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# Water productivity of different land uses in watersheds assessed from satellite imagery Landsat 5 Thematic Mapper

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## 1. INTRODUCTION

The parameters of water productivity on large scale is an important tool to support the planning of agricultural policies and decision making about the use of natural resources. The water applied to plants provides increase of biomass production (BIO) and evapotranspiration (ET) rate in a large scale. For the determination of WP, evapotranspiration (ET) to be quantified. The SAFER (Simple Algorithm for Retrieving Evapotranspiration) allows to estimate ET using the Penman-Monteith equation in conjunction with biophysical parameter data generated through the use of remote sensing. The objective of the research is to determine the spatial and temporal water productivity in watersheds with different types of use and occupation of land in their driest conditions, during the period 1997-2010, using Landsat TM-5 together with the Monteith model to estimate the parameters of BIO and SAFER for determination of ET on a large scale.

## 2. MATERIAL AND METHODS

The three watersheds summed up a total of an area of 103.10 km$^2$ and have different types of use and occupation of land occupied mostly by pasture and irrigated agriculture that began in 1997, due to favorable growing conditions, with water availability, relief and soil fertility (Figure 1). Other types of land use are sugarcane and natural vegetation, the later with lowest area. One automatic agrometeorological station was used together with 14 Landsat images for the periods of water deficit from 1997 to 2010. Figure 2 shows the schematic representation of the calculation of the water productivity.

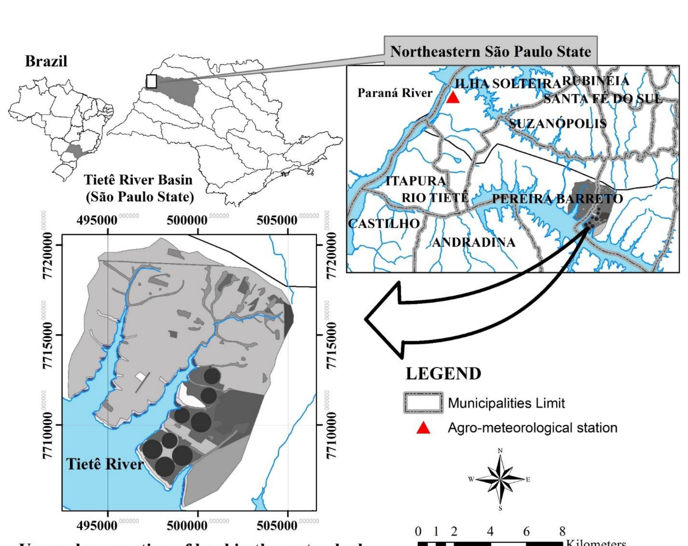


**Figure 1.** Location of the research area.

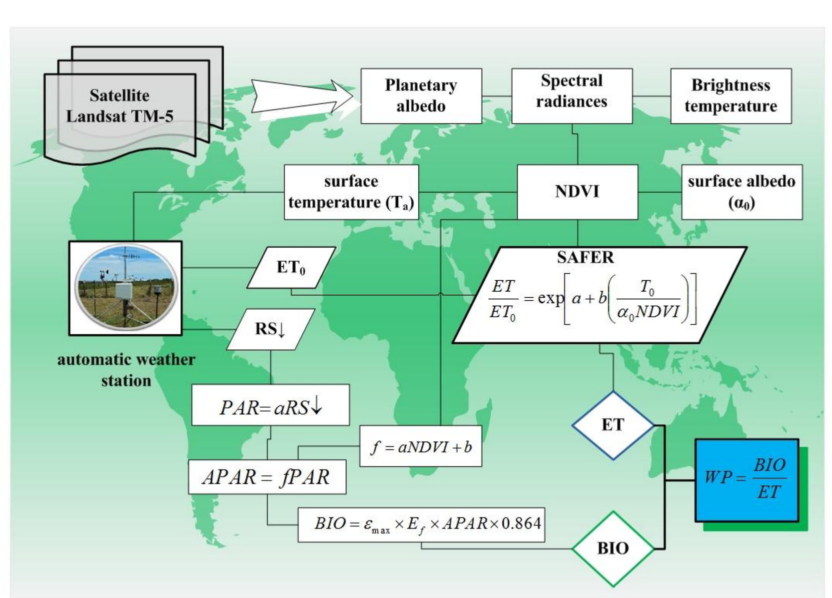


**Figure 2.** Schematic flowchart for calculation of biophysical water productivity (WP) based on evapotranspiration (ET).

## 3. RESULTS AND DISCUSSION

Figure 3 presents spatial variation of the NDVI values and the average for each JD/year of the assessed watersheds. The average study period was 0.40, the lowest mean value was 0.31 and occured in 2008. The highest value occurred in 2001, with an average value of 0.53 (Figure 3). Analysing only irrigated crops, in 1998 (DJ: 208) the are irrigated by center pivots presented in average 116.4 kg ha$^{-1}$d$^{-1}$ (SD: ± 21.4) and in 1999 it was 76.2 kg ha$^{-1}$d$^{-1}$ (SD: ± 44.7). In September 2000 (JD: 261), the maximum value was 277.4 kg ha$^{-1}$d$^{-1}$ and an average of 142.8 (SD: ± 64.2) (Figure 4).

In the northeastern São Paulo State, the image of March (2004/80) showed high value of BIO due to the rainy season in the region. In the dry season there is a reduction in the value of BIO in watershed, the values of BIO are high in irrigated areas due to the daily irrigation center pivots.

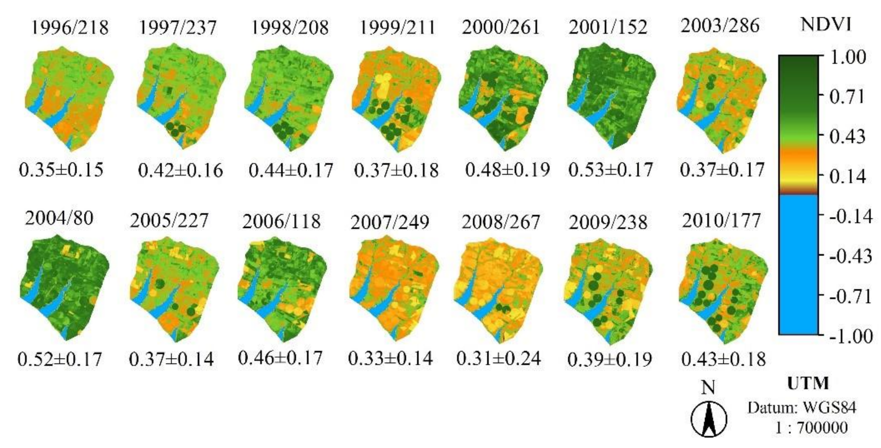


**Figure 3.** Spatial distribution of the value of the NDVI for the watersheds during the years from 1996 to 2010, for every day of the year (DOY), average NDVI and SD value.

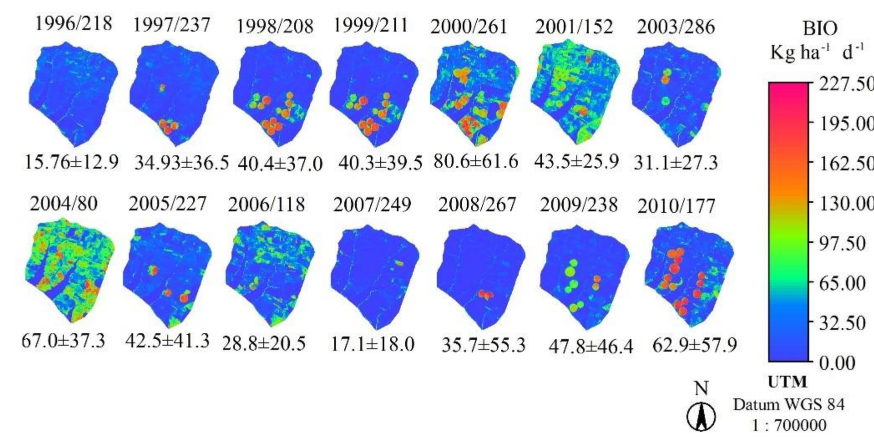


**Figure 4.** Spatial distribution of the value of BIO for the watersheds during the years from 1996 to 2010, for every day of the year (DOY), average BIO and SD value.

Figure 4 the spatial distribution of the ET mean values for the period 1996-2010. The highest mean values of ET occurred in 2000 (SD: ±1.26), because the area irrigated by center pivot that averaged 2.2 mm-1 d-1 (SD: ±1.4). Mean values of ET showed an increment of 153.2% during the period 1997-2010, with the irrigated areas this increases in ET the values of watersheds.

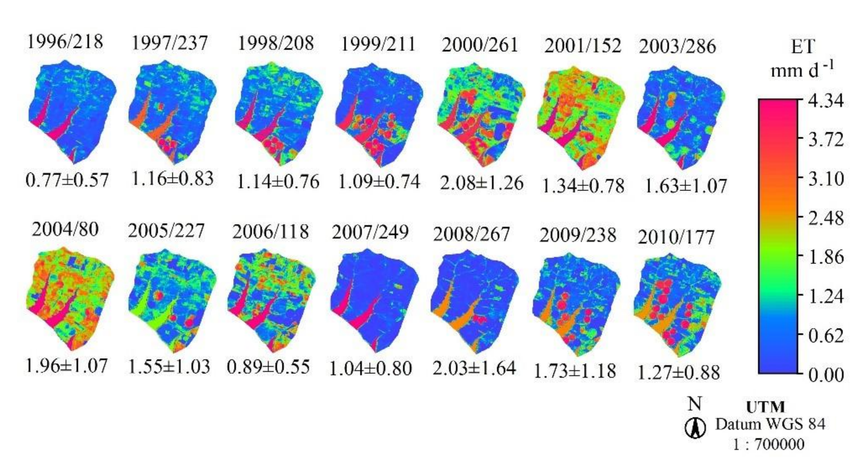


**Figure 5.** Spatial distribution of the value of evapotranspiration (ET) for the watersheds during the years of 1996 to 2010, for every day of the year (DOY), average ET and SD value.

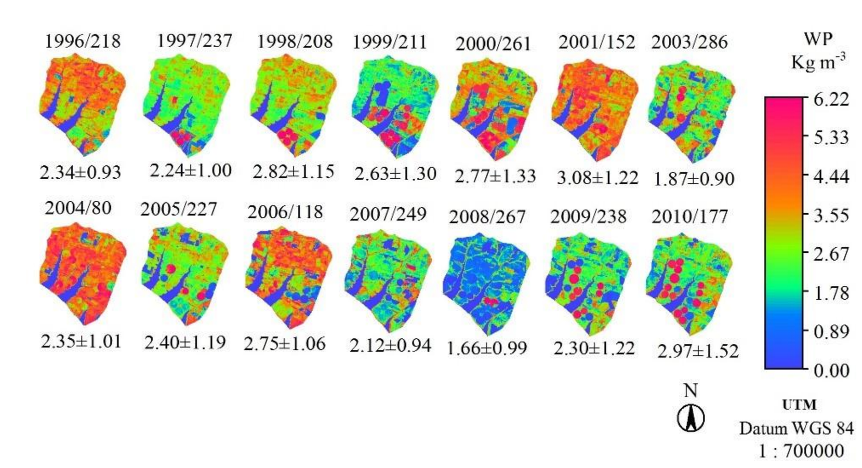


**Figure 6.** Spatial distribution of the value of WP for the watersheds during the years of 1996 to 2010, for every day of the year (DOY), means WP and SD value.

The maximum WP value occurred in June/2001, with 3,08 kg m$^{-3}$ (SD: ±1.22), the second highest value was in 2010 (June), with a value of 2,97 kg m$^{-3}$ (SD: ±1.52) (Figure 6). Irrigated agriculture show the highest WP value in 2010, with maximum value of 6.7 kg m$^{-3}$ and mean value of 3.1 kg m$^{-3}$ (SD: ±2.0). The lowest WP was obtained for images of DOY 249 (September, 2007) and 267 (September, 2008), because of the dry season with low soil moisture conditions, with 90 and 120 days without rain above 10 mm, respectively.

## 4. CONCLUSIONS

The mean values of ET showed an increase of 153.2% during the period 1997-2010, with the irrigated areas this increase in ET values in watersheds. SAFER model was efficient for the study and to identification of the thermo-hydrological conditions of the images evaluated in the dry season. WP values were higher in the irrigated, mainly in the crop production and reduction during the fallow period, represent by pixel reddish.

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