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Evaluative mapping of the area irrigated by center pivot in Mozambique

Abstract

Knowledge of expansion, number; size and spatial distribution of center pivot irrigated areas may represent an important contribution to socio-economic and environmental studies of a given territory. In view of the above, this work aimed to understand the space-time dynamics of areas irrigated by central pivot in Mozambique using remote sensing. For this, images of Landsat satellites 5 and 8 were acquired respectively from the year 2000 to 2017. RGB images were generated for the discrimination of the targets. Based on the results, Mozambique has 200 central pivots. The province of Sofala has a larger number with 110 pivots followed by the province of Maputo with 49. The province of Niassa has a smaller number with 2 pivots. The central pivot irrigated area in Mozambique totals 14 685 ha and the average area irrigated by central pivot is approximately 80 ha.

Keywords: remote sensing, water resources, center pivot

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Introduction

Mozambique is a country with huge agricultural potential, with some 36 million hectares of arable land. However, about 24% of this area has farms, of which 99% are farms characterized, generally, by low productivity. The potential for the implementation of irrigated agriculture is 3 million hectares.[1] The predominant type of irrigation in Mozambique is surface irrigation, practiced by small associated farmers who have settled along the banks of the rivers that cross the country. According to MINAG,[2] it is estimated that surface irrigation currently covers about 70 % of total irrigated area. The central pivot irrigation system is generally used by large companies engaged in the commercial production of sugar cane and vegetables for export.

According to Mantovani,[3] center pivot is a circular drive system, self-powered hydraulic or electric power. (2015) states that the production of food using irrigation requires a large amount of water, which may result in conflicts between users of water and environmental problems if basin support capacity is not respected. Mozambique has 13 major river basins and is a downstream country, sharing 9 of the 13 international river basins in the SADC region.[1] The use of geotechnologies for mapping the central pivots is mainly applicable to the standard circular geometry of the central pivots.[4,5]

In order for the growth of irrigated agriculture to occur in a sustainable manner, respecting the capacity to support the environment and with a low risk of generating conflicts over water use, knowledge of the relationship between availability and water demand in river basins is fundamental. Although the central pivot irrigation system is little used in Mozambique, due to the high initial investment, knowledge of the expansion, number; size and spatial distribution of center pivot irrigated areas may represent an important contribution to socio-economic and environmental studies of a given territory.[6] In view of the above, this work aimed to study the space-time dynamics of central-pivot irrigated areas in Mozambique using remote sensing.

Material and methodology

Characterization of the study area

Mozambique is a country located in the southeast of the African continent (Figure 1A), on the eastern coast of Southern Africa, georeferenced between the parallels 10°27' and 26°52' of South Latitude and between the meridians 30° 12'and 40° 51' East Longitude (Figure 1B). It is bordered by Tanzania to the north, to the west by Malawi, Zambia, Zimbabwe, South Africa and Swaziland, has a coastline of 2,500km, occupying an area of 799,380 km^2.

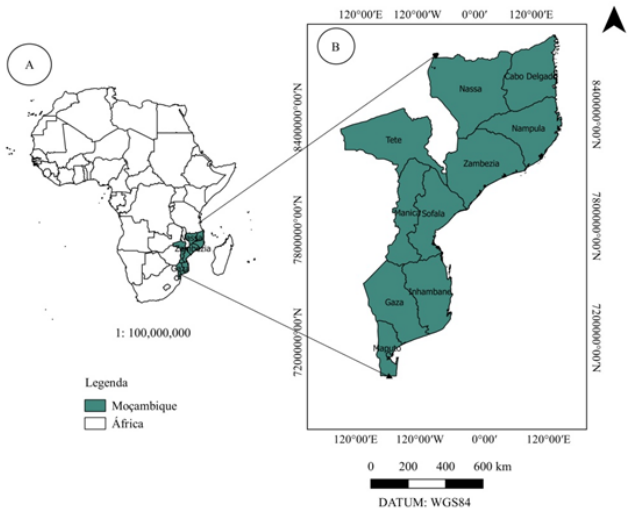


Figure 1 Location of Mozambique on the African continent.

Administratively the country is divided into four levels: province, district, administrative post and locality. It has eleven provinces distributed in the three regions. It presents a humid tropical climate, with a cool and dry season (between the months of April and September) and a hot and humid one (from October to March). The location, topography and distribution of hydrographic networks are determining factors for the great ecological diversity of Mozambique.[1]

Identification and mapping of central pivots

First an overview of the whole country was made through Google earth pro. This allowed visualizing all areas with pivots. To perform the evolutionary monitoring of the pivots, satellite images were downloaded through Landsat8 satellite from year 2000 until 2017 in this site https://earthexplorer.usgs.gov/

In the geographic information system (GIS) the geographical coordinates and the radius for each of the central pivots were imported. This allowed the execution of the buffer operation that produced a file in vector format with the circles corresponding to the areas irrigated by each of the existing pivots. The free software QGIS 2.14.21 was used for the composition of the colored images. The vector data of the political and administrative division of Mozambique were purchased free of charge from the website: www.cenacarta.com of the National Remote Sensing Center of Mozambique (CENACARTA).

After the acquisition of the images and in order to minimize the atmospheric effect on the reflectance data captured by the sensor, the atmospheric correction was performed by the DOS-1 method (Dark Object Subtraction) from the SCP (Semi-Automatic Classification Plugin), available in QGIS 2.14.21 software.

Results and discussion

In total, 200 center pivots were identified, occupying an irrigated area of 14.685 ha (Table 1). From the table above, can be seen in 2017, Sofala province has 110 pivots making up 55% of the whole country, followed by the province of Maputo with 49 making up 24.5%. The Manica province has 27 pivots making up 13.5% of the total. The Gaza and Zambézia provinces, both have 6 each making up 3%. The Niassa province has only 2 pivots that make up 1%. In general it is observed an increase in the number of pivots over time. However, the Gaza province in 2010 presented 18 pivots, but from 2015 the number reduced to 6. This fact can be explained by the heavy rains that flooded the zone of the pivots and as a consequence were removed.

Table 1 Evolution of center pivots by province

Province	2000	2005	2010	2015	2017
Niassa	0	0	0	2	2
Zambézia	0	0	0	6	6
Manica	0	16	20	24	27
Sofala	12	20	90	91	110
Gaza	0	0	18	6	6
Maputo	13	19	19	40	49
Total	25	55	147	169	200

Adapted from Author (2018)

Silveira et al.[7] concluded that the scenes of the CBERS-2 satellite CCD sensor were suitable for identification of central pivots. On the other hand, Leite et al.[8] developed similar work of mapping the space-time dynamics of central pivots in the north of Minas Gerais through remote sensing where they concluded that the region of the North of Minas presented a considerable increase in the analyzed 24 years (1986, 1996 and 2010), with growth of 23.4% in 1986, and growth of 102% from 1996 to 2010.[9]

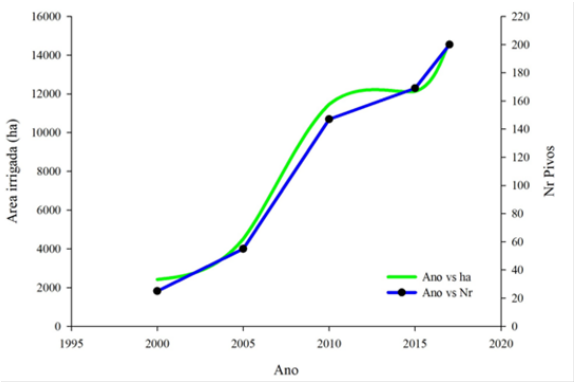
Table 2 shows the evolution of the irrigated area. The Sofala province has a larger area irrigated by pivots with 10,015ha, followed by Maputo province with 2.827ha. The Niassa province presented a smaller irrigated area with only 91ha.

The graph 1 also shows the evolution of the irrigated area and the number of pivots in Mozambique. Significant growth is observed between the years 2005 and 2015.

Table 2 Evolution of irrigated area by province (ha)

Province	2000	2005	2010	2015	2017
Niassa	0.0	0	0	91	91
Zambezia	0.0	0	0	6	173
Manica	0.0	836	999	1.172	1.304
Sofala	1.418	2.269	7.943	8.365	10.015
Gaza	0.0	0	1.110	275	275
Maputo	999	1.410	1.410	2.219	2.827
Total					14.685

Adapted from Author (2018)



Graph 1 Expansion of irrigated areas in Mozambique.

Figures 2,3&4 represent satellite images Landsat_5 and 8, respectively, in the RGB color composition for three districts with the highest concentration of pivots in Mozambique. The district of Marromeu presented in 2000 about 12 central pivots and by 2017 it had 71 pivots, representing growth of 59 pivots (Figure 2).

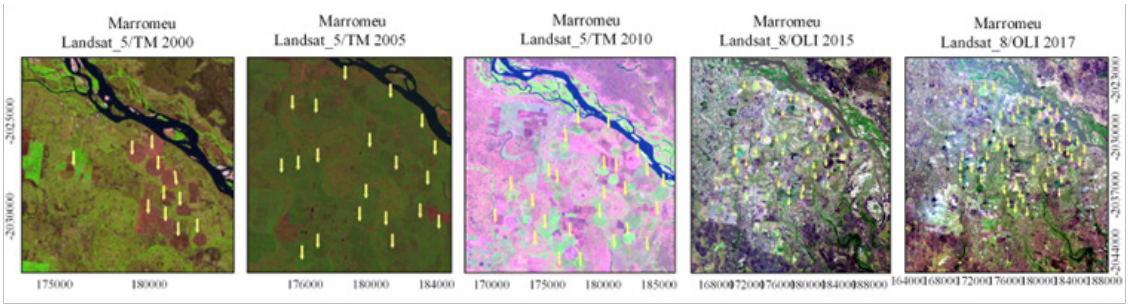


Figure 2 Image cutouts TM / Landsat_5, OLI / Landsat_8, in RGB color composition 543 and 432 respectively, referring to the period between 2000 and 2017 for Marromeu district in Sofala.

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The Nhamatanda district did not have any pivots in 2000, the installation started in 2007 with 22 and from the following year until 2017 it had 41 central pivots, representing a growth of 21 pivots (Figure 3).

The administrative post of Xinane in Maputo province in 2000 had 13 pivots and from 2010 to 2017 the number increased to 23pivots, represented an increase of 10 pivots (Figure 4).

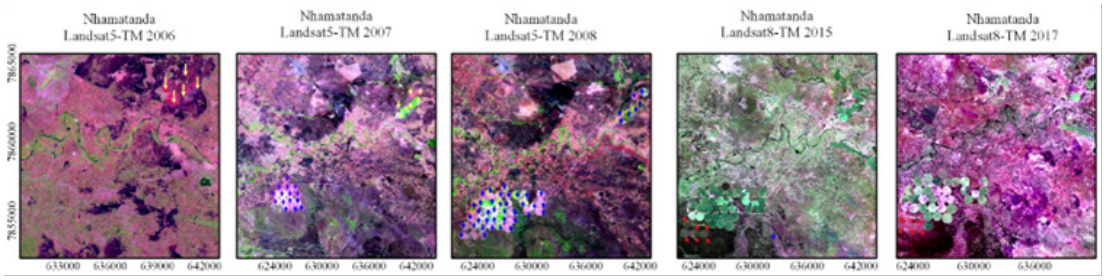

Figure 3 Image cutouts TM / Landsat_5, OLI / Landsat_8, in RGB color composition 543 and 432 respectively, referring to the period between 2006 to 2017 for Nhamatanda district.

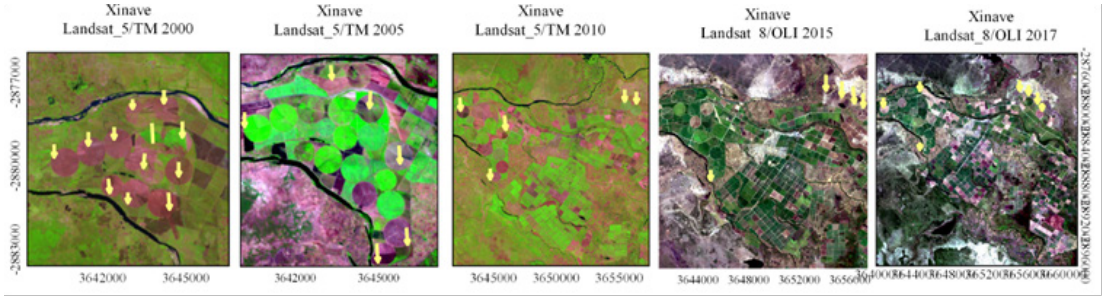

Figure 4 Image cutouts TM / Landsat_5, OLI / Landsat_8, in RGB color composition 543 and 432 respectively, referring to the period between 2000 and 2017 for Xinavane.

Conclusion

Based on the results generated by the present research, it was concluded that remote sensing, together with satellite image processing techniques, allowed monitoring of the evolution of areas irrigated by central pivots in Mozambique.

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None.

Conflicts of interest

Author declares that there is no conflict of interest.

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