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Summaries from the Natural Resources Systems Programme

Agro-Meteorological Information from Meteorological Satellite Data

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Project Purpose

Agro-meteorological data in developing countries are often sparse, irregular, unreliable and both expensive and slow to collect, process and disseminate. Nevertheless, such data (e.g., temperature, evaporation, radiation, vegetation status) are linked to various processes (e.g., pathogen insect development, crop growth, famine prediction, water management), and therefore can be of great use to workers of forestry, veterinary services, irrigation planning, plant protection, early warning, hydrology, etc. particularly if they are available in timely fashion.

The objective of the project was to determine the potential of satellite imagery (free, direct access, real time) (i) to monitor changes in agrometeorological variables, (ii) to provide real time fine resolution information to complement sparse observations at the surface, and (iii) to demonstrate that when incorporated in environmental information systems, and combined with data from other sources, extracted agrometeorological variables will provide information useful for the local resource managers. Three main activities were undertaken: (i) to assess existing methodologies to extract agrometeorological variables from remote sensing in terms of operational use (ii) to develop and adapt into operational prototypes those methods that could be implemented without requiring major basic research, (iii) to demonstrate in actual cases the capabilities of the approach.

Background

In recent years, remote sensing by satellite has become a major component of many ecological investigations, especially those where large areas of, often inaccessible, terrain need to be surveyed or monitored regularly. Satellites provide data which can be captured and processed, in real time, on personal computers at minimal cost (usually less than the cost of ground surveys and data collection). The NOAA-AVHRR polar-orbiting satellites and Meteosat geostationary satellites specially provide a useful tool due to their large and frequent coverage, as well as their direct reception locally.

Agriculture, especially, has benefited from these complementary new technologies. Crop yield may be estimated on large areas, and plant damage due to the predation of pests and diseases monitored. This in turn can lead to more appropriate crop management practices. Such developments have involved the integrated use of satellite remote sensing of vegetation changes and the measurement of appropriate agro-meteorological parameters, in association with ground-based environmental observations and agricultural husbandry. Agro-meteorological parameters, which have been found to be of greatest importance, include temperature, solar radiation and evapotranspiration.

Agro-Meteorological Data from NOAA-AVHRR and Meteosat

Despite much investigation, the successful use of satellite data to determine surface fluxes as an aid to agricultural monitoring has been achieved for few sites. Several techniques have been developed to retrieve information on vegetation status and agro-meteorological parameters. The table below summarises the data which can be assessed using AVHRR and Meteosat data.

Variable	Comment
Net Radiation (Rn)	Accuracy limited for absolute values
Evapotranspiration (Eta)	Accuracy limited for absolute values
Land surface temperature (LST)	Accuracy limited for absolute values, Good estimation for changes in time
Water deficit index	Good estimation for change monitoring
Vegetation indices (NDVI)	Good estimation of the vegetation status

Whereas indicators of vegetation status and land surface temperature are valuable when relative information is required, extracting evapotranspiration with accuracy requires better estimation of the net radiation and land surface temperature. The latter requires a better assessment of emissivities. These require then substantial research and validation. Nevertheless, the development of indices relating chlorophyll activity and temperature can provide a good alternative to monitor changes in vegetation canopy as well as proxy to environment variables.

Some agrometeorological variables (land surface temperature, vegetation status) can be provided on an operational basis to provide spatial and temporal relative information. However, further adaptive research and validation approaches are required to improve the assessment of land surface emissivities and atmospheric corrections to increase the precision of land surface temperature. Similarly, both radiation and evapotranspiration retrieval from remote sensing data require further adaptive research to make their assessment operational and useful. More validation, as well as design of approaches to combine both remotely sensed data and local meteorological data should lead to invaluable agrometeorological information at a 1km scale. The continuation of implementation of these approaches into operational tools is also essential. The applicability of these approaches is going to increase even further with new satellite providing better precision in time and space, allowing diurnal patterns to be looked at.

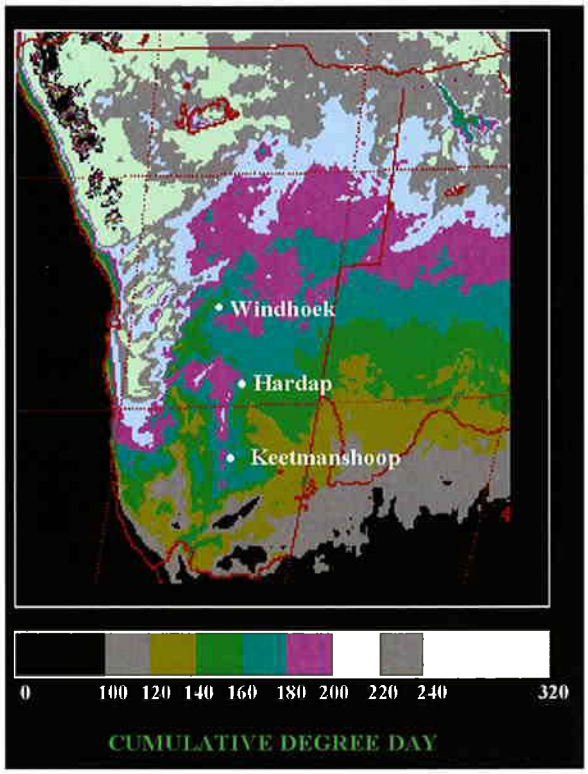
Practical demonstration of the potential for using remotely sensed data by local natural resources managers.

The application of current techniques and models to retrieve these variables has been investigated to assess the possibility of developing operational systems for use by agricultural and natural resources managers.

In collaboration with practical projects, it has been demonstrated how managers can already benefit from using estimation of agro-meteorological variables.

Direct use of METEOSAT in a veterinary application in Namibia. (Flasse et al., 1995, 1997)

The Veterinary Department of the Ministry of Agriculture, Water and Rural Development of Namibia issues warnings to farmers in the south of the country concerning the likelihood of infestation by the small-stock nasal fly, *Oestrus ovis*. Farmers can then treat their stock at the most appropriate time. The *Oestrus ovis* pupae over-winter at shallow depths in the soil and the timing of emergence is directly dependant on climatological conditions, specifically the number of degree-days above a particular threshold soil temperature. Based on temperature measurements from only a few stations scattered throughout the country, the Veterinary Department was issuing outbreak warnings to the farmers. During two seasons, a system produced locally accumulated temperature data from METEOSAT images. This application demonstrated that the temperature information (See Figure), provided automatically, could help to better assess the place and time of hatching and improve the precision and reliability of warnings given to farmers.

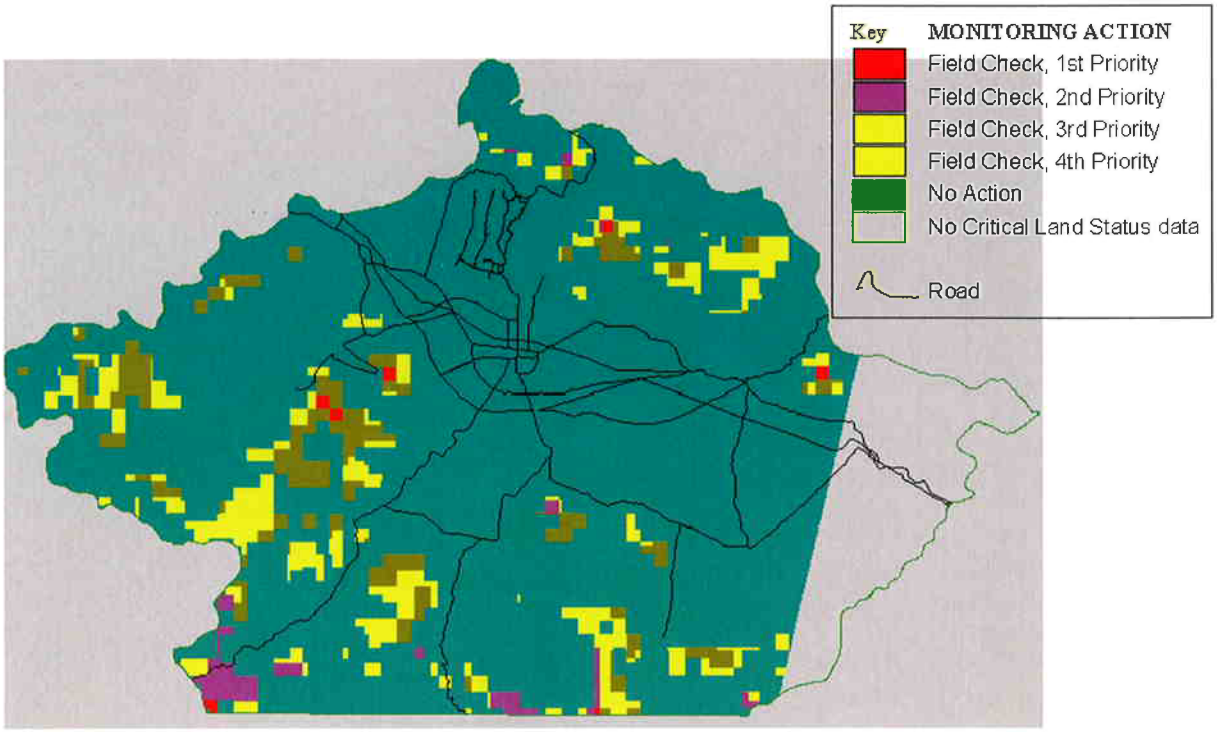


Rice production in Indonesia (Mubekti et al., 1996)

In collaboration with the DFID-funded Indonesian-UK Environment Monitoring Project, it has been shown that indicators of land surface temperature and vegetation status from NOAA AVHRR data provide useful information on rice development, which, in turn, could be used for qualitative and timely pre-harvest assessments. Initial results are encouraging, with a good correspondence between NOAA and field observations. This correspondence suggests that free NOAA data, integrated with more detailed field and satellite studies, could provide the basis for a national (pre-harvest) production forecasting system.

Identifying forest changes in watershed management in Indonesia. (Hartanto et al., 1996)

The ability to monitor vegetation loss over land areas susceptible to degradation is of great potential use in watershed management. Such information can assist in prioritising land use planning, rehabilitation and regulation activities to preserve and protect critical areas. This in turn can help to reduce soil erosion and associated



Monitoring Action Map

sedimentation problems, improving water conservation and reducing the possibility of flooding. In collaboration with the DFID-funded Indonesian-UK Environment Monitoring Project, a prototype technique was demonstrated for monitoring land use changes occurring within critical watershed areas. The magnitude of AVHRR-derived vegetation changes was cross-referenced with critical land status as a basis for prioritising management action (see Figure). The approach is flexible, and could be enhanced in numerous ways according to specific management requirements, such as in forest-agriculture interface. Incorporation of other information from local or satellite sources (such as seasonal trends) is seen as an essential further step to increase the robustness of the technique.

Irrigation planning in Indonesia (Rahmadi et al., 1996)

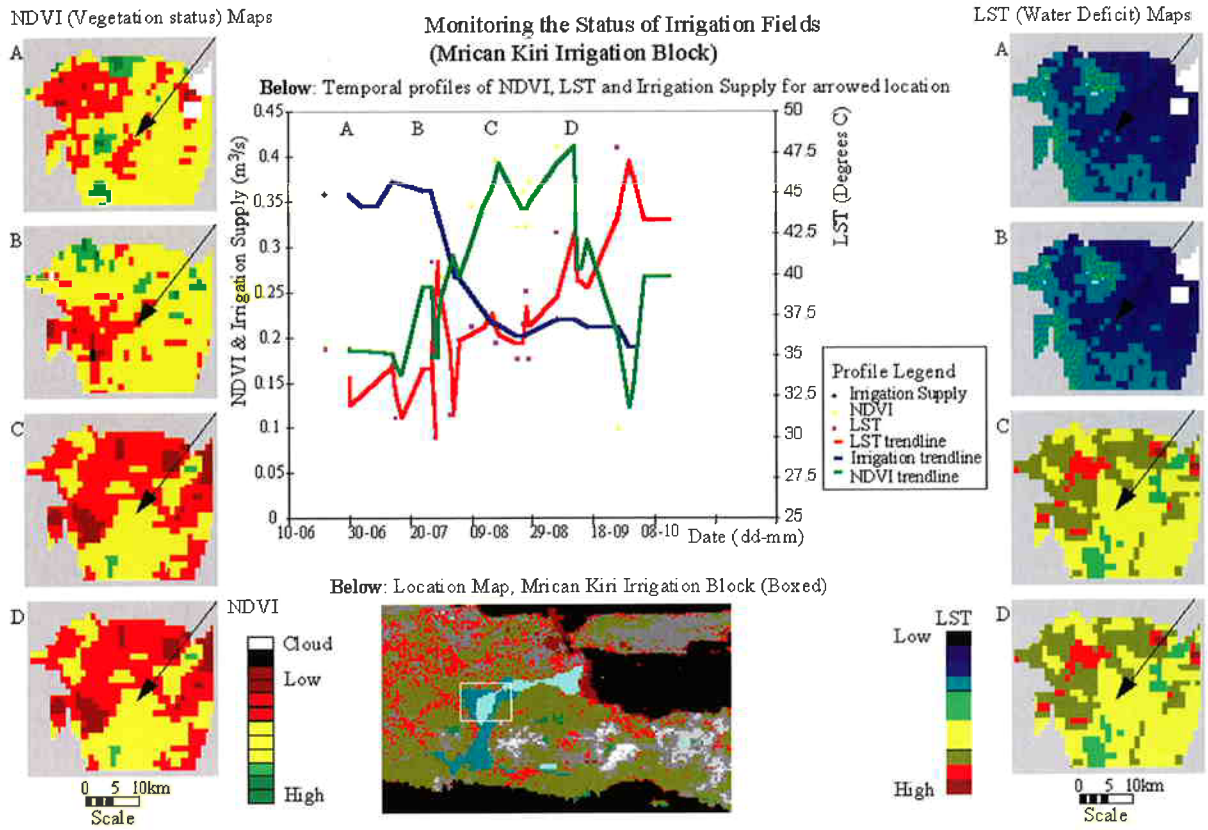
During the dry season, water is very precious. When the demand for irrigation water starts overtaking its availability, the water manager has to make difficult choices. In collaboration with the DFID-funded Indonesian-UK Environment Monitoring Project, this application demonstrated how NOAA-AVHRR data (indicating water deficit and vegetation status, see Figure page 4) can contribute to the prioritisation of water delivery, as well as monitor the state and evolution of the crops. These indicators could be used to help watershed managers assess the performance of the annual irrigation plan and prioritise water flow to balance the opposing demands of water conservation and irrigation demand.

A malaria application in Africa (Thomson et al., 1995, 1996)

In collaboration with the Liverpool School of Tropical Medicine, a study was carried out to show how agro-meteorological variables estimated from remote sensing could successfully be incorporated along with other data into a geographical information system to contribute to the goals of monitoring malaria transmission patterns, predicting epidemics and planning control strategies.

Uptake

The various demonstrations illustrated by these outputs have already promoted a lot of interest from practical users in the field. In Namibia the Veterinary Services are interested in improving and using the current installed methodology. In Indonesia, various institutions have officially requested help (through the DFID-funded Indonesian-UK Environment Monitoring Project) in implementing satellite reception and using derived agro-meteorological information (e.g. BULOG-National Rice Stock Agency, BPS-National Statistical Agency, P.T. Jasa Tirta-watershed management company, Ministry of Forestry- INTAG). In Argentina, the Centro de InvestigaÁiones Entomologicas has suggested collaboration to support the mosquito control programme (*Aedes albifasciatus*, whose development is dependent on surface temperature conditions, and affects milk and beef production). NRI has recently been included in an DFID project to support work on the control of Malaria



outbreaks. Similarly, an DFID-funded project to monitor locust outbreaks in Eritrea has shown interest in the developed approaches. Finally, collaborations with projects in Nicaragua (MARENA – Ministero del Ambiente y Recursos Naturales- support for environment monitoring through local satellite data reception) and Indonesia (UK-Indonesia Tropical Forest Management Project-ITFMP, and EU-Indonesia Forest Sector Support Program-IFSSP), should soon use the approaches developed in this project for the mapping of vegetation fire risk.

Conclusion

The project has contributed to DFID's development goals by applying remote sensing and GIS techniques to demonstrate how people in the field can benefit from free, readily available environmental data. More specifically, it has demonstrated that

- remote sensing data can provide a first assessment of some agro-meteorological variables;
- when integrated with local knowledge, the freely available remotely sensed data offer temporal and spatial information on the environment and agriculture;
- such information can be of great value to help natural resources manager in areas such as yield forecasting, forest/agriculture changes, and pathogen insect development control, and focus their efforts to achieve greatest impact;

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