

Abstract

In the dry regions of West Asia, irrigated agriculture is consuming a major proportion of the available groundwater. To assess whether abstractions in a low-rainfall zone were sustainable, water use was recorded jointly with farmers and the irrigated area was mapped. The resulting ground truth data set was utilized to test possibilities for remote recognition of irrigated areas. Satellite images at the beginning and the end of the rainfall season were interpreted to distinguish between irrigated barley and wheat due to their different water use. By applying an NDVI threshold, most of the irrigated fields were correctly identified on the images and the two crops could be distinguished. However, non-irrigated vegetation also appeared on the images, which reduced determination accuracy.

Methods

Areas with intense photosynthetic activity, supposedly irrigated, were identified in Idrisi32[®] above a chosen threshold NDVI (barley: 0.18; wheat: 0.24). An area of 17 x 20 km (Figs 2, 3) was delineated as a subset of the LANDSAT (ETM+) images. The corresponding raster layers of polygons were transformed into vector layers, smoothed with a 3 point low pass filter in Idrisi32[®] and overlaid with the layers of irrigated fields in Arc GIS[®]. As determination coefficient to measure the accuracy of detection, the ratio between the intersection of the areas above the threshold NDVI and the mapped fields, and their respective united areas was taken (Fig 1).

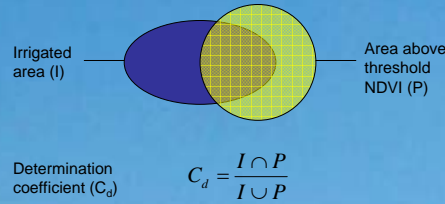


Fig. 1 Coefficient indicating geographical determination accuracy (\cap = intersection; \cup = union)

Tab. 1 Computation of determination coefficients of irrigated crops

| | Barley (ha) | Wheat (ha) |
|------------|-------------|------------|
| I | 118.5 | 404.5 |
| P | 197.3 | 647.4 |
| $I \cap P$ | 47.1 | 279.8 |
| $I \cup P$ | 268.7 | 772.1 |
| C_d | 0.18 | 0.36 |

Results and discussion

The determination coefficient (Tab. 1) was lower for barely (0.18) than for wheat (0.36). Without further scrutinizing the detection accuracy, irrigated areas were over-estimated by 67% (barley) and 60% (wheat) based on the NDVI thresholds. In terms of abstraction volume, the over-estimate equalled 170,426 m³ or 0.3 mm of rain (barley) and 575,531 m³ or 1 mm of rain (wheat) across the 340 km² subset area. The discrepancy was substantial considering that groundwater recharge in this region (annual rainfall average: ~ 210 mm) is only about 1 – 4 mm · yr⁻¹. The results are very sensitive to the dimension of the threshold NDVI. In this case, it was chosen by visual comparison with mapped fields. The determination coefficient can also be taken as core element of algorithms for a mathematical optimization of such process.

Conclusions

The timing of the satellite images permitted a clear distinction between barley and wheat, whereas it was more difficult to differentiate green vegetation, e.g. in runoff concentration areas, from irrigated crops. Due to their more irregular shape, such areas could be excluded with object-based image analysis. The determination coefficient is a suitable measure to calibrate threshold NDVI's for better recognition. An accurate identification of irrigated fields, including those with supplemental irrigation, helps to compute groundwater abstractions in water-scarce regions.

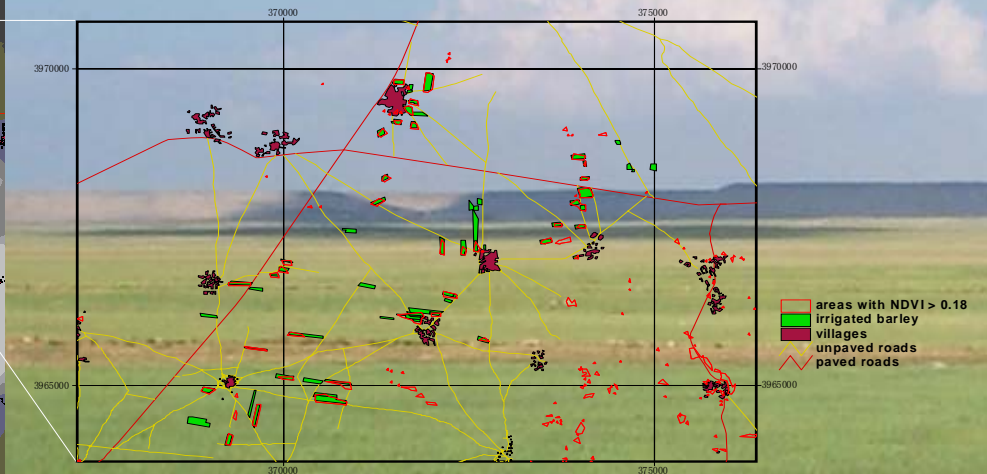
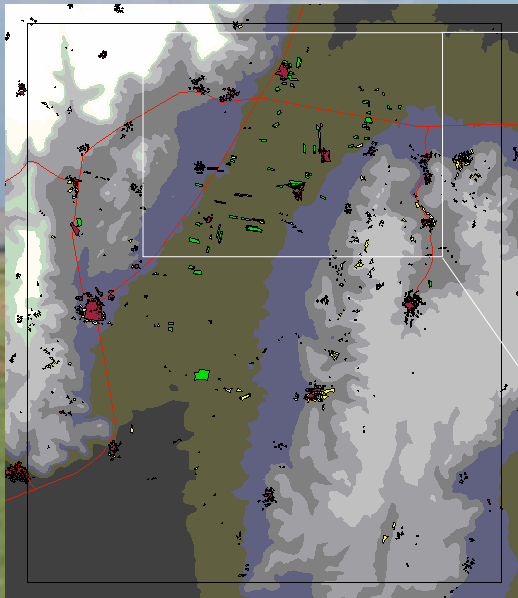


Fig. 2 Left: Mapped barley superposed on green vegetation areas with NDVI > 0.18 on Nov. 28, 2002 (the outer frame delineates an image subset of 340 km²)
Above: Close-up from the northern part of Khanasser Valley

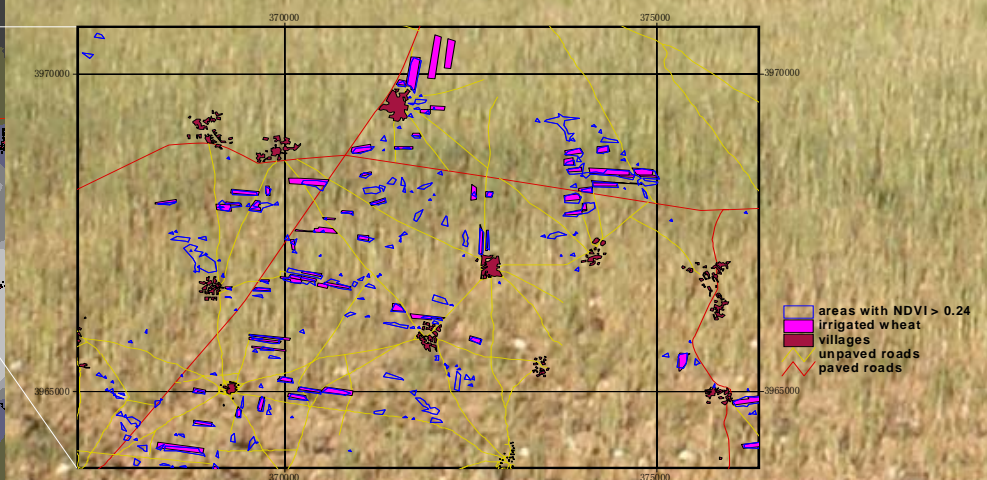
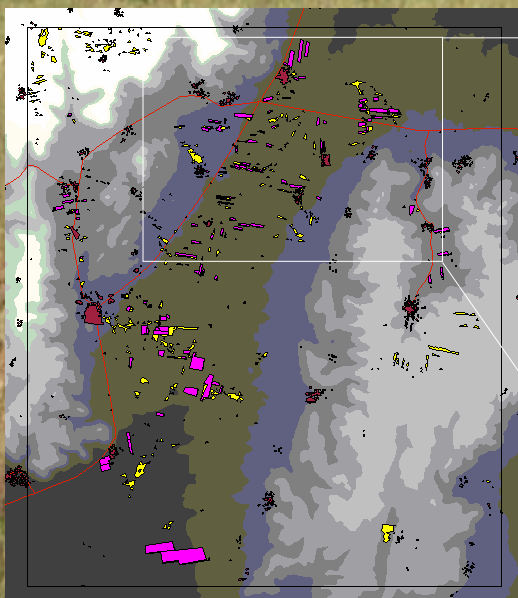


Fig. 3 Left: Mapped wheat superposed on green vegetation areas with NDVI > 0.24 on May 05, 2003 (vertical difference between elevation lines: 50 m; range < 100 m a.s.l., > 400 m a.s.l.)
Above: Close-up from the northern part of Khanasser Valley

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