Irrigation performance and yield gap analyses

Case Study: Xinavane Sugarcane Estate

The Xinavane sugarcane estate, located in southern Mozambique, is a major producer of processed sugar and relies heavily on the water supply from the Incomati River. Following the drought of 2016 and the subsequent stress on the sugarcane crop, it became increasingly clear that the limited water resources available should be used more effectively.

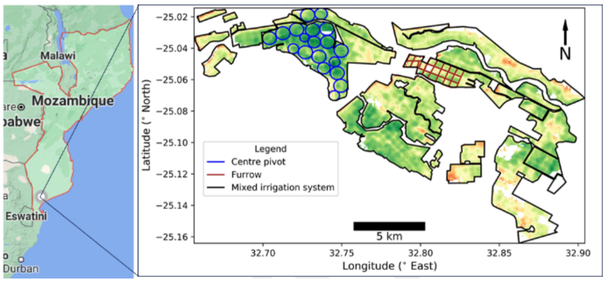

Figure 1: Xinavane sugarcane estate showed in the map of Mozambique (Map data © Google Maps 2021, AfriGIS(Pty) Ltd)

Country: Mozambique

Climate: Tropical

Crop(s): Sugar cane

Irrigated land analysed: 10,012 ha

Water source: Surface water from the Incomati River Basin

Irrigation method(s): Furrow, centre pivots, and sprinkler irrigation

Study period: Data seasonal and averaged over 5 growing seasons (October 1st to September 30th) from 2014/2015 to 2018/2019

The objective of this case study was to provide insight on how to improve agricultural water management to increase agricultural yield while maintaining factory production in the Xinavane sugarcane estate. This was done by analysing the spatiotemporal variability in water productivity, land productivity, and other irrigation performance indicators for different irrigation methods. In addition, the impacts of increasing water productivity to a target value ("closing the productivity gap") is assessed.

Methodology

The methodology involved four steps:

1) remotely sensed derived data from the WaPOR portal (FAO portal to monitor Water Productivity through Open access of Remotely sensed derived data) and local data were collected and processed using Python,
2) seasonal water consumption and above-ground biomass production were calculated,
3) irrigation performance indicators were analysed, and
4) the impact of closing productivity gaps on water consumption and biomass production were explored.

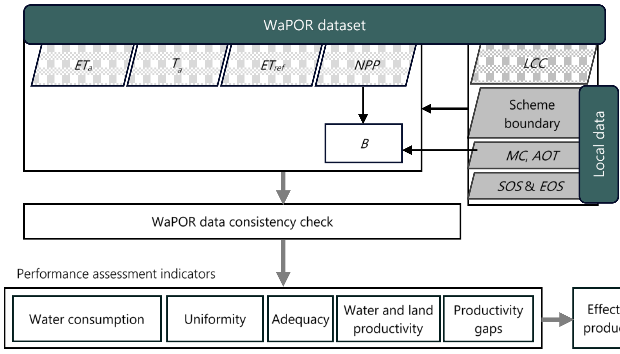

Figure 2: Flow chart for calculating indicators for irrigated sugarcane at Xinavane, where ET_a stands for actual evapotranspiration, T_a for actual transpiration, ET_{ref} for reference evapotranspiration, NPP for net primary production, ET_p for potential evapotranspiration, LCC for land cover classification, MC for moisture content in fresh biomass, AOT for the above ground over total biomass, K_c for crop coefficient, SOS for start of season, EOS for end of season, and B for above-ground biomass.

Assumptions & Uncertainties: Cropping season was assumed to be 12 months aligned with the hydrological year (starting October each year), although the individual fields in reality have different start and end dates. In absence of field data, many parameters used in the methodology were obtained from literature. The WaPOR land cover class is static for 2015 and only differentiates the agricultural land cover class into rainfed and irrigated areas on a yearly basis.

Results

Irrigation Performance Analysis

The comparison of the irrigation technologies using the different performance indicators showed that there is not one irrigation method that stands out the best across all indicators. Mixed irrigation and furrow were very similar, which is not surprising as a large part of the mixed irrigation consist of furrow irrigation. Centre pivots had higher adequacy, land productivity and equity, but lower water productivity and excess seasonal water consumption compared to furrow irrigation. This implies that more water is consumed under pivot irrigation compared to furrow irrigation to produce the same biomass, while more land is required under furrow irrigation to produce the same biomass as centre pivots.

The study showed that water deficit is not the underlying problem for furrow irrigation and centre pivots and some productivity gaps can be attributed to other stress factors (such as water logging and salinity) which may require further studies and different management actions.

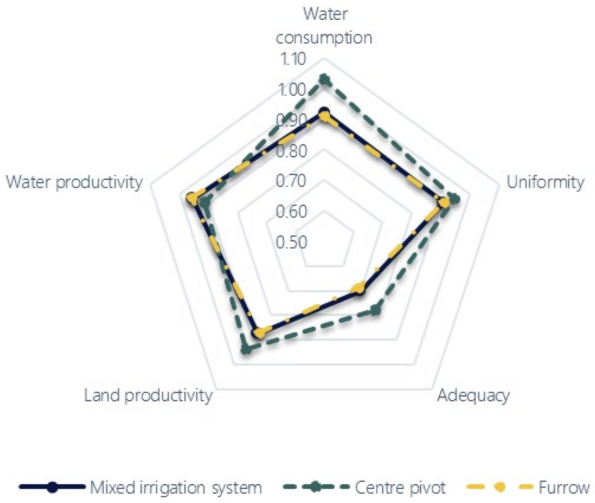

Figure 3. Summary of the performance indictors averaged over five seasons by irrigation method. The five indicators in the figure are normalized using their maximum (100%) or target values. Thus the indicators show extremely low performance at 0 and high performance at 1. For water consumption, a value greater than 1 indicates over consumption.

Closing the Productivity Gap

Increasing production though intensification of land could potentially save water compared to producing the same amount of production from land expansion. By closing biomass gaps through intensification of existing land, the Xinavane sugarcane estate could increase production by up to 105,860 tons/year, which would require 10.5 Mm3/year of additional water. This amount is much smaller than water consumed to produce the same from land expansion. Using target productivity, the same increase in production would require 17.6 Mm^3/year of water on 1,203 additional ha of land. At current productivity, it would require 18.5 Mm^3/year on 1,375 additional ha of land.

More Information on this case study and water productivity:

- Full report of the Xinavane Case Study: Project report, and Paper in HESSD
- FAO portal of WAter Productivity through Open access of Remotely sensed derived data (WaPOR): https://wapor.apps.fao.org/
- WaPOR Quality Assessment: Technical report on the data quality of the WaPOR FAO database version 1.0: http://www.fao.org/documents/card/en/c/ca4895en
- Water Productivity GitHub: http://github.com/wateraccounting/WAPORWP

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