Location	Red River Basin, Vietnam
Contractor	Asian Development Bank
Period	2005

Scope of the project

The Red River is formed by the confluence of the Da, Thao and Lo rivers just upstream of Hanoi. 24 million live in the basin, of whom 17 million live in the Delta, making it one of the more densely populated areas in Asia. The Red River Basin has a monsoon climate with pronounced wet and dry seasons. Rice is the main crop and intensive production relies on a combination of gravity and pumping from both irrigation and drainage canals.

Floods and droughts are a major problem in the Red River Basin. Serious water shortages have been experienced in the dry seasons of 2004 and 2005, and the stress on the water system is likely to increase in the near-future due to higher agricultural, domestic and industrial water demands. Contradictory views on the extent and severity of drought during the winter of 2004-2005 exist.

The 2nd Red River Basin Sector Project aims to improve agriculture performance of poorer communities. The Cau sub-basin has been selected to develop the participative Integrated Water Resource Management (IWRM) process to implement better drought management. This study is a pilot project within this project to evaluate and test the added value for remote sensing techniques on (1) quantifying drought; and (2) determining water productivity of rice systems. The advanced SEBAL technique is used for the development of a Remote Sensing based Drought Monitoring System (RDMS) within the IWRM framework of the Cau sub-basin.

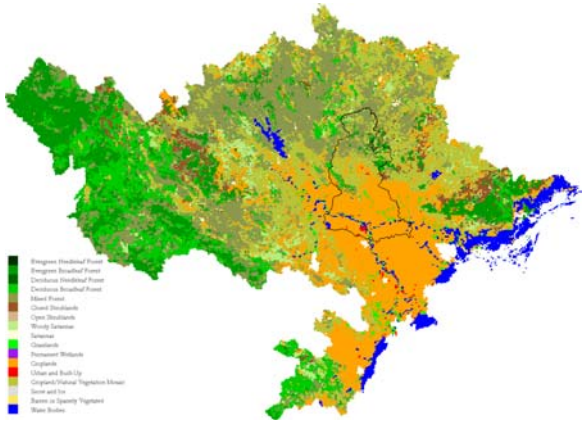

Figure 1 Land cover map of the Red River Basin derived for 1992 and 1993 (source: IGBP)

Study approach

The Surface Energy Balance Algorithm for Land (SEBAL) has been applied in conjunction with Moderate Resolution Imaging Spectrometer (MODIS) data aboard the Aqua satellite and routinely measured meteorological data to prepare an analysis of the extent and severity of drought in the Cau sub-basin and the Red River Basin.

For each MODIS pixel (1 km^2) the following hydrological variables have been quantified:

- actual evapotranspiration (ET_{act});
- potential evapotranspiration (ET_{pot});
- soil moisture (θ/θ_{sat}) ; and
- biomass production (bio).

These distributed hydrological variables will be used to compute a composite water stress index. With these data, current water balances for the different sub areas of the Cau sub-basin can also be evaluated.

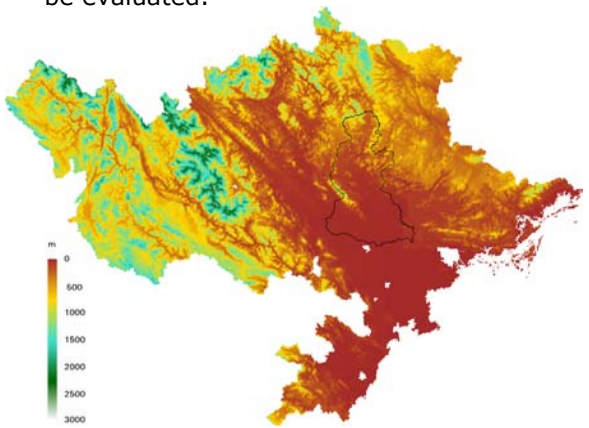

Figure 2 Digital Elevation Model of the Red River Basin in Northern Vietnam with de Cau Basin delineation imposed

Results

The images of 12 Nov 2003 and 14 Feb 2004 were of the best quality. Figure 3 and 4 demonstrate the average biomass production and ET_{act} values obtained during these two acquisition days. The first impression is that there is a considerable variation in water consumption and thus access to water resources across the Cau sub-basin.

Figure 5 shows the accumulated real water deficit for the period of 6 months with values ranging between ET_{def}=0 to 400 mm. Figure 6 shows the accumulated real water deficit of irrigated land. Clearly the lower land adjoining the Red river and its branches exhibit less water shortage.

Most cropland areas, especially those in the downstream part of the Cau sub-basin do not have real water shortages (<25 mm). Deciduous forests however show deficits of 300-400 mm. It is evident that forests are more affected by drought than crops, because the latter are compensated by irrigation supplies and perhaps capillary rise from shallow groundwater tables.

The same remote sensing drought analysis was extended to the entire Red River Basin in Northern Vietnam. Figure 7 shows the average real water deficits of 12 November 2003 and 14 February 2004 for each district. The overall trend is that deficits are lower towards the Gulf of Tonkin and in districts in close vicinity of the Red River. In some districts at the coast the extreme low deficits indicate that the soil is at – or above – field capacity. This indicates water excess conditions and improper drainage systems. The biomass production map in figure 8 shows that crop production in the Thanh Hoa is among the highest in this part of Vietnam, with values exceeding 11,000 kg/ha, despite its ET_{def} values.

Table 1 provides a summary of the water consumption, access to water resources, real water deficit and dry matter production of the main land cover types. Grasslands and water bodies/wetlands have the highest biomass production.

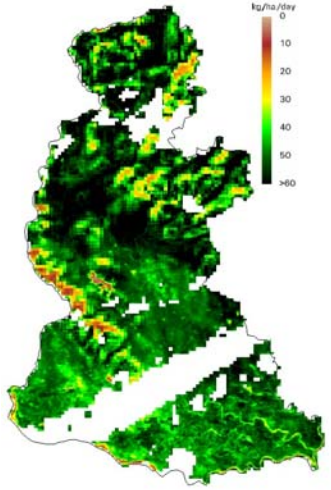

Fig. 3 Biomass production in the Cau sub-basin (mean of 12 Nov and 14 Feb)

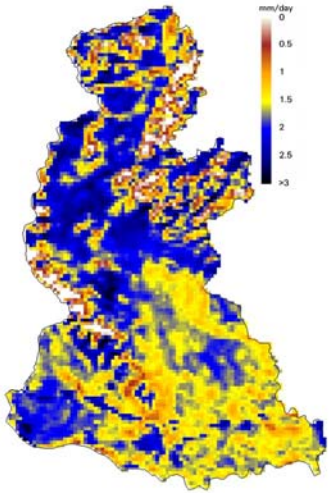

Fig. 4 Water consumption in the Cau sub-basin (mean of 12 Nov and 14 Feb)

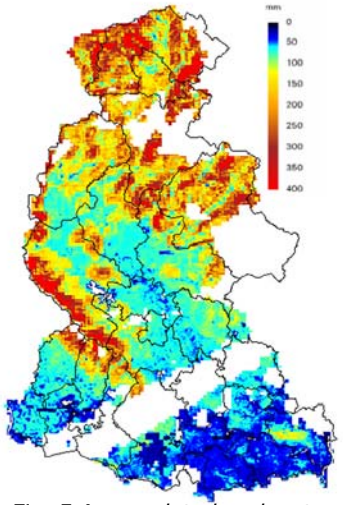

Fig. 5 Accumulated real water deficit in the Cau sub-basin (Nov-April 2004-5)

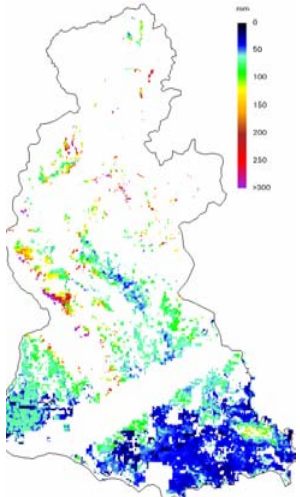

Fig. 6 Accumulated real water deficit for irrigated land in the Cau sub-basin (Nov-Arpil 2004-5)

Table 1 Land cover-wise presentation of drought indicators accumulated for the period Nov 2003 – April 2004

	Red River Basin				*Cau sub-basin*			
	Biomass [kg/ha]	ET_{act} [mm]	ET_{def} [mm]	Area [ha]	Biomass [kg/ha]	ET_{act} [mm]	ET_{def} [mm]	Area [ha]
Grasslands	10083	274	80	88900	9773	248	65	11900
Cropland	9695	264	113	2366800	9745	256	85	370100
Cropland/Nat. veg. mosaic	9426	281	182	2287900	10273	302	159	153800
Forest	7998	255	273	5234800	10120	308	199	155700
Water bodies/wetlands	10107	339	80	450700	9615	269	41	13900

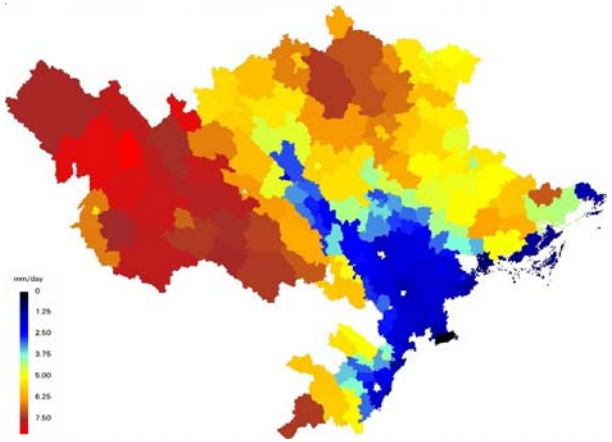

Figure 7 Average ET deficit for each district in the Red River Basin (average values of 12 Nov 2003 and 14 Feb 2004)

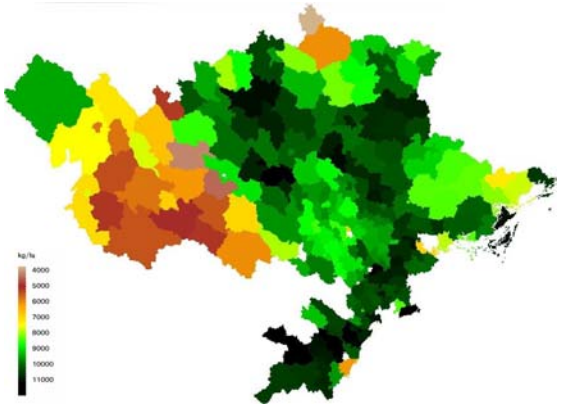

Figure 8 Accumulated biomass production per district in the Red River Basin for all land cover classes for the period elapsing between 1 Nov 2003 and 30 April 2005

Table 2 District ranking based on water shortage (upper) and agricultural performance(lower) in the irrigated areas of the Cau sub-basin between Nov 2003-April 2004

Rank	*District*	*Name*	*Area [ha]*	*Total ETdef [mm]*
1	10115	Bach Thong	106700	149
2	21911	º□i T□	58200	139
3	21513	VΓ Nhai	49500	139
4	10117	º□nh Ho□	51700	134
5	21501	ºσng H√	47500	94

Rank	*District*	*Name*	*Area [ha]*	*Biomass [kg/ha]*
1	20707	Chε ºσn	13400	8899
2	21507	Sπc S¼n	24900	9065
3	21911	º□i T□	58200	9224
4	21909	M¬ Linh	32600	9420
5	21515	º½ng Anh	17400	9484

Water bodies consume most water and consequently have a relatively low real water deficit.

The administrative districts with a minimum of 10,000 ha are ranked to demonstrate where water shortage is manifested most significantly, and where production has not been able to keep pace with normal standards (table 2).

Conclusions

The main conclusions are:

- The Cau sub-basin is drier than other irrigated areas in the Delta;
- The majority of the irrigated areas has a real water deficit of 50 mm, which implies a very mild stress only;
- water shortage in irrigation systems occur mainly in the Central-West and Northern part of the Cau sub-basin;
- Although upland forest systems have real water deficits of 100-200 mm, biomass production is not affected, which is possibly related to ecosystem adaptation;
- The Cau sub-basin is not exposed to any systematic physical land degradation. In contrary: fractional vegetation cover in both wet and dry season have increased by 4% over the last 23 years.

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