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Mapping the extent of waterlogged crop using satellite imagery

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Satellite image data from the LANDSAT Thematic Mapper (TM) have been used to map waterlogged crop in Western Australia's Upper Great Southern.

Accurate maps of the occurrence of waterlogging were produced for a 27,000 ha study area.

Before this work there was no practical ground-based method to assess the extent of waterlogging, and scientists and farmers could only guess the value of crop losses.

The results showed that satellite imagery can be useful for catchment planning and management of individual farms.

Satellite imagery

The Landsat TM satellite collects data over the whole State every 16 days with a ground resolution of 30 m by 30 m (1 pixel). This is an area of about 0.1 ha. Data collected by the satellite has two great advantages: low-cost broadscale coverage, and routine collection which allows for future monitoring.

The satellite's digital detectors record spectral energy in a particular waveband as numbers; these numbers can be converted to colours to produce images.

In addition to visible light, digital detectors can record information which is invisible to the naked eye in the infrared and thermal wavelengths. The LANDSAT TM sensor records in seven channels or bands; three visible, three infrared and one thermal.

The number and the location of the detectors is important when choosing a scanner to collect spectral data. Early work indicated that waterlogged crop could not be accurately identified on aerial photographs which record in the visible part of the spectrum; the colours could not be consistently associated with crop known to be waterlogged. However, vegetation reflects strongly in the infrared portion of the spectrum and this spectral region provided the best discrimination between waterlogged and non-waterlogged crop.

The study

To test the value of remotely sensed data, several sites were selected on which crop condition was known. Spectral data from these areas was statistically analysed to determine if the waterlogged crop could be separated from non-waterlogged crop. If the analysis showed that there was good discrimination of waterlogging, then a reliable map could be produced from the image data.

In 1987, the first year of the study, an aircraft was used to collect high quality spectral data from a small test site in the Yornaning district. An accurate mapping of waterlogging was produced from this data (see inset photo on facing page).

Following this success, TM satellite image data (see photo above) were used over a much larger area in 1988. The study area is about 27,000 ha and includes about 90 per cent of the East Yornaning Catchment. This area was chosen because it contains all the major landforms common in the Upper Great Southern. About 30 per cent of the catchment was sown to cereal crop, mainly wheat.
Figure 1. Two dimensional ordination of spectral data from 32 wheat training sites.

Analysis of the spectral data shows the overall distribution of 32 sites. Although there is variation between sites, the waterlogged and non-waterlogged sites are clearly separated.

BELOW: Aerial photo and classification map (inset) from the 1987 study of the 45 ha test site (outlined in white) in the Yornaning district. The yellow in the inset photo represents waterlogged crop, the other colours represent other crop conditions.
A classification map of waterlogged crop in the Yor-naning Catchment. The thin white lines are paddock boundaries, the thick white lines are roads. The area shown is about 1,200 ha.

Code:
C = crop; P = pasture
Green = Non-waterlogged crop
Brown = Waterlogged crop - standing crop; some yield possible
Blue = Waterlogged crop - severe depression of growth, weedy understorey; minimum yield
Black = Not classified - includes bush, most pasture and rock outcrops

AN ON-FARM EXAMPLE

The waterlogging study provides an example of how satellite data can be useful for management at the farm and catchment level.

The photo on this page shows the classification map of a sample area of the Yornaning catchment; paddock boundaries and roads are in white. At this scale the information is relevant for farm planning.

The map can help farmers locate areas which are suited to interceptor drains. It may also help to identify paddocks or portions of paddocks which are unsuitable for cropping.

Landforms in this catchment consist of small gravelly hilltops (Norrine) giving way to long gentle slopes with some rocky outcrops (Noombling). Together, these two units make up about 86 per cent of the landforms common in the Upper Great Southern. The paddocks marked 'C' in the photo were sown to crop; paddocks marked 'P' were under pasture. The colours in the classification map represent the various crop conditions.

Paddocks 1 and 2 were waterlogged throughout most of the growing season and poor yields resulted in substantial financial losses to the farmer. Both paddocks have small areas of good crop (green) located on the higher ground. Below the high ground the land slopes to a saline waterway along the southern boundary fence. The slopes were badly waterlogged, the most severe being the blue area in paddock 1.

Paddock 4 has a gradual north-west fall to the same waterway. This paddock was waterlogged throughout (brown), with only a few isolated patches of non-waterlogged crop (green).

Because of the sloping nature of these paddocks, the effect of the waterlogging on grain yield could have been minimized by installing reverse bank interceptor drains.

Because of the large area being covered and the limited time to collect ground information on waterlogging in a growing season, local farmers were asked to help identify suitable training sites within the study area. Their cooperation was a significant contribution to the success of the project. Forty-four sites (27 waterlogged and 17 non-waterlogged) were identified in wheat crops, 32 sites were used for analysis and 12 kept kept for verification. After statistical analysis (Figure 1), the satellite data were used to produce a classification map of ground conditions.

The accuracy of the satellite mapping was extremely good when compared with ground information. Waterlogged pixels were correctly identified on all verification sites; the error on area estimates was less than 10 per cent.

The map showed that about 32 per cent of the area sown to crop was moderately to severely affected by waterlogging. A further 3 per cent was severely affected, causing crop failure. Based on these figures, the financial losses for the farmers caused by waterlogging were estimated to be $1.1 million in 1988 (see ‘The extent and cost of waterlogging’ on page 44).

Acknowledgements

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