Change in Water Productivity as a Result of ThirdEye Services in Mozambique

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Preface

Securing Water for Food is a Grand Challenge for Development is supported by the United States Agency for International Development (USAID), the Swedish International Development Cooperation Agency (Sida), and the Ministry of Foreign Affairs of the Kingdom of The Netherlands (MFA-NL) collectively. Through Securing Water for Food, our goal is to source and accelerate innovations in the following areas that will enable the production of more food with less water and/or make more water available for food production, processing, and distribution.

In response to a call for proposal launched at the 2013 World Water Week in Stockholm, FutureWater submitted a proposal titled “The ThirdEye: Flying Sensors to Support Farmers’ Decision Making”. Of the over 500 submissions 17 were selected to be granted. The ThirdEye project was one of these.

On 3-Nov-2014 the contract was awarded:

- Cooperative Agreement No. AID-OAA-A-15-00008.
- Start date: 3-Nov-2014
- End date: 2-Nov-2017.

This report shows the results of the water productivity study that has been undertaken as part of the ThirdEye project from 3-Nov-2015 to 2-Nov-2016.

Disclaimer: This project is made possible through the support of the Securing Water for Food: a Grand Challenge for Development partners: the United States Agency for International Development (USAID), the Swedish International Development Cooperating Agency (Sida), and the Ministry of Foreign Affairs of the Kingdom of the Netherlands. It was prepared by FutureWater and does not necessarily reflect the views of the Securing Water for Food partners. Further information about Securing Water for Food can be found at www.securingwaterforfood.org

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1 Introduction

FutureWater and its core partner HiView have been active in Mozambique since 2013. This was part of a strategic widening of its operations in Africa. In 2014 FutureWater/HiView was granted a prestigious development grant from USAID, Sida and the Netherlands Ministry of Foreign Affairs to develop Flying Sensor business operations in Mozambique. This project is called 'ThirdEye: Flying Sensors to Support Farmers' Decision Making'.

The Third Eye project supports farmers in Mozambique by setting up a network of Flying Sensors operators. These operators are equipped with Flying Sensors and tools to analyse the obtained imagery. Flying Sensors have been proven to provide useful information in supporting farmers. However, this project is unique as it is a first trial in a developing country to supply information on a regular base using Flying Sensors.

So far, ThirdEye has a team of operators and experts based in Chòkwé and Xai-Xai and the following progress was made:

- 14 local Flying Sensor operators have been trained and obtained their certificate.
- 10 Flying Sensors are now operational.
- Over 2,800 farmers are receiving our service, of which 71% is female.
- The number of people benefitting is over 14,000.
- ThirdEye's service area is over 1600 ha.

As part of the ThirdEye project, the team has focussed on studying changes in water productivity as a result of ThirdEye services given to smallholder farmers.

2 Saving Water and Water Productivity

Author: Peter Droogers. Editor in Chief: Elsevier Agricultural Water Management

Over the last years Agricultural Water Management received a substantial amount of manuscript claiming to save water. Many of these savings are not real savings and are based on flaws in conceptual thinking. The most important ones are:

- Water savings are expressed as a reduction in irrigation amount, ignoring changes in soil moisture and use of rainfall by crops
- Water savings are only determined at local scale, ignoring return flows to either groundwater and/or downstream users
- Water savings are based on a limited time horizon, ignoring depletion of soil moisture.

Agricultural Water Management therefore recommends avoiding using the word "water saving" and using only the term Water Productivity to express enhancement in water use.

This Water Productivity concept has been introduced by the International Water Management Institute (IWMI) in 1997 and is widely accepted (by Institutions like FAO, IFPRI, ICID, ICARDA, DGIS, USAID, World Bank, amongst others) as the standard to measure water savings.

Some selected key references on water "savings" and water productivity:

- Cai, X., & Rosegrant, M. W. (2003). 10 World Water Productivity: Current Situation and Future Options. Water Productivity in Agriculture: Limits and Opportunities for Improvement, 1, 163.
- FAO, (2015.) Water Productivity. http://www.fao.org/nr/water/topics_productivity.html
- Hellegers, P. J. G. J. (2006). The role of economics in irrigation water management. Irrigation and Drainage, 55(2), 157–163. http://doi.org/10.1002/ird.223
- ICARDA, (2016) Water Productivity. http://www.icarda.org/water-productivity
- Kijne, J. W., Barker, R., & Molden, D. J. (2003). Water Productivity in Agriculture: Limits and Opportunities for Improvement.
- Molden, D. (2007). Summary A Comprehensive Assessment of Water Management in Agriculture. Earthscan.
- Molden, D., Oweis, T., Steduto, P., Bindraban, P., Hanjra, M. A., & Kijne, J. (2010.). Improving agricultural water productivity: Between optimism and caution. http://doi.org/10.1016/j.agwat.2009.03.023
- Perry, C. (2011). Accounting for water use: Terminology and implications for saving water and increasing production. Agricultural Water Management, 98(12), 1840–1846. http://doi.org/10.1016/j.agwat.2010.10.002
- USAID. (2013). USAID Water and Development Strategy.
- van Halsema, G. E., & Vincent, L. (2012). Efficiency and productivity terms for water management: A matter of contextual relativism versus general absolutism. Agricultural Water Management, 108, 9–15. http://doi.org/10.1016/j.agwat.2011.05.016
- Zwart, S. J., & Bastiaanssen, W. G. M. (2004). Review of measured crop water productivity values for irrigated wheat, rice, cotton and maize. Agricultural Water Management, 69(2), 115–133. http://doi.org/10.1016/j.agwat.2004.04.007

3 Farmers Questionnaires

To measure water productivity changes in ThirdEye service areas smallholder farmers were surveyed in areas where ThirdEye is active and where it is not. The latter is used as control group to correct water productivity results expressed by ThirdEye farmers.

Questionnaires were conducted in Chókwè and Xai-Xai. Plan was to interview at least 50 ThirdEye-users and at least 50 non-users, in both districts. Figure 1 gives a schematic overview of the methodology used for the questionnaires.

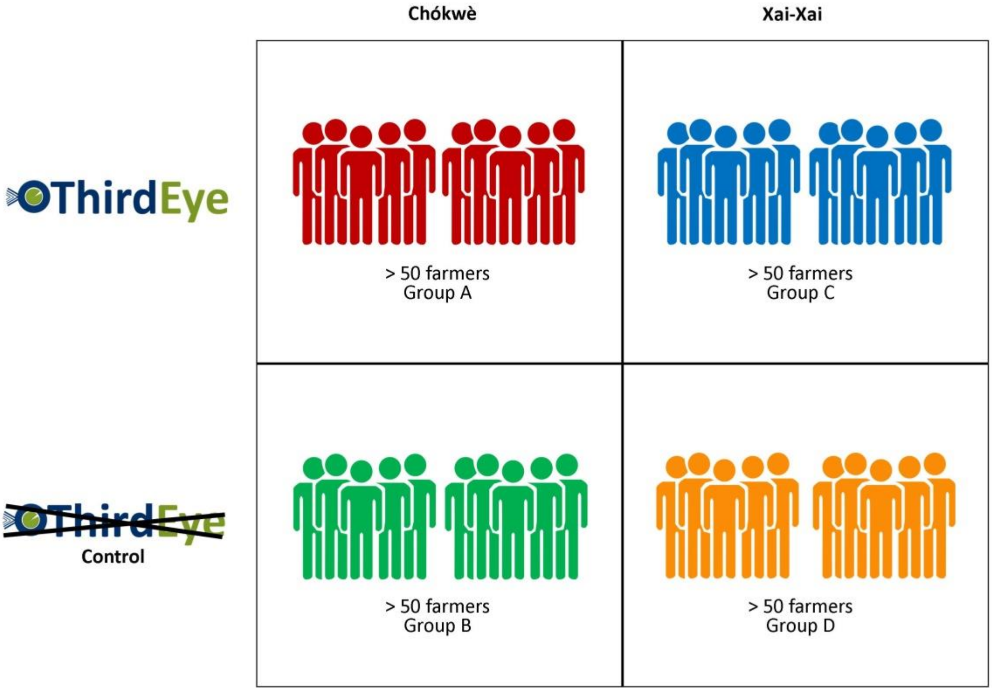


Figure 1. Schematic view of the methodology used for the farmers questionnaires.

All groups were questioned about changes in crop production and water use between last year and this year.

Table 1 shows the results from the questionnaires in Xai-Xai and Chókwè, both in ThirdEye service areas and control areas.

Table 1. Results from questionnaires in ThirdEye areas and control areas in Xai-Xai and Chókwè.

Location	ThirdEye area		Control area	
	Yield (change compared to last year)	Irrigation (change compared to last year)	Yield (change compared to last year)	Irrigation (change compared to last year)
Xai-Xai	+69%	+19%	+20%	+36%
Chókwè	+17%	-41%	-18%	-37%

In Xai-Xai more water was used for irrigation, but not as much as in the control area. The yield, however, was much higher in the ThirdEye area compared to the control area. In Chókwè less water was used due to the drought and breakdown of the Massingir Dam[1] upstream. In the control area this led to a lower crop production, while in the ThirdEye area the crop production was increased.

By taking into account the areas and main crop a reference yield and water use was determined per area (Table 2).

Table 2. Parameters used to calculate water reduction and crop yield increase.

Location	ThirdEye Service Area (ha)	Main crop	Reference values[2]		
			Yield (kg/ha)	Irrigation (mm)	Water Productivity (kg/m3)
Xai-Xai	770	Corn	797	400	0.20
Chókwè	832	Rice	414	600	0.07

Water use and crop production was calculated by using the parameters above and the questionnaire results in Table 1. Table 3 shows the results. It can be clearly seen that in total 663,059 m3 water was saved. Furthermore, 420,549 kg of extra crop was produced, all as a result of the ThirdEye service.

Table 3. Water use and crop production in ThirdEye and control area.

Location	ThirdEye area		Control area		Difference	
	Water use (m3)	Production (kg)	Water use (m3)	Production (kg)	Water use (m3)	Production (kg)
Xai-Xai	3,675,000	1,034,103	4,178,315	733,407	-503,315	300,697
Chókwè	2,965,248	402,311	3,124,992	282,458	-159,744	119,853
Total	**6,640,248**	**1,436,414**	**7,303,307**	**1,015,865**	**-663,059**	**420,549**

The direct water use reduction due to the ThirdEye service was 664,058,894 liters, or 9.1%. If the extra crop production would have been produced in the control area, extra water would have been used. This indirect water use reduction was calculated by dividing the extra production through the water productivity in the control area, giving 3,039,106,429 liters, or 41.4%. In total the ThirdEye service led to a water use reduction of 3,702,165,322 liters, or 55.0% (Table 4).

Table 4. Direct and indirect water use reduction due to the ThirdEye service.

Relative direct water use reduction	9.1%
Total direct water use reduction	663,058,894 liters
Relative crop production increase	41.4%
Total indirect water use reduction	3,039,106,429 liters
Relative water productivity increase	55.0%

[1] https://en.wikipedia.org/wiki/Massingir_Dam
[2] FAO Stat. http://faostat3.fao.org/home/E

Total water use reduction	3,702,165,322 liters

4 Actual Crop Production

In Xai-Xai the irrigation district Regadio do Baixa Limpopo (RBL) collects information on crop production in the different agrarian houses. Since ThirdEye is active in more 60% of the area of agrarian house Nahmpondzoene, crop production results from this agrarian house well-represent the effect of ThirdEye services in this area. As a control field, two different agrarian houses, with similar crop types, area and water use were chosen: the agrarian house of Inhamissa and Piombo.

Figure 2 shows the relative distribution of crops in the total crop production in Nahmpondzoene. In the second, wetter, season more rice and vegetables are grown in comparison to the first season, where mostly corn is planted. It is interesting to note that this year more vegetables and less rice was grown in comparison to last year. This was also spotted in the field.

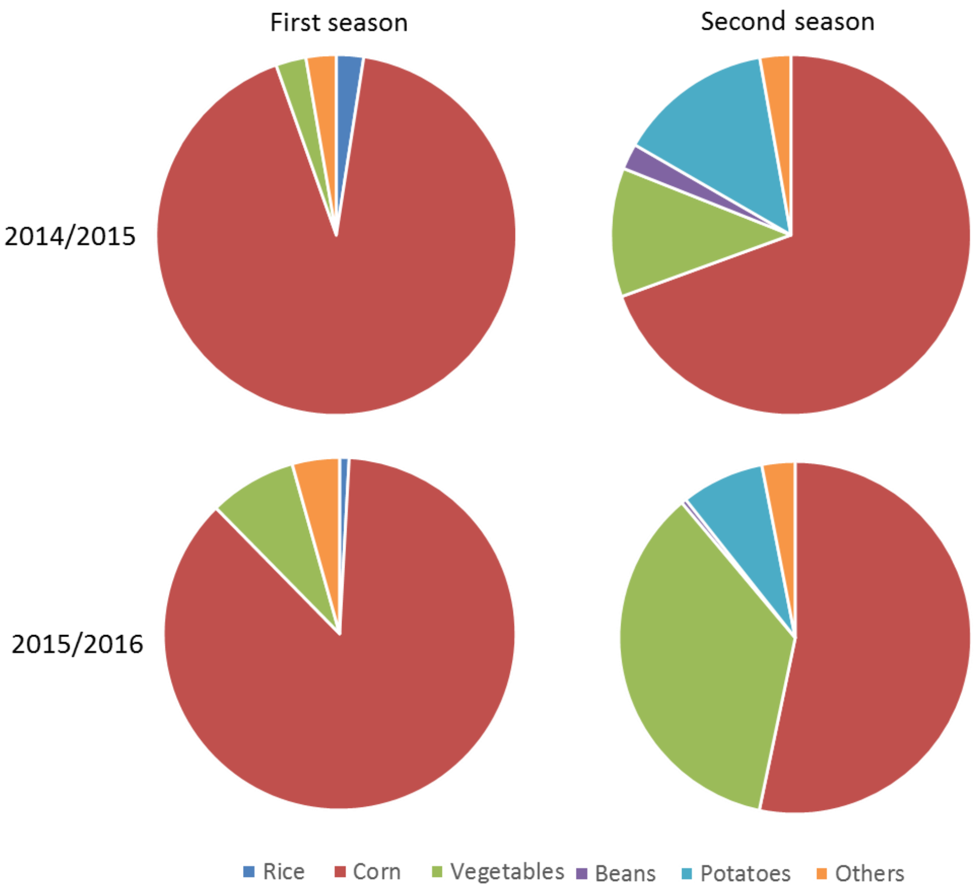
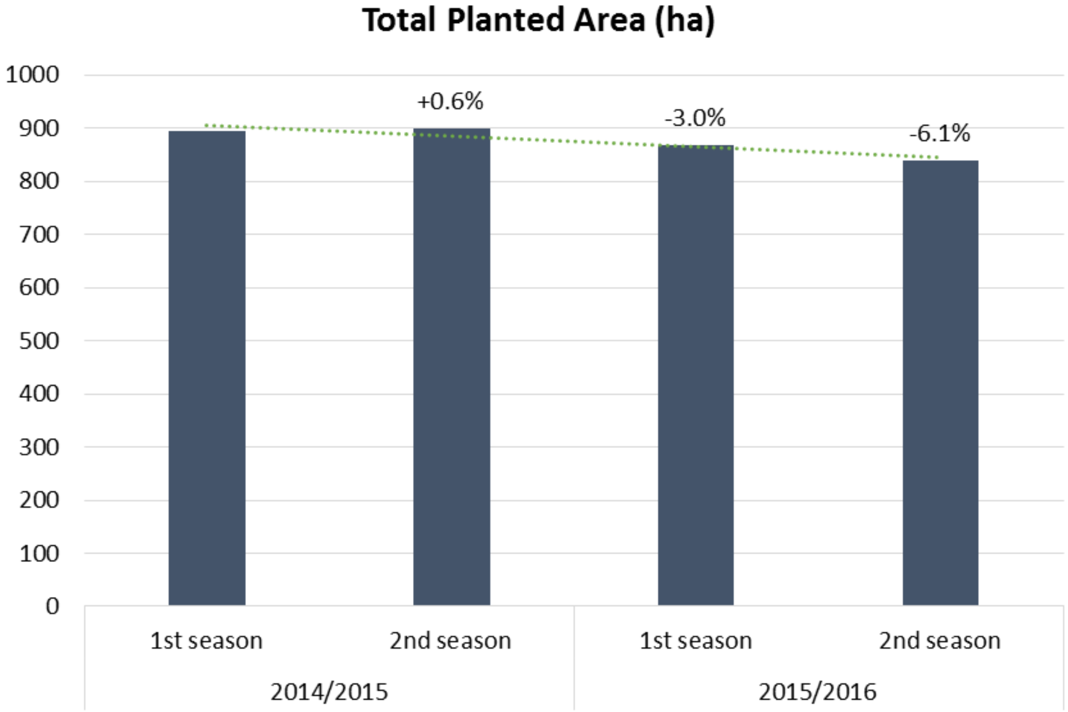


Figure 2. Relative distribution of crops in total crop production in Nahmpondzoene, Xai-Xai.

The total planted area in Nhampondzoene decreased slightly, while the crop production increased (Figure 3).



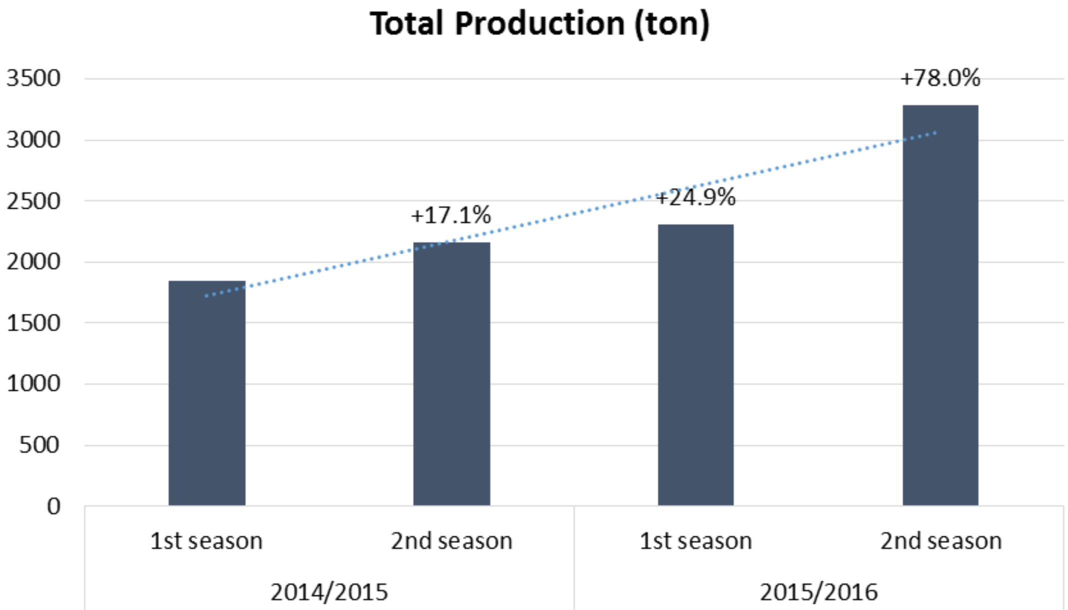


Figure 3. Total planted area and crop production in Nhampondzoene.

The average yield in ton/ha also increased (Figure 4).

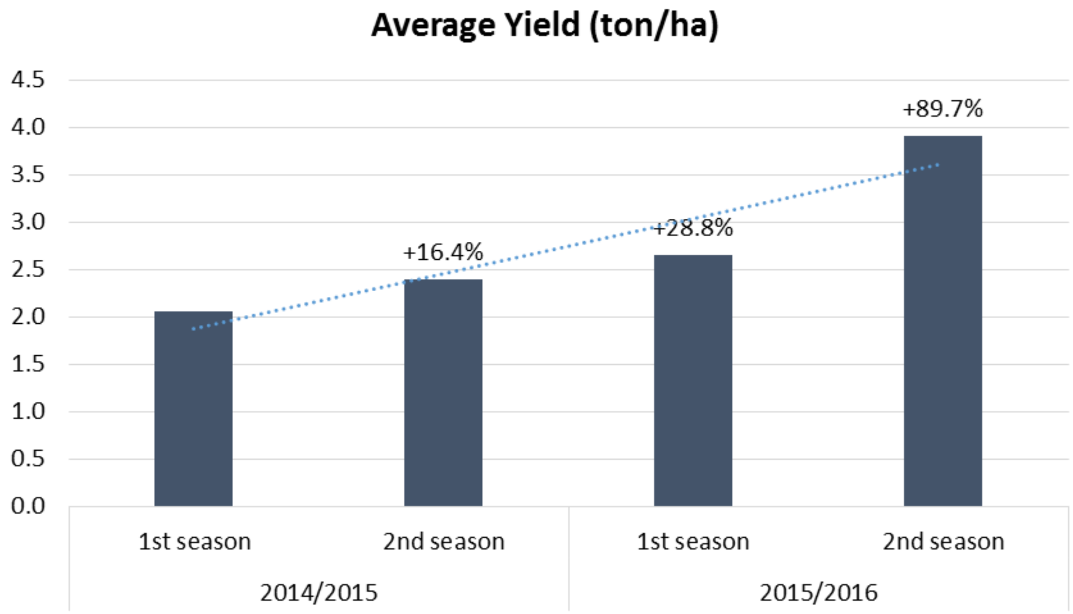


Figure 4. Average yield in Nhampondzoene.

Figure 5 shows the average yield in Nhampondzoene compared to two areas with almost the same crops, area, water use and climatic conditions. It can be clearly seen that the crop production in Nhampondzoene increased significantly over time due to the ThirdEye service.

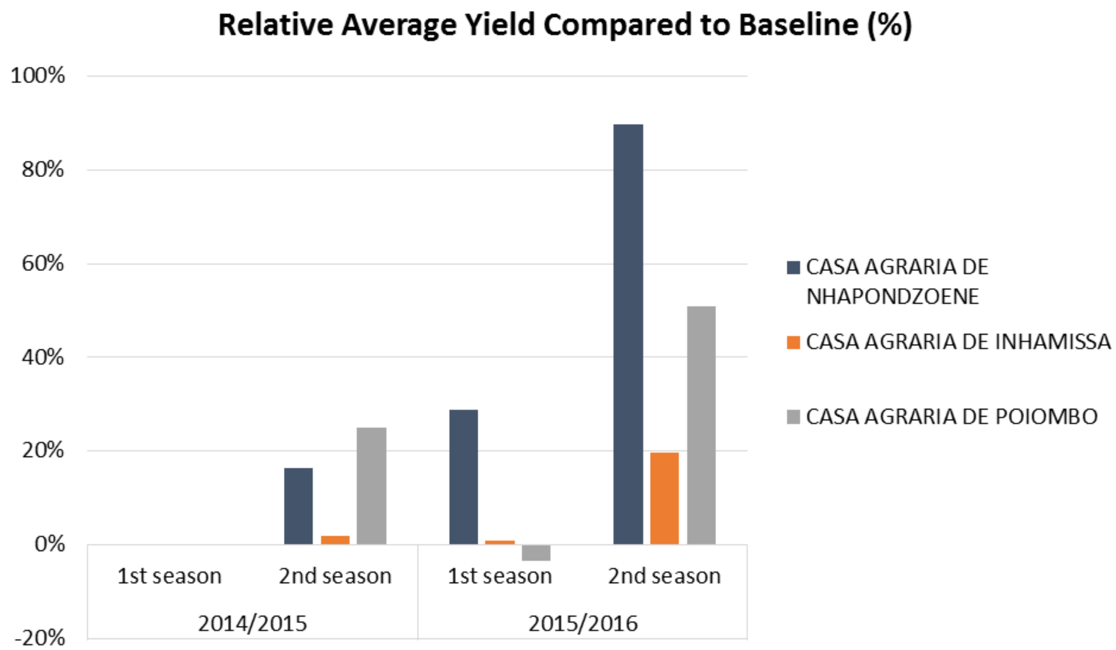


Figure 5. Relative average yield in ThirdEye area and two other areas with same parameters.

5 Remote Sensing

The crop production data was verified by making using of remote sensing techniques, obtained from Landsat.

Landsat

Landsat represents the world's longest continuously acquired collection of space-based moderate-resolution land remote sensing data. Four decades of imagery provides a unique resource for those who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research. Landsat images are also invaluable for emergency response and disaster relief. As a joint initiative between the U.S. Geological Survey (USGS) and NASA, the Landsat Project and the data it collects support government, commercial, industrial, civilian, military, and educational communities throughout the United States and worldwide.

Launched on February 11, 2013, Landsat 8 (formerly the Landsat Data Continuity Mission, LDCM) is the future of Landsat satellites. It is collecting valuable data and imagery to be used in agriculture, education, business, science, and government. The Landsat Program provides repetitive acquisition of high resolution multispectral data of the Earth's surface on a global basis. The data from Landsat spacecraft constitute the longest record of the Earth's continental surfaces as seen from space. It is a record unmatched in quality, detail, coverage, and value.

Derived from the most recent imagery from Landsat 8. Normalized Difference Vegetation Index (NDVI) is a compilation of visible and near infrared bands, ranges in value from -1.0 to 1.0, and is used to measure the vigor of vegetation on Earth. Landsat 8's Operational Land Imager collects new imagery for a given location every 16 days. Data on NDVI was gathered for both Nahmpondzoene and the control fields.

Normalized Difference Vegetation Index (NDVI)

The shortage of water available to vegetation in a drought limits the growth and productivity of vegetation. Chlorophyll, which is the pigment in plant leaves, strongly absorbs red light (from 0.6 to 0.7 µm) for photosynthesis. The cell structure of the leaves strongly reflects near-infrared light (from 0.7 to 1.1 µm). The magnitude of absorption and reflection of red and near-infrared light is strongly a function of leaf area and vegetation vigor. Satellite imagery has long been used to evaluate differences in plant reflectance and to determine their spatial distribution. A common satellite image index of vegetation vigor is the Normalized Difference Vegetation Index (NDVI) (Huete et al., 1985; Jackson and Huete, 1991), which ranges from -1 to 1, with ~ 0.5 to 1 representing high vegetation vigor. Effects of drought can be visualized through computing time series and spatial anomalies of NDVI.

- *Huete, A. R., Jackson, R. D., and Post, D. F. (1985), Spectral response of a plant canopy with different soil backgrounds, Remote Sens. Environ. 17:37-53.*
- *Jackson, R. D., and Huete, A. R. (1991), Interpreting vegetation indices, J. Preventative Vet. Med. 11:185-200.*

Figure 6 shows the areas used to study the difference in NDVI between the ThirdEye area (Block 1 in Nahmpondzoene, Xai-Xai) and control area (Southern part of Block 3 and 4 in Nahmpondzoene, Xai-Xai).

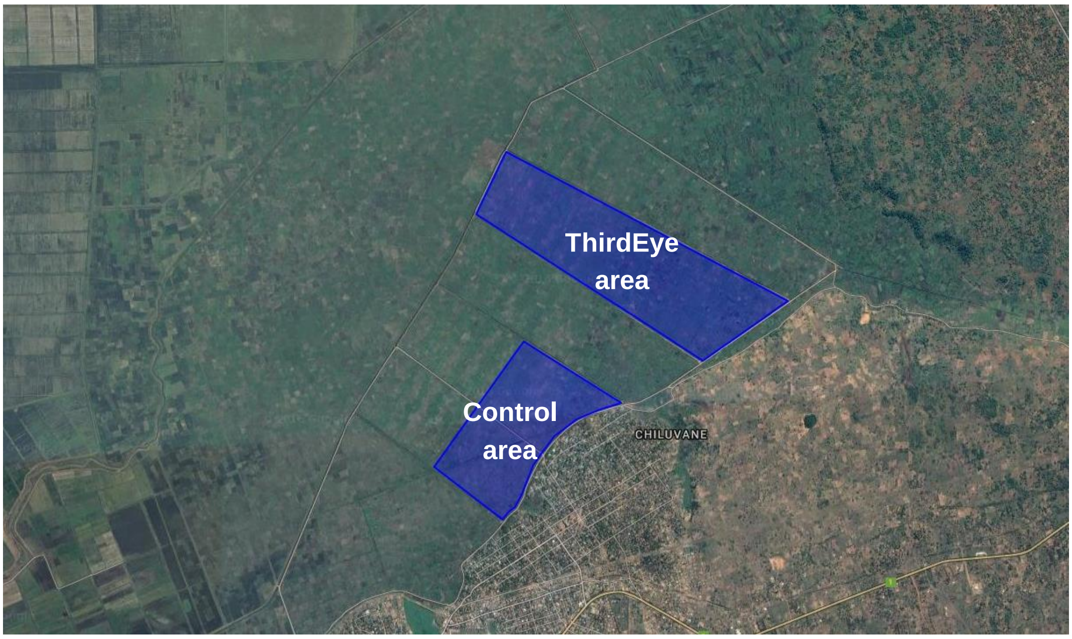


Figure 6. Areas used to study NDVI from remote sensing data.

Figure 7 shows the difference in NDVI between the ThirdEye area and control area.

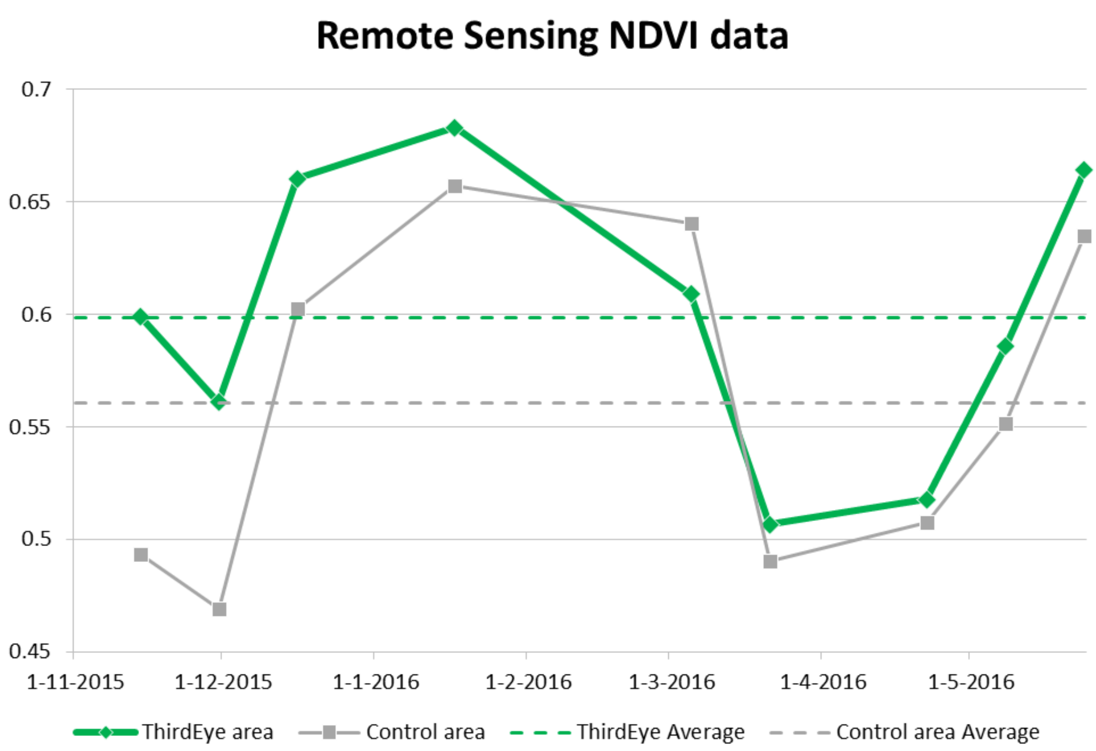


Figure 7. Difference in NDVI between the ThirdEye area and control area.