FAO SOMALIA – SWALIM

PROSCAL UN Joint Programme

Technical report

Update of analysis of very high-resolution satellite images to generate information on the charcoal production and its dynamics in South Somalia from 2011 to 2019.

22 January 2020

The following report provides an update to the "Analysis of very high-resolution satellite images to generate information on the charcoal production and its dynamics in South Somalia from 2011 to 2017" report. It includes information about charcoal production sites, stockpile trends and quantity estimates obtained analyzing an extended PROSCAL study area (42,000 km^2 approx.) and including 2018 and 2019 data.

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SWEDEN

The VHR satellite imagery was provided by the U.S. Department of State (USDS) Humanitarian Information Unit through Digital Globe EVWH portal, under the NextView License. This study could have not been possible without the considerable support given by the U.S. Department of State (USDS).

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1. Charcoal stockpile locations and trends.

Kismayo has three active stockpile locations on the outskirt of the city (Figure 1). The two main stockpile areas are in Saamogia on the road to Afmadow (North) and in Dalcadda near the road to the airport (South-West of Kismayo), while a smaller site is located about 1km West of Saamogia site.

Figure 1 – Locations of charcoal stockpiles in Kismayo - © [2019] DigitalGlobe, NextView License.

Buur Gaabo has one active stockpile locations on the northern edge of the town (Figure 2).

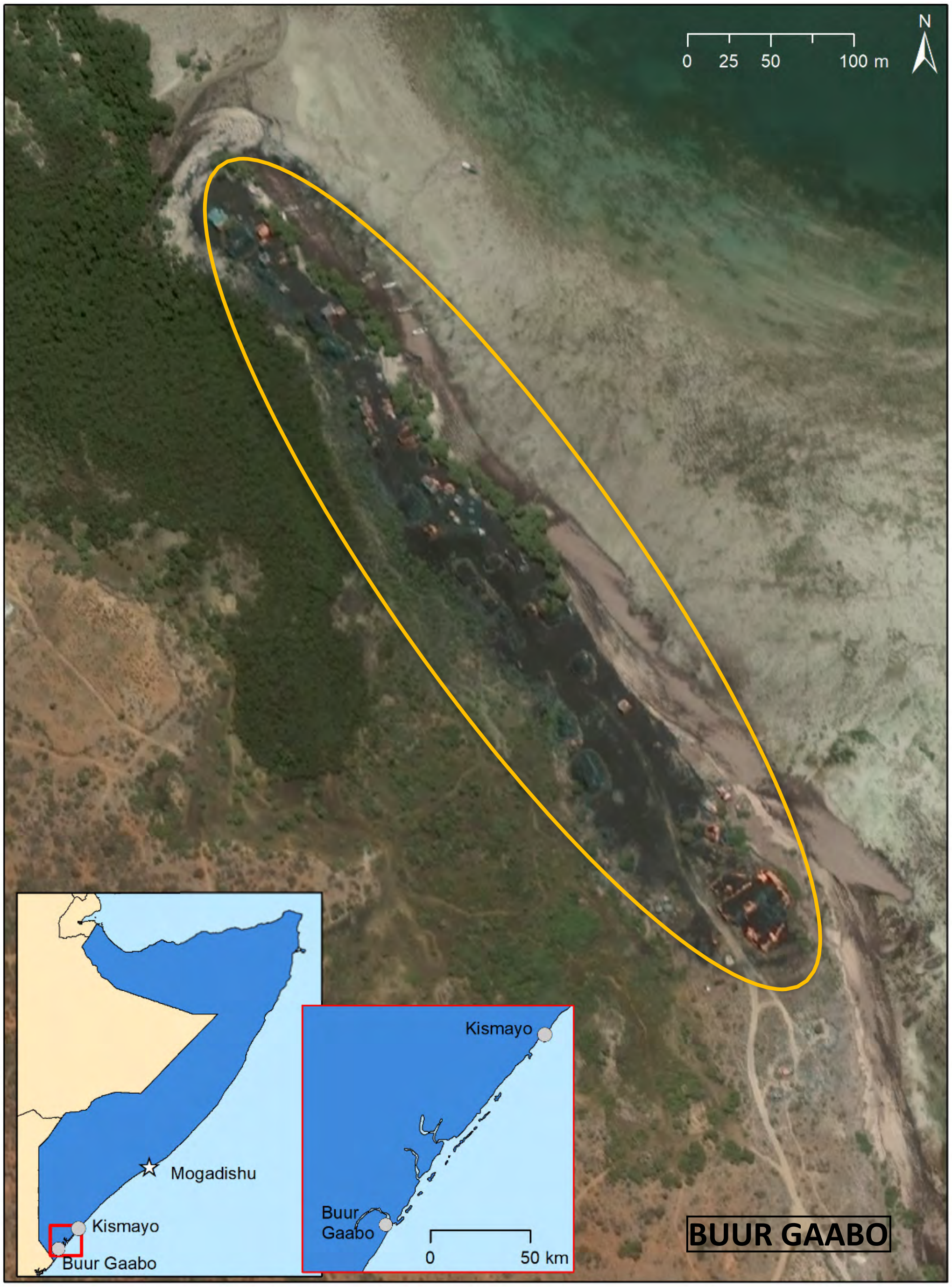

Figure 2 – Location of charcoal stockpiles in Buur Gaabo - © [2019] DigitalGlobe, NextView License.

Visual interpretation of VHR satellite, with the support of aerial and ground photos, produced information about charcoal stockpiles. Likewise, the interpreters performed stockpile fluctuation assessment by comparing visible differences in stockpile spatial distribution and appearance. The comparison of each image to the images of the previous and following available dates helped detecting changes of piles spatial distribution and appearance.

Table 1 shows the trend analysis of the three main stockpile locations, indicating date of satellite images used for the interpretation and volume variation (increase, decrease, no change) compared the previous available date.

Table 1 – Stockpiles fluctuation analysis

Buur Gaabo	
Image Date	
27/04/2017	-
01/07/2017	↓
09/07/2017	=
23/12/2017	↑
28/03/2018	↓
10/04/2018	↑
04/06/2018	↓
31/10/2018	↓
16/11/2018	=
04/01/2019	=
21/03/2019	=
29/03/2019	=
20/04/2019	=
19/09/2019	=
07/10/2019	=
20/10/2019	=
04/11/2019	=
28/11/2019	=
11/12/2019	=
19/12/2019	=
06/01/2020	=

Kismayo	Saamogia	Dalcadda
Image date		
24/06/2017	-	-
30/10/2017	↑	↑
01/11/2017	=	=
05/11/2017		=
20/11/2017	↓	=
06/12/2017	↓	
30/12/2017	↑	↑
06/01/2018	=	=
27/01/2018	=	=
22/02/2018	↓	↓
25/02/2018	=	
11/03/2018	↓	↓
23/03/2018	↑	↑
07/04/2018	↑	=
24/08/2018	↓	↓
14/10/2018	↑	↑
12/01/2019	↑	
03/02/2019	=	↑
23/02/2019	=	=
13/03/2019	=	=
24/03/2019	=	=
18/04/2019	=	=
24/04/2019	=	=
27/06/2019	=	=
13/07/2019	=	=
17/08/2019		=
20/08/2019	=	
19/09/2019	=	=
07/10/2019	=	=
21/10/2019	=	=
08/11/2019	=	=
21/11/2019	=	=
04/12/2019	=	=
19/12/2019	=	=
06/01/2020	=	=

↓ stockpile decrease compared to the previous available date

↑ stockpile increase compared to the previous available date

= no change compared to the previous available date

Although temporal gaps between satellites image acquisitions, the analysis shows that fluctuations of charcoal stocks exist. This suggests that all three main stockpiles locations have been actively used for charcoal trade.

The smaller site west of Saamogia was built between August and October 2018 and up to January 2020 no significant changes have been detected.

Sharp decrease in stockpiles could be related to shipments of charcoal and, based on the findings, these are the period when they could have taken place:

Shipments from Buur Gaabo

- Between 27/04/2017 and 01/07/2017
- Between 23/12/2017 and 28/03/2018
- Between 10/04/2018 and 04/06/2018
- Between 04/06/2018 and 31/10/2018

No charcoal stock fluctuation is visible in Buur Gaabo since 31/10/2018, with the latest available image acquired on 06 January 2020.

Shipments from Kismayo

- Between 01/11/2017 and 20/11/2017
- Between 20/11/2017 and 06/12/2017
- Between 27/01/2018 and 22/02/2018
- Between 25/02/2018 and 11/03/2018
- Between 07/04/2018 and 24/08/2018

No sensitive stockpile fluctuation is visible in Kismayo since February 2019, with the latest available image acquired on 06 January 2020.

These findings have been confirmed by crosschecking with relevant agencies that have access to information regarding charcoal shipments (UNODC and PoES).

1.1. Estimation of charcoal stored at the stockpile sites.

A standard charcoal bag weight 27kg and quantity of stocked bags have been estimated with the following formula:

$$\frac{\textit{area covered by charcoal stockpiles } (m^2)}{\textit{dimension of the base of a charcoal bag } (0.4\ m^2)} \times \textit{average number of bags piled up (15 bags)}$$

The *area covered by charcoal stockpiles* has been estimated through visual interpretation of available satellite imagery. The *dimension of the base of a charcoal bag* has been set to 0.4 m^2 based on local experts' knowledge, reporting the charcoal bag dimension to be of 80 cm in length and 50 cm in width. The *average number of bags piled up* has been set to 15 following the analysis of photos taken at Buur Gaabo and Kismayo storing sites, and it is considered a conservative measure as stockpiles can be higher.

In the attempt to provide updated estimates of the amount of charcoal stored at the three main locations, the areas covered by charcoal stockpiles on the most recent VHR satellite image available was manually digitalized through visual interpretation, with the support of aerial and ground photos. For both Kismayo and Buur Gaabo, the latest available satellite acquisition were taken on 06 January 2020.

The analysis needs to take into account illumination condition and perspective distortion that inevitably affect the interpretation of the images. For this reason, the figures provided below are susceptible to error, but nonetheless, they can still give a good idea of the amount of charcoal stored.

Buur Gaabo:

The area covered by charcoal stockpiles is about 4,500 m^2 that, according to the formula presented above, translates in approx. 170,000 charcoal bags.

Kismayo:

- Saamogia / Afmadow rd: the area covered by charcoal stockpiles is about 2,500 m^2, which correspond to approx. 95,000 charcoal bags.
- Dalcadda: the area covered by charcoal stockpiles is about 3,500 m^2, which correspond to approx. 135,000 charcoal bags.
- Smaller site west of Saamogia: it is estimated that about 40,000 bags are stored here.

The total number of charcoal bags stored at visible stockpiles is approx. 440,000. This is a conservative figure as the assumptions it is derived from.

2. Analysis of charcoal production occurred in the area of interest of South Somalia over the period 2011-2019 covered by multi-temporal VHR images.

The FAO SWALIM remote sensing unit performed visual interpretation of multi-temporal very-high resolution satellite images made available through the DigitalGlobe's EnhancedView Web Hosting Service, NextView licensed.

The remote sensing unit identified and recorded all kilns traces observed over the period 2011 – 2019 on the satellite images acquired. As there is no homogeneous imagery coverage for each year, data has been aggregated into three periods: 2011-2013, 2014-2016 and 2017-2019.

Figures 3, 4, 5 show the distribution of identified charcoal sites and image coverage per period.

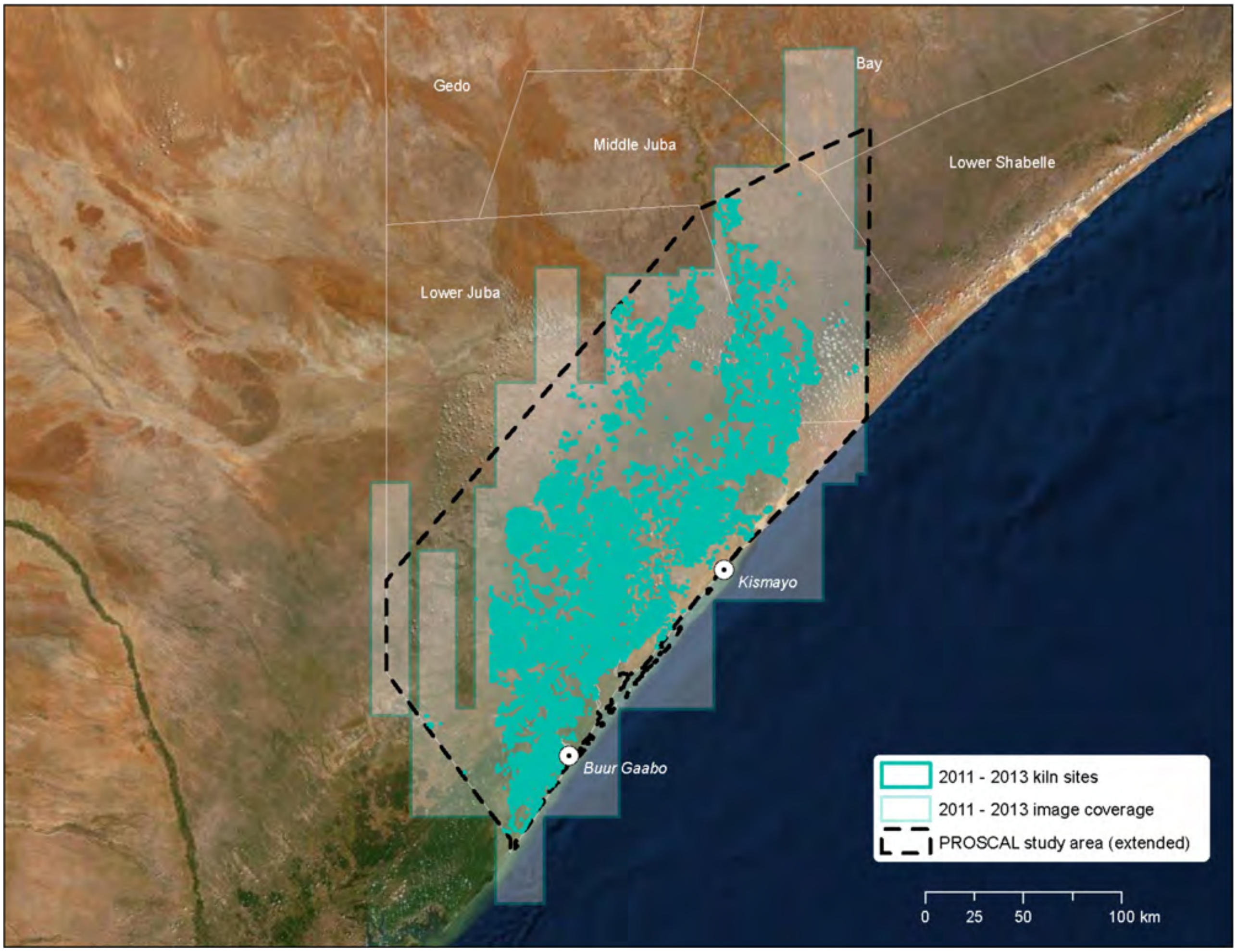

Figure 3 – Distribution of identified charcoal sites and image coverage for the period 2011-2013. Background image sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

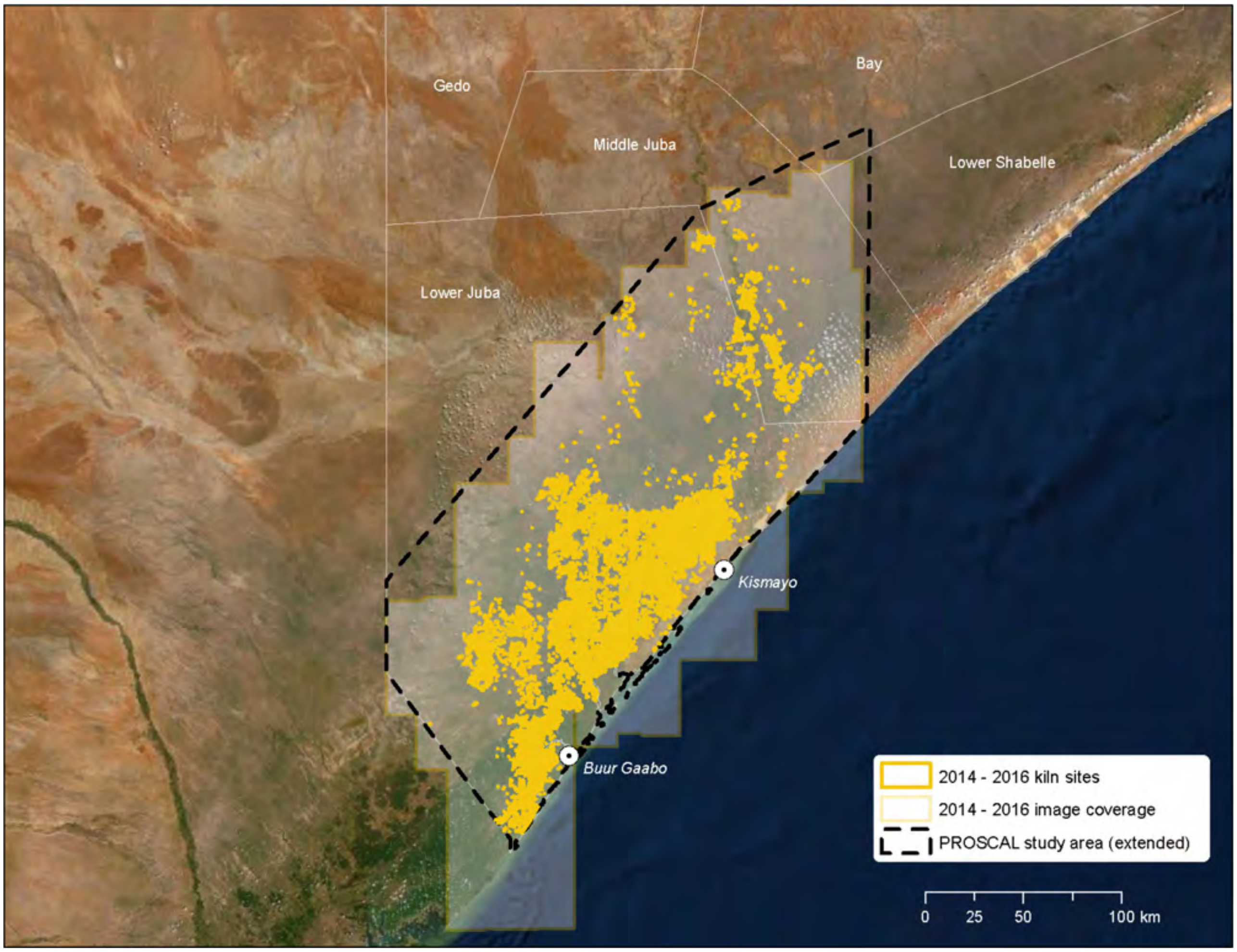

Figure 4 – Distribution of identified charcoal sites and image coverage for the period 2014-2016. Background image sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

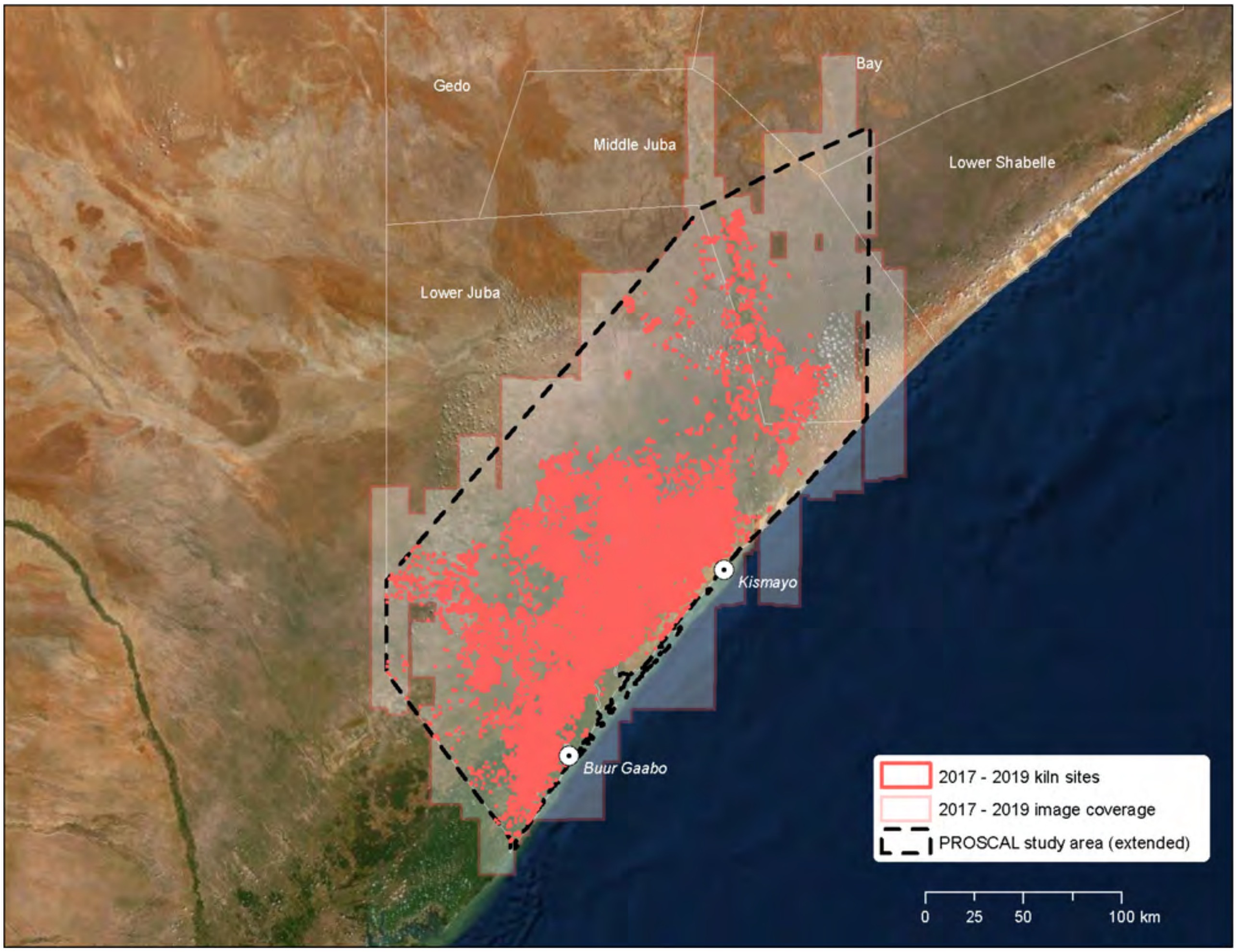

Figure 5 – Distribution of identified charcoal sites and image coverage for the period 2017-2019. Background image sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

The following table shows the analysis results based on the image coverage analyzed for the three periods (amounts are rounded to the nearest thousand):

Period	**Identified charcoal sites** (#)	**Charcoal production** (tons)	**Charcoal bags** (#)
2011 - 2013	124,000	247,000	9,149,000
2014 - 2016	61,000	123,000	4,561,000
2017 - 2019	110,000	188,000	6,953,000
Total	**295,000**	**558,000**	**20,663,000**

The charcoal production for the period 2011 – 2013 was of about 3,050,000 bags per year, while it dropped to 1,520,000 bags per year during the period 2014 – 2016. It then increased in 2017 – 2019 to an average of 2,318,000 bags of charcoal produced per year. This translates in an estimated overall production of over 20 million bags over the 9-year period.

Unavailability of images and excessive cloud cover were limiting factors that prevented full coverage of the study area with VHR imagery.

2.1 - Analysis of kiln size distribution

Trends of kiln sites distribution per radius size are similar over the 3 periods (Figure 6 and 7).
The percentage of 3 m radius sites is higher in 2014-2016 and 2017-2019 than in 2011-2013. Also, compared to previous periods, in 2017-2019 there is a general drop in percentage of larger size sites (radius ≥ 4 m) opposed to an increase in smaller sites (2 m). This could be due to the intensity of charcoal production that is causing a decline in larger trees and producers to move to smaller ones.

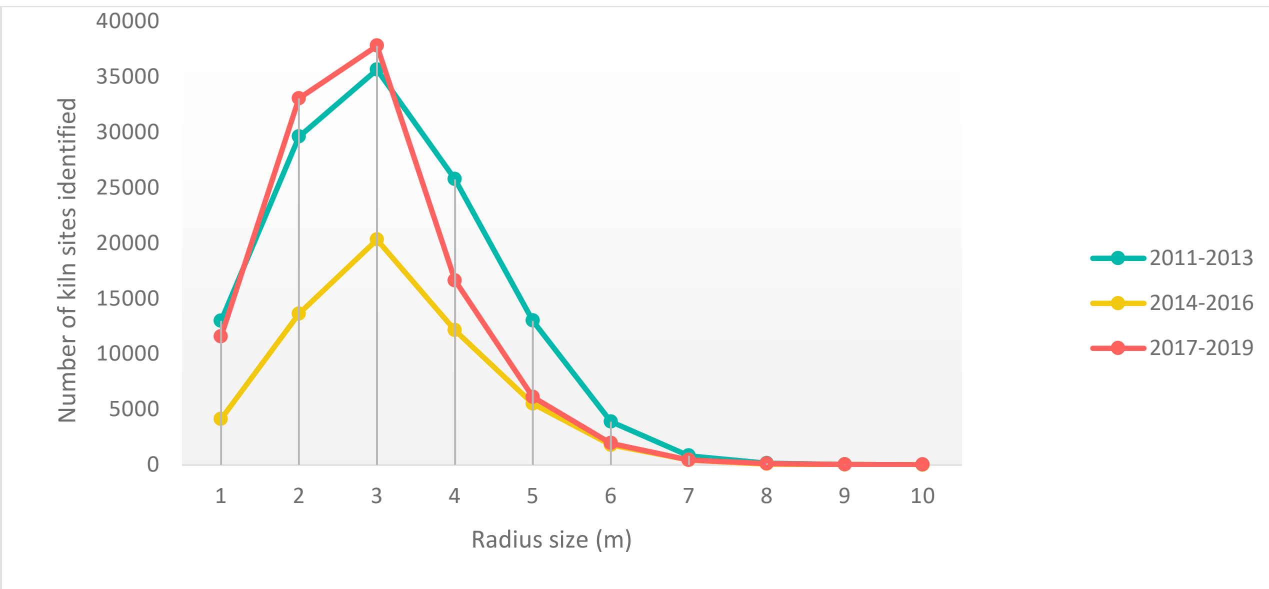

Figure 6 - Kiln sites distribution per radius size over the three periods.

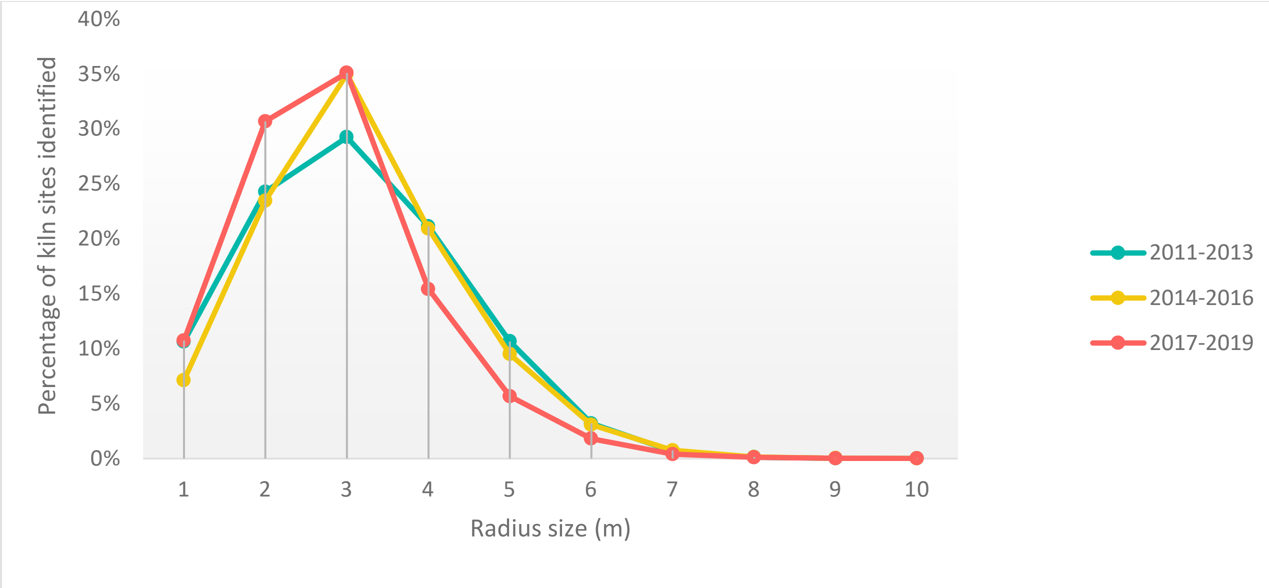

Figure 7 - Distribution in percentage of identified kiln sites, grouped by radius size.

2.2 - Analysis of production dynamics

The study area was divided in a grid of 1km x 1km squares and the number of kiln sites within each square was counted. On figures 8-9-10, darker red means higher density of sites per km^2 that translates in higher exploitation intensity. For example, in the period 2011 – 2013 the most affected areas are located north-northeast of Kismayo, around Jilib, and west of Buur Gaabo. During both 2014 – 2016 and 2017 – 2019 periods, the most affected areas are located in the proximity of Kismayo and Buur Gaabo.

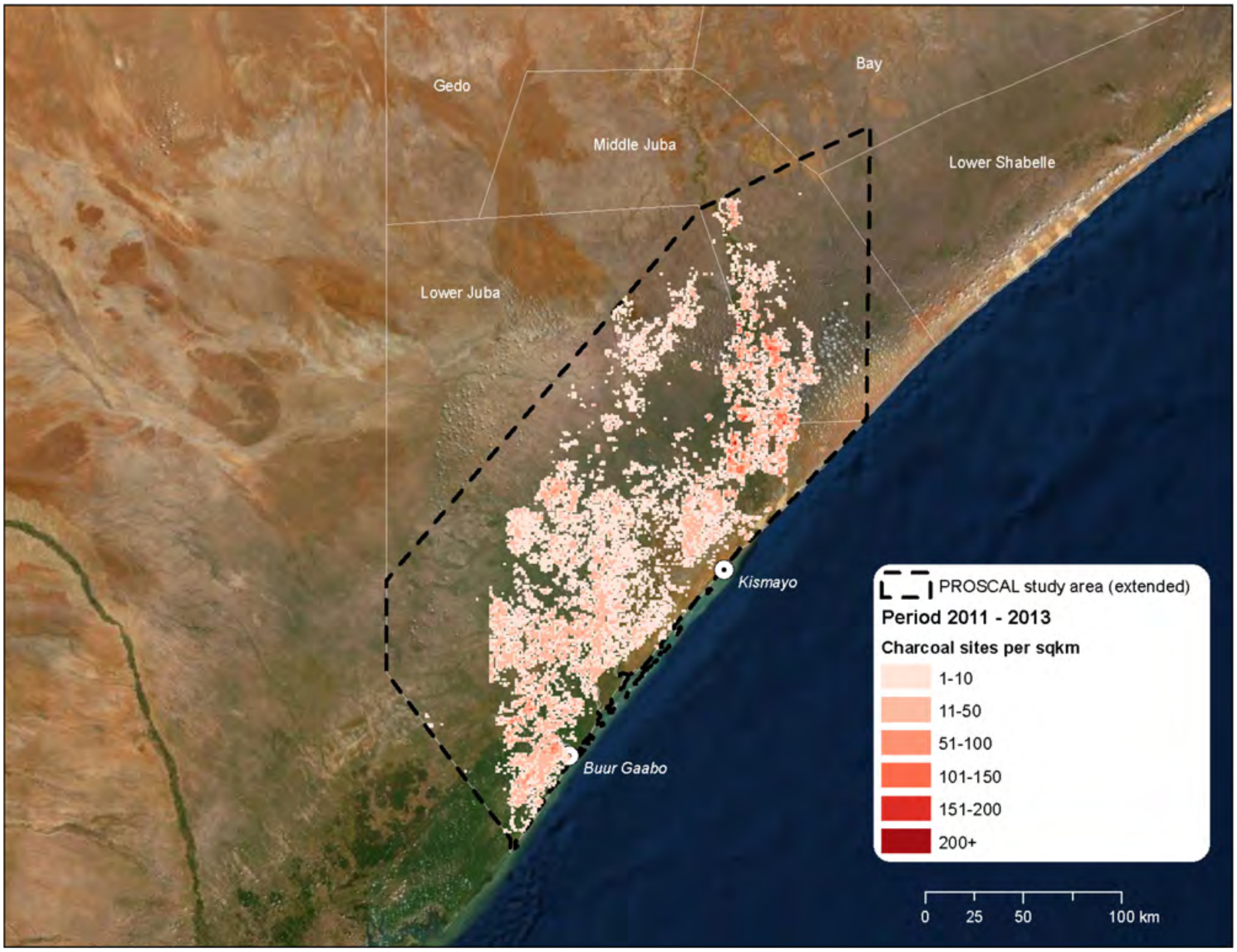

Figure 8 – Spatial distribution of charcoal production for the period 2011-2013. Charcoal sites are grouped by 1 km × 1 km grid cells. Background image sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

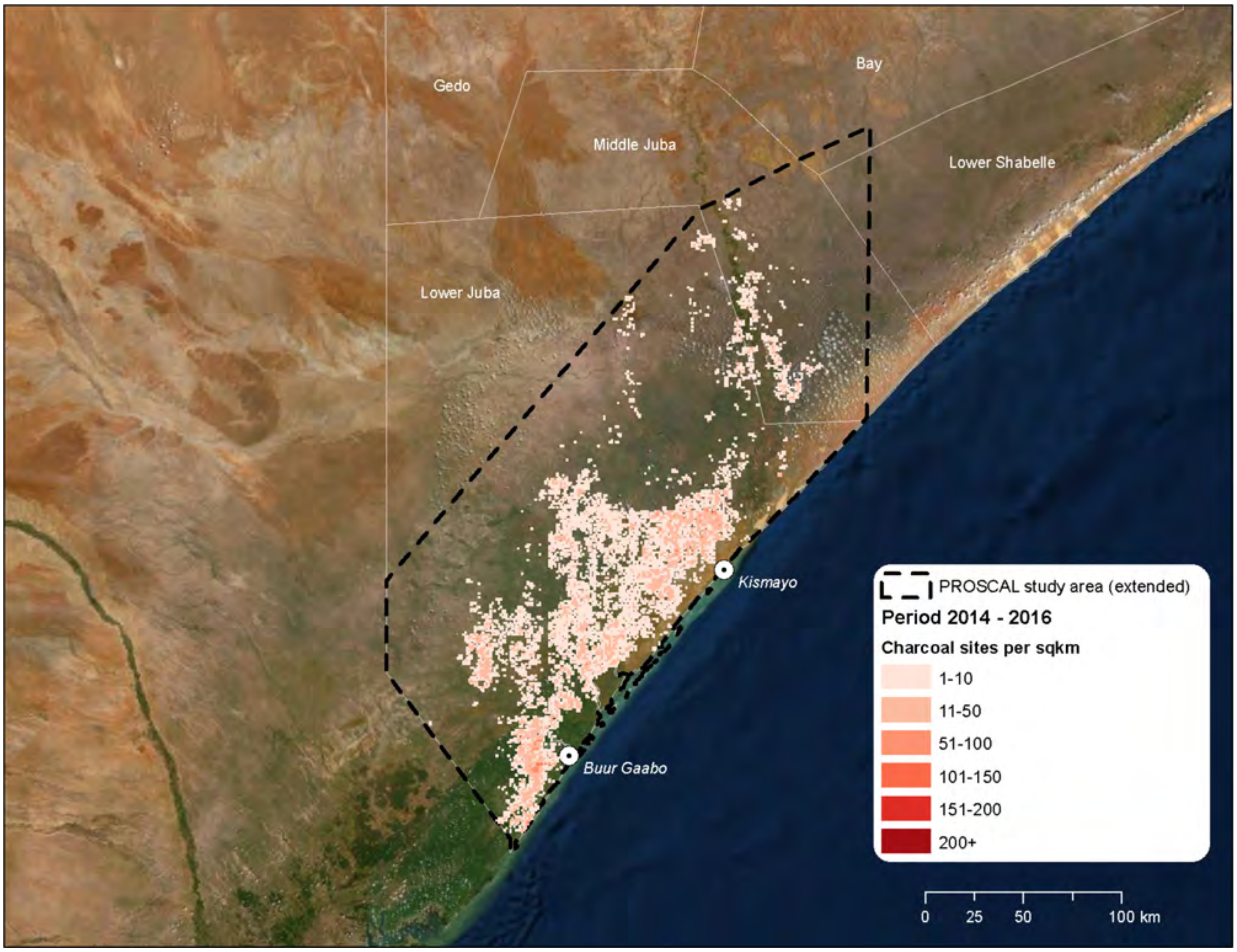

Figure 9 – Spatial distribution of charcoal production for the period 2014-2016. Charcoal sites are grouped by 1 km × 1 km grid cells. Background image sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

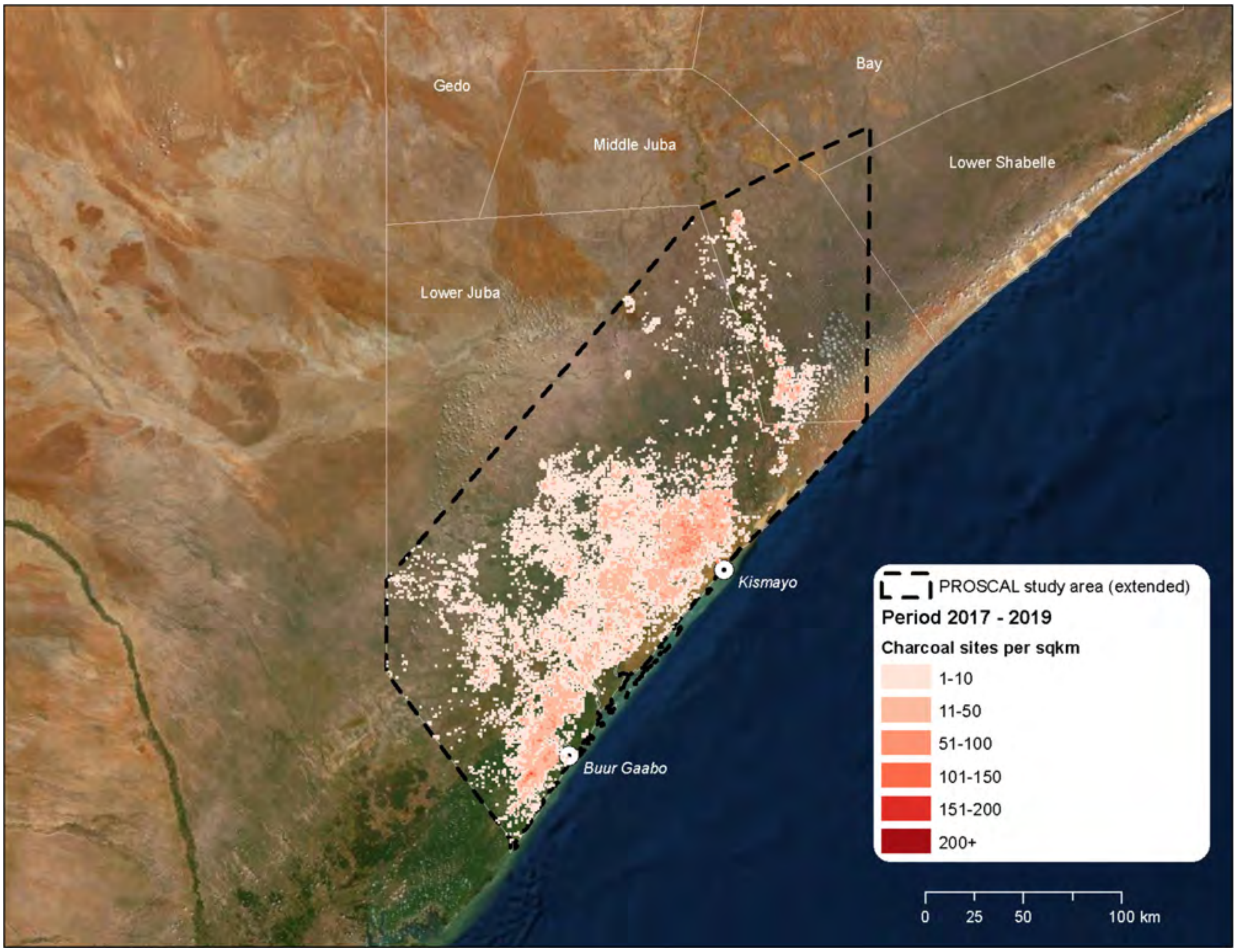

Figure 10 - Spatial distribution of charcoal production for the period 2014-2016. Charcoal sites are grouped by 1 km × 1 km grid cells. Background image sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

The analysis is affected by the availability of images and by the presence of clouds on available images, but nevertheless it gives a good understanding of the most affected areas and the shifting in locations of charcoal production. The comparison of the distribution of kilns from 2011-2013 to 2017-2019 shows an overall decreased of charcoal production in the area north-northeast of Kismayo (along the Juba river) and an intensification around the central and south portions of the study area.

Figures 11, 12 and 13 highlight changes in number of site based on a 1 km^2 grid, considering only the overlapping image coverage over the three periods.

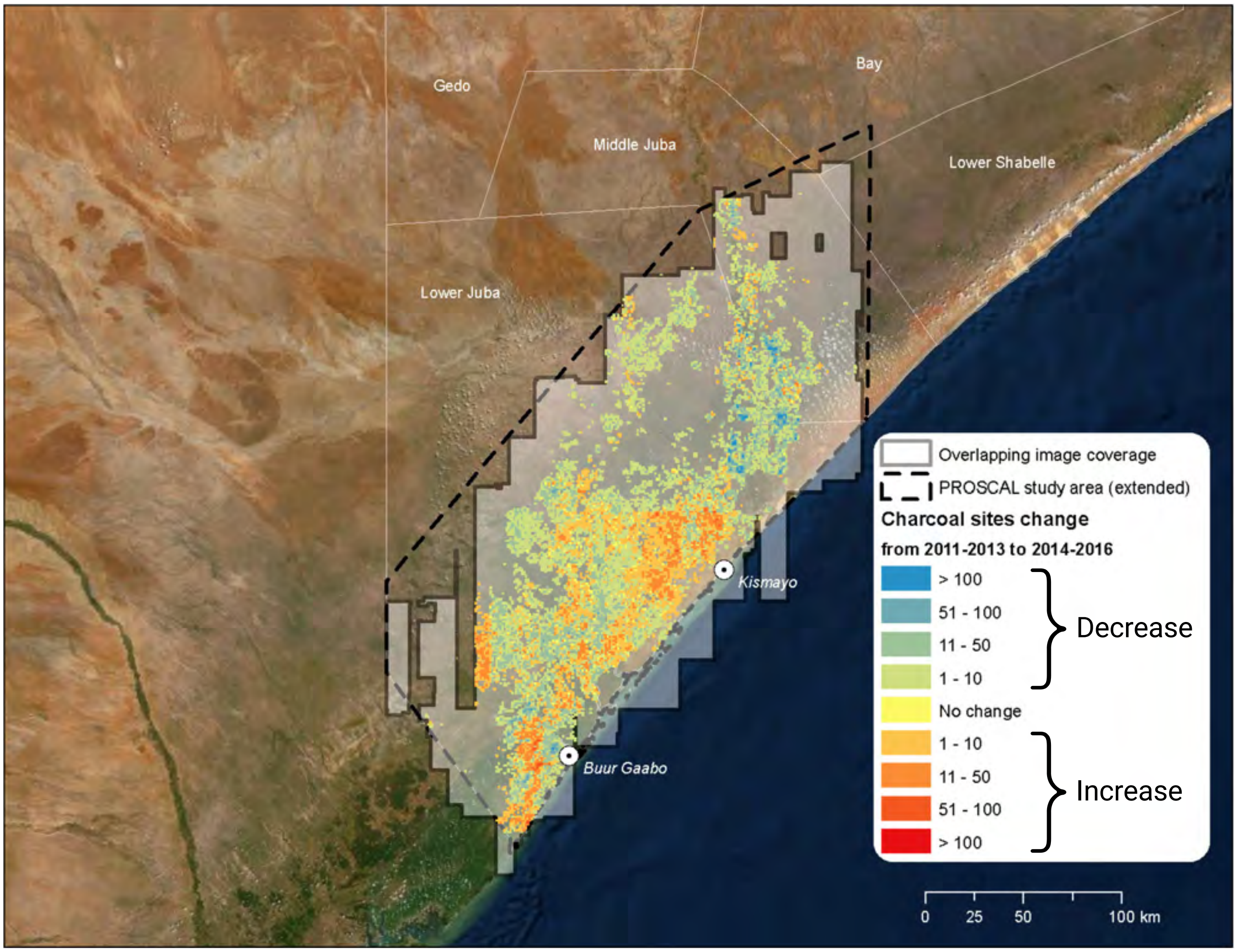

Figure 11 - Changes in number of sites between 2011-2013 and 2014-2016 based on a 1 km² grid. Background image sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

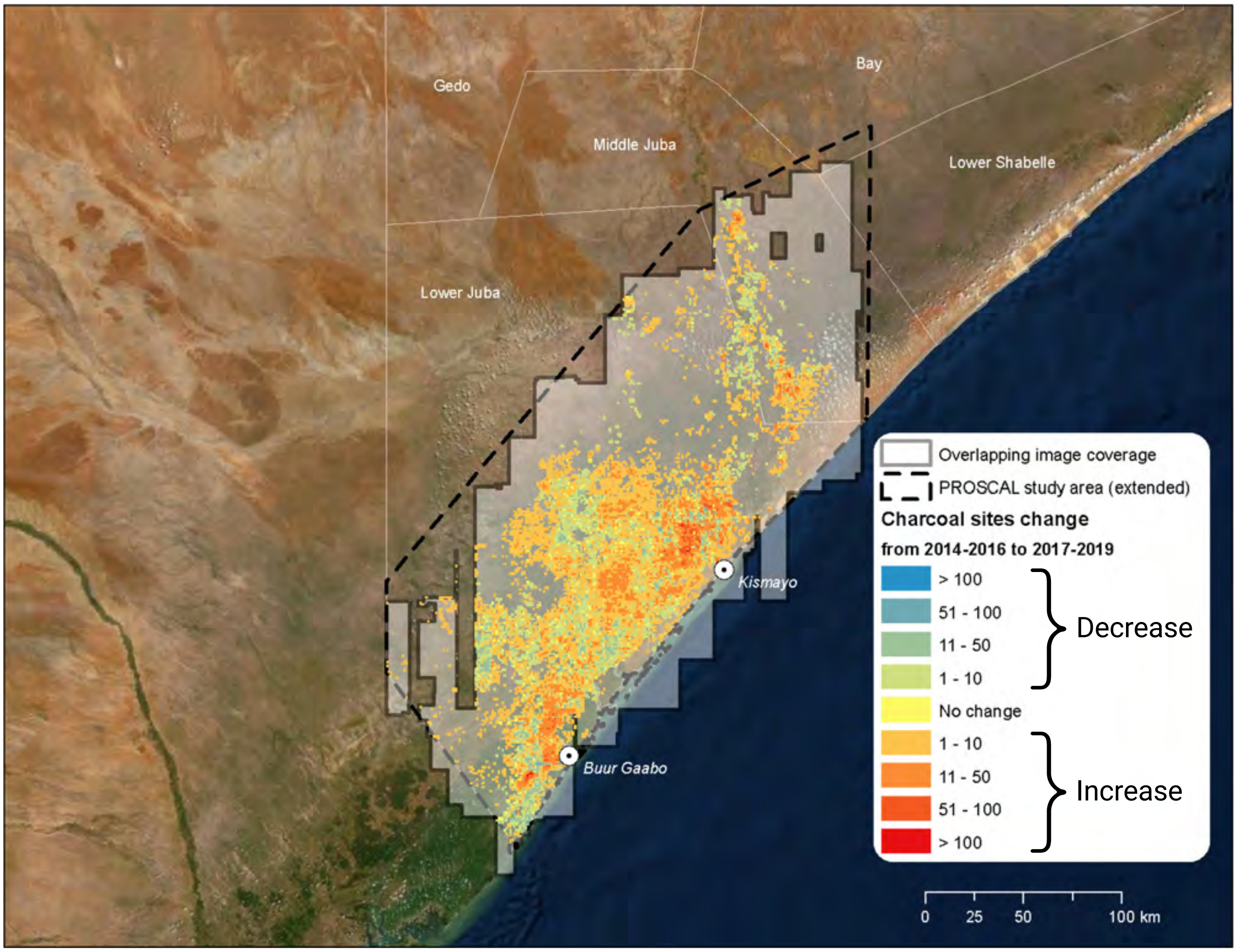

Figure 12 - Changes in number of sites between 2014-2016 and 2017-2019 based on a 1 km² grid. Background image sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

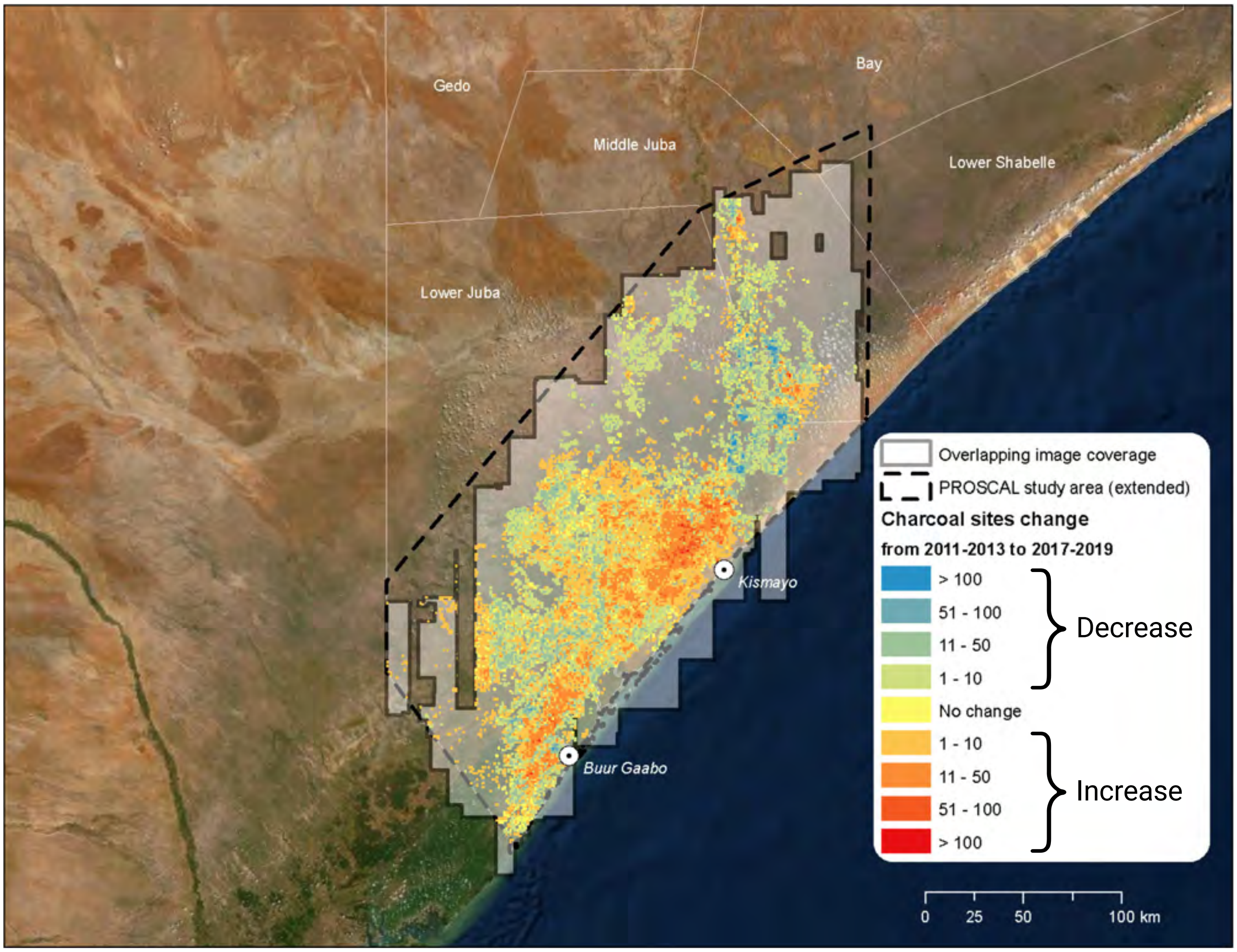

Figure 13 - Changes in number of sites between 2011-2013 and 2017-2019 based on a 1 km^2 grid. Background image sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

Comparison of satellite images and information collected from the ground between October 2018 and January 2020 shows that known stockpiles have not changed substantially in the last two years, suggesting that large-scale exports have not occurred. Nevertheless, charcoal is still consumed domestically, and this consumption would account for small variations in stockpile size. The fact that charcoal production for the period that includes 2019 is still high, while the stockpiles seem to remain unchanged, is in line with the increased supply of charcoal to the local markets that resulted in price dropping as reported by local sources and confirmed by PoES. At the same time, the price of charcoal is increasing in the Gulf States due to reduced imports from Somalia as reported by PoES.