatial data. Useful layers would include village locations, vegetation cover and resilience images at different times, ground measurement sites, roads and land use boundaries. Social, economic and livestock data which are not geo-referenced can be included by attributing them to the villages where they were collected, and hence defining the village boundaries, rather than just a central location. These boundaries are then used to view spatially examples from the grazing and social surveys.



Degradation status, as indicated by vegetation response in the 2001 monsoon, of grazing land within 5 km of Shergarh village. Field sites are shown by small white squares.



Settlement pattern – % dhanis (scattered settlements) within 3 & 5 km of villages.



Grazing distance of cows, sheep and goats at four surveyed villages.

The example (page 3) shows contrasting response of vegetation to the 2001 monsoon within 5 km of Shergarh village, indicating both degraded (red) and resilient (blue) grazing land. Ground measurements made at three sites (white squares) confirm this assessment. Selected survey data show that the disparity between existing and desired grazing pressure is less for Shergarh village than Sointra, that animals are grazing to an intermediate distance from water for Shergarh village and that the proportion of scattered settlements (dhanis) is relatively high 5 km from Shergarh, suggesting grazing pressure may be higher at this distance for Shergarh than for other villages.

Scaling up to regional assessments

So far, the integration of these technologies to determine the extent and causes of degradation has only been tested within a limited geographic area. The value of remote sensing lies in its ability to monitor vegetation cover quickly over much larger areas. Scaling up the technologies will enable assessments over whole regions and hundreds of villages, and will identify which areas need to be targeted for attention. This creates an opportunity to influence mainstream thinking on policy development, for example, by providing a tool for prioritising areas in need of government funding assistance.

District or regional scale assessments are undertaken for a purpose, not just to quantify degradation. Quantification has to be followed by action – to improve management of grazing land. How this should happen needs to be investigated on the ground. We suggest initiating a case study to explore how the state administration might respond to a village whose grazing lands appear to be particularly degraded. Involving the community in planning management responses is a key element. Once actively involved, groups can be supported by government development initiatives, underpinned by resource information available from government agencies. Strategies to optimise outcomes can be explored, for example, whether focusing on better management of marginal farmers' lands will disproportionately benefit these farmers. The most likely route to success is to progressively identify villages which are particularly responsive to change, and work with them.

A review of government programs should also be part of upscaling in order to learn from past successes and failures. Consideration of economic issues relating to the development of grazing lands and opportunity costs is also important for policy development. Building and maintaining a dialogue with agencies and initiatives should underpin all efforts at implementation. Rajasthan's State Remote Sensing Application Centre (SRSAC) is a key agency for assessing land use capability and for land use planning. It can provide land type stratification and other potentially useful resources for upscaling.

On the technical side, grazing gradient methods need further testing under much more extensive pastoral conditions in western parts of Rajasthan (eg Jaisalmer region). Ground validation is essential but should be strategic, due to its cost. For example, to validate the cover index, traverses and field inspection together with available maps of land resources should determine those land types where the index works well and others where it doesn't. Only these latter would need quantitative cover assessment. Validation of socio-economic and livestock attributes should also be selective, using key variables, eg livestock grazing distances, contribution of livestock to income, settlement patterns, and sample villages which are clearly different.

Provision of infrastructure and training ensures that the project team can analyse and interpret remote sensing imagery independently.

Imagery can be pre-processed by a remote sensing agency under contract. In Rajasthan, landscape stratification can be obtained from SRSAC or by image classification. Infrastructure can also be obtained from SRSAC, and combined with other data layers in the GIS. CAZRI scientists have the skills and facilities to implement regional assessment of degradation in collaboration with other agencies. To ensure that this translates into better grazing land management, they also need to develop efficient and effective methods for reporting survey results together with district administrators.

This Research Note is based on ACIAR Project No. LWR1/1998/17 "Integrative technologies for assessing the extent and cause of degradation in arid community rangelands", conducted in Australia (CSIRO Sustainable Ecosystems, Centre for Arid Zone Research) and India (ICAR Central Arid Zone Research Institute). Project Leaders: Dr Margaret Friedel (Australia) and Dr Suresh Kumar (India). Contact: margaret.friedel@csiro.au

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