# Improving Knowledge of Cropping Systems to Support Food Security

## A case study from Nepal

**Faisal Mueen Qamer**, GIS/Remote Sensing Expert, ICIMOD, Nepal, fqamer@icimod.org
**Wataru Takeuchi**, Associate Professor, Institute of Industrial Science, University of Tokyo, Japan, wataru@iis.u-tokyo.ac.jp

Agriculture is the most important livelihood activity in the HKH region, providing a substantial proportion of rural income and employment opportunities for its estimated 210 million inhabitants. Around 80 per cent of the population of the HKH is engaged in various land-based activities (Tang and Tulachan 2003).

Agriculture originally evolved from communities' need to feed themselves in a given environment. Given the lack of alternative sources of income, mountain communities have remained essentially agriculture based, and farming systems are the key determinant of household food security. Mountain people often depend on what they grow on their marginal lands for food.

Estimating agricultural output has not been a research priority in the Himalayan region (Aase et al. 2009). However, the dramatic climatic and environmental changes that are taking place in the Himalayas will change the conditions for food production. Local farming practices in the region have been structured around a traditional weather calendar based on a previously undisturbed climate (Vedwan and Rhoades 2001). Any changes in temperature, rainfall, snowfall, and duration of snowfall accumulation will affect crop phenology and production. Together with associated uncertainties, these changes make the local agricultural system highly vulnerable. We need to understand the relationship between crops and climate in today's changing environment in order to estimate local production and understand the consequent responses and adaptive strategies of local people.

Generally, the more subsistence oriented the farming, the more the system is constrained by its biophysical and socioeconomic environment. Remote sensing data, in combination with other types of data, can reveal valuable information about environmental conditions that may affect farmers' livelihoods. Geographic information system (GIS) and remote sensing technologies can help in identifying regions experiencing unfavourable crop growing conditions and food supply shortfalls, and determine food insecure areas and populations (Minamiguchi 2004).

Major world food crop production has been monitored since the mid-1980s. A number of programmes use satellite observations for agricultural monitoring on a regional to global scale; examples include the crop forecasting system maintained by the United States Department of Agriculture (USDA) Foreign Agricultural Service (FAS), and food security monitoring systems such as the Food and Agriculture Organization of the United Nations (FAO) Food Security Global Information and Early Warning System (GIEWS), the United States Agency for International Development (USAID) Famine Early Warning System (FEWS), and the European Union Global Monitoring of Food Security (GMFS).

Agriculture and food security are emerging as pressing issues in the HKH region. In this context, ICIMOD is using Earth observation for improved knowledge on agriculture production systems in the HKH region, specifically to:

- establish past and recent responses to climate variability and extreme events in agricultural production in selected HKH areas;

- customise spatial methods and tools to model biophysical crop suitability in the region;
- develop spatially referenced socioeconomic data to characterise food security and agricultural production; and
- support the development of a regional and national food security atlas.

## Case study: Exploring the variability of agricultural patterns in Nepal using hyper-temporal satellite data

ICIMOD and the Institute of Industrial Science, University of Tokyo, Japan are working together to compile crop parameters and phenological trends and to identify drought conditions in agricultural areas of Nepal. Remote sensing is an effective way of monitoring agricultural fields and provides a synoptic view of the results of field practices, which can then be processed to aid agricultural scientist in making meaningful decisions. Remotely sensed green leaf phenology can be used to distinguish the type of land cover and land use change, and has significant applications for the monitoring of agricultural practices. The vegetation indices produced are used to derive a measure that correlates with surface biophysical properties, which facilitates the analysis of large amounts of satellite data, providing valuable spatial and temporal analyses at large scale (Myneni et al. 1995). The fact that vegetation indices are directly related to plant vigour, density, and growth conditions means that they can be used to detect environmental conditions such as drought in semi-arid regions (Li et al. 2004).

In the current study, phenological patterns of agricultural areas were assessed for all of Nepal by analysing time series anomalies in the vegetation index for the period 2001 to 2010. The selected vegetation index was the Normalized Difference Vegetation Index (NDVI) acquired by the moderate resolution sensor MODIS at 16-day time intervals and 250 m spatial resolution, a standard product coded as MOD13Q1. A total of 230 NDVI 16-day composite images were employed in the analysis.

Phenology studies often use a curve-fitting algorithm to analyse the observed datasets. A curve fit simplifies the parameterisation necessary for the identification of metrics such as the start of dry season minima and the amplitude of maxima (e.g., Bradley et al. 2007; Zhang et al. 2003). This study employed Earth Trends Modeler (ETM), which provides an integrated platform for the exploration and analysis of remote sensing time series. While the smoothing and fitting of NDVI and other series data is supported, ETM implements a Seasonal Trend Analysis (STA) method based on harmonic analysis of time series (HANTS), developed by Roerink et al. (2000), which differs significantly from earlier work.

The temporal variability of NDVI in the irrigated areas of the Terai region of Nepal (Figure 1) and rainfed agricultural areas of the middle hills (Figure 2) are analysed throughout the time series. In the Terai region of Nepal there are two annual growing seasons, rabi (spring) and kharif (autumn); whereas in the middle hill areas where agriculture is rainfed there is a single vegetation cycle. No extreme vegetation anomalies are evident from the NDVI graph, except for the effect of a winter drought in 2008–2009.

Figure 3 reflects the monotonic trend, based on the Mann-Kendall Tau test, in all agricultural areas of Nepal. This test measures the degree to which a trend is increasing or decreasing consistently. In a range of -1 to 1, positive values indicate an increasing trend and negative values a declining trend. Much of the western area of the Terai exhibits an increasing NDVI trend, a significant portion

Figure 1: **NDVI time series chart for the irrigated areas of Sunsari district, Terai region, Nepal**

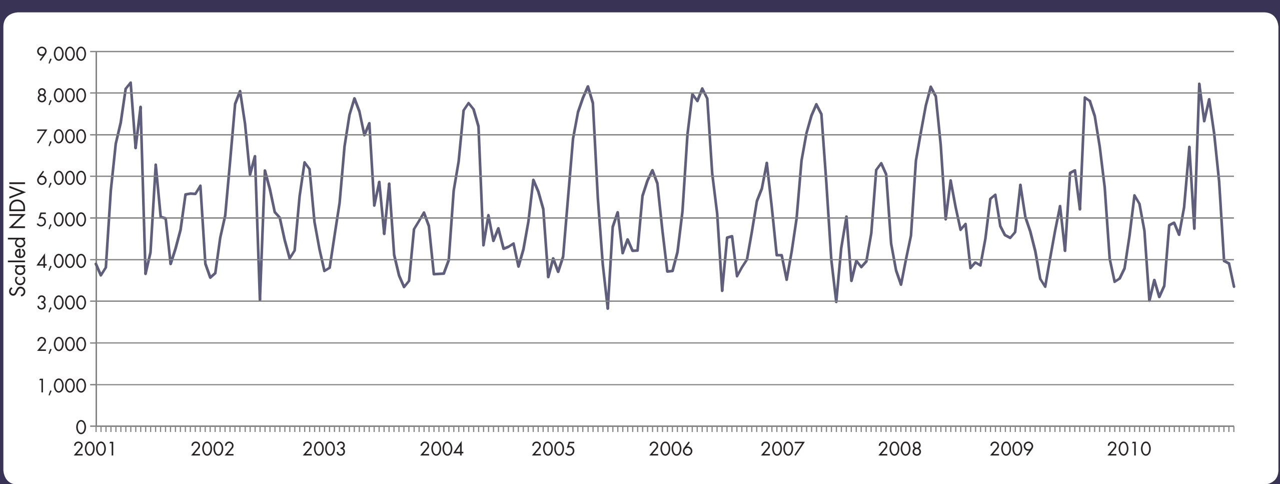


Figure 2: **NDVI time series chart for the rainfed agriculture areas of Kabhre district, middle hills, Nepal**

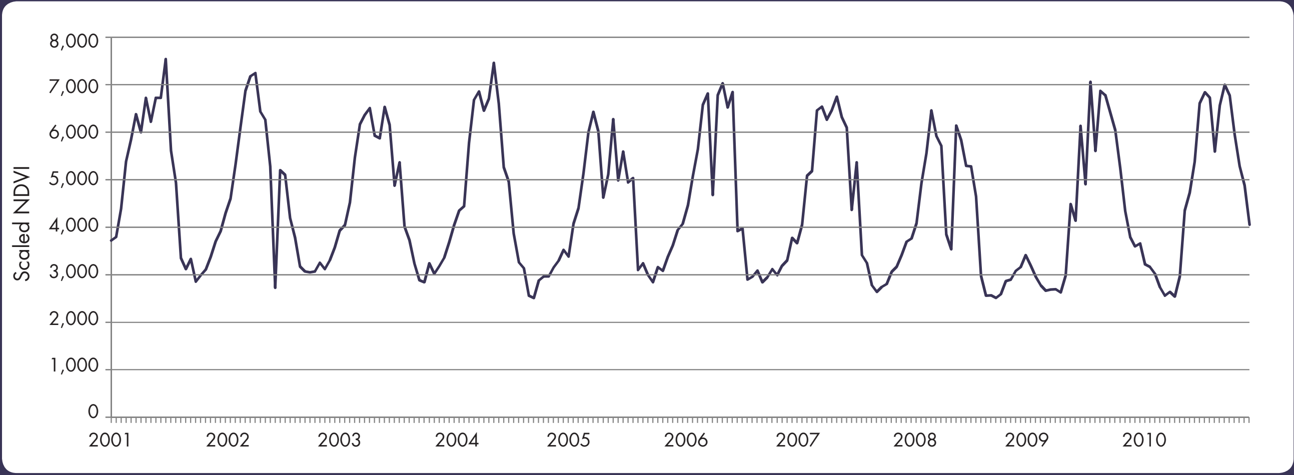



Figure 3: **Mann-Kendall Tau coefficient for trend-adjusted monotonic series of 10 years' NDVI**

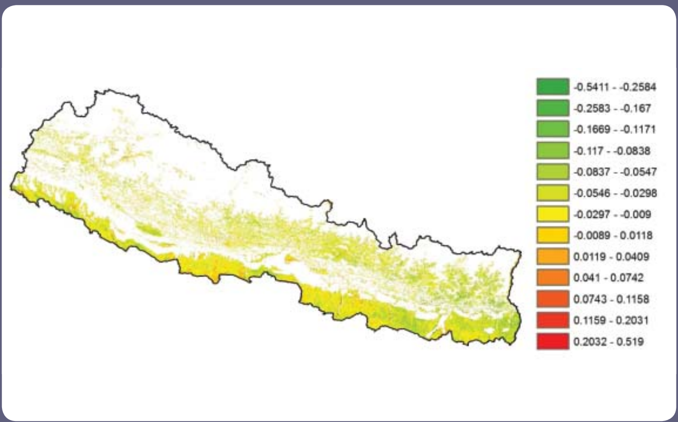
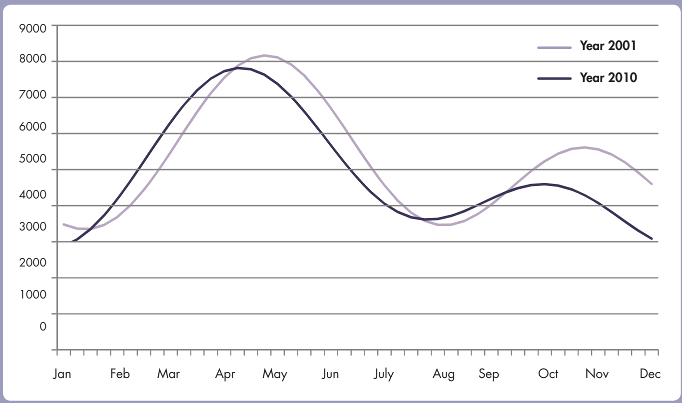



Figure 4: **Fitted seasonal curve in the irrigated areas of the Terai**




shows no change, and the extreme eastern part of the Terai region exhibits a decreasing NDVI trend.

Along with temporal profiles, seasonal trend analysis was performed in representative areas, using two stages of time series analysis to map trends in the shape of the seasonal curve. The results (Figure 4) show that on average spring and autumn both occurred a little earlier in 2010 than in 2001.

## References


Aase, TH; Chaudhary, RP; Vetaas, OR (2010) 'Farming flexibility and food security under climatic uncertainty: Manang, Nepal Himalaya.' *AREA* 42(2): 228–238

Bradley, B; Jacob, R; Hermance, J; Mustard, JF (2007) 'A curve-fitting technique to derive inter-annual phenologies from time series of noisy NDVI satellite data.' *Remote Sensing of Environment* 106: 137–145

Li, J; Lewis, J; Rowland, J; Tappan, G; Tieszen, LL (2004) 'Evaluation of land performance in Senegal using multi-temporal NDVI and rainfall series.' *Journal of Arid Environments* 59: 463–480.

Minamiguchi, N (2004) *Drought and food insecurity monitoring with the use of geospatial information by the UN FAO*. Regional Workshop on Agricultural Drought Monitoring and Assessment Using Space Technology, Hyderabad, India, 3–7 May 2004.

Myneni, RB; Hall, FG; Sellers, PJ; Marshak, AL (1995) 'The interpretation of spectral vegetation indexes.' *IEEE Transactions on Geoscience and Remote Sensing* 33: 481–486

Roerink, GJ; Menenti, M; Verhoef, W (2000) 'Reconstructing cloud free NDVI composites using Fourier analysis of time series.' *International Journal of Remote Sensing* 21(9): 1911–1917

Tang, Y; Tulachan, PM (2003) *Mountain agriculture in the Hindu Kush-Himalayan region: Proceedings of an International Symposium*. Kathmandu, Nepal, 21 to 24 May 2001. Kathmandu: ICIMOD

Vedwan, N; Rhoades, RE (2001) 'Climate change in the Western Himalayas of India: A study of local perception and response.' *Climate Research* 19: 109–117

Zhang, X; Friedl, MA; Schaaf, CB; Strahler, AH; Hodges, JCF; Gao, F; Reed, BC; Huete, A (2003) 'Monitoring vegetation phenology using MODIS.' *Remote Sensing of Environment* 84: 471–475