Mapping charcoal driven forest degradation during the main period of Al Shabaab control in Southern Somalia

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Felix Rembold
European Commission

Hussein Gadain
Food and Agriculture Organization of the United Nations

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F. Rembold [a,*], S.M. Oduori [b], H. Gadain [b], P. Toselli [c]

[a] Joint Research Centre of the European Commission, MARS Unit, Via Fermi 2749, TP. 266, 21027 Ispra (VA), Italy
[b] Food and Agriculture Organization of the United Nations, Somalia Water and Land Information Management (FAO-SWALIM) Project, P. O. Box 30470-00100, Nairobi, Kenya
[c] Delegation of the European Union to the Republic of Kenya, EU Mission to Somalia, P. O. Box 45119-00100, Nairobi, Kenya

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ABSTRACT

Following more than 20 years of civil unrest, environmental information for Southern Somalia is scarce while there is clear evidence that the war economy fuelled by the conflict is rapidly depleting the country's natural resources and especially the woody biomass. Wood charcoal production is one of the most relevant businesses supporting war regimes such as the extreme Islamist group Al Shabaab, which has ruled in Southern Somalia from 2006 to 2012 and is still occupying large areas. In this study we map and quantify the tree loss suffered by the region due to the rapid increase in illegal charcoal production and export over recent years. Very high resolution (VHR) satellite imagery is used to visually count charcoal production sites as a proxy of tree loss in two sample areas within the lower Juba region of Southern Somalia. The image interpretation allows mapping the charcoal production sites as well as estimating tree loss rates above 7% over 5 years. The results are crucial for understanding the exact dimension and effects of the loss of woody biomass and for planning conservation and recovery interventions in the concerned area.

Introduction

Wood charcoal is the main cooking fuel across rural sub-Saharan Africa and to a large extent in urban centres. More than 90% of urban households in sub-Saharan Africa use charcoal as their main source of cooking energy (Zulu and Richardson, 2013), and the demand is likely to increase for several decades with growing urbanisation (Arnold et al., 2006). Charcoal production is an important source of income or coping strategy for subsistence farmers and pastoralists (Ghilardi et al., 2013) and the scarcity of alternative jobs makes the business attractive mainly for large portions of the young and unemployed male population (Kirkland, 2011).

In Somalia, charcoal is the major fuel for domestic cooking in urban areas including the capital Mogadishu and the country's charcoal need is met by domestic production. Before the civil war, industrial uses of charcoal were relatively minor and exports prohibited by law, while production areas were licenced by the former National Range Agency (Robinson, 1988). Since the beginning of the civil conflict in the early 1990s, charcoal production has been increasing dramatically and despite several export bans launched by regional governments, export to the Arabic Gulf countries has seen a rapid and steady increase (UNEP, 2005). Exact numbers on production, export and deforestation rates are generally scarce. An earlier study by FAO estimated that Somalia consumed an estimated 80,000 tonnes of charcoal in 1983, with Mogadishu accounting for over half of this with 42,000 tonnes recorded entering the city that year (Robinson, 1988). The main tree species exploited are *Acacia bussei* and *Acacia senegal* and annual deforestation rates of ca. 3% were found in semi-arid areas of North Eastern Somalia by using Very High Resolution (VHR) satellite imagery (Oduori et al., 2011). But in the Southern and Central parts of the country, where access has been extremely limited over the last 20 years and practically impossible from 2008 under the control of the Al Qaida linked Islamist group called Al Shabaab, no recent data can be found.

In July 2011 the charcoal business in Southern Somalia was suddenly brought to the attention of the media by a report of the United Nations Monitoring Group for Somalia and Eritrea (SEMG) (UN, 2011). The document affirmed that: “charcoal is the single most important source of income for Al Shabaab” and estimated the tax entries from charcoal trade to 25 million USD for the year 2011. In February 2012 the UN Security Council passed resolution 2036 (UN, 2012a) which issued a ban on charcoal exported by Somalia. Again in July of the same year, the SEMG provided more detailed evidence of a sharp increase of illegal charcoal exports in 2011 to the United Arab Emirates (UAE) and to the Kingdom of Saudi Arabia (KSA), due mainly to higher demand in these countries and to the practise of humanitarian aid transport vessels to transport charcoal on their return from Somalia (UN, 2012b). Before 2011, charcoal export to the Gulf countries had already increased in 2000 following a ban on livestock exports from Somalia, which pushed pastoralists towards charcoal production to compensate the lost income (Holleman, 2002).

* Corresponding author. Tel.: +39 0332 786337, fax: +39 0332 789029.
E-mail address: felix.rembold@jrc.ec.europa.eu (F. Rembold).

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In August 2011 Al Shabaab was forced out of the capital Mogadishu by the Somali National Defence Forces (SNDF) with the support of the African Union Mission in Somalia (AMISOM) but the group continued to hold vast parts of South and Central Somalia, including the important port of Kismaayo, from where most of the international charcoal export was operated. In 2011 it was estimated that 80–90% of the illegal charcoal exports were leaving Somalia through the port of Kismaayo (Kirkland, 2011). When the international forces under AMISON control entered the port of Kismaayo in October 2012, they found the port surrounded by an impressive wall of piled up charcoal bags ready for shipment. Early estimates talked about 4 million bags, at a total value of approximately 40 million US Dollars (McConnell, 2012).

Despite the very large media coverage of the finding and of the negotiations on its final use, no information was available on the source areas of the charcoal, nor on the extent and impact of the resulting forest degradation. The need for clear evidence on the origin of the Kismaayo charcoal and in general for detailed information on charcoal driven deforestation reached a peak in late 2012, but continues to remain high, following information that the business continues at a similar intensity as before October 2012 (United Nations Security Council, 2013).

The objective of the work presented here is first of all to localize major charcoal production zones under the main period of the Al Shabaab regime (2006–2012) and then to analyse the degree of forest degradation for hotspots within the main area identified. Since most of the rural areas in Southern Somalia are still occupied by Al Shabaab militias, field surveys were impossible to undertake. The study hence opted for the use of Somali expert interviews for the first zonation and for Google Earth and additional VHR imagery for the forest degradation analysis.

Methodology

This study generally follows a similar approach as used by Oduori et al. (2011), which allowed the detection of tree cutting rates in Northern Somalia over a 10 year period by using VHR satellite images.

Somali experts from the region were interviewed and asked to draw on a topographic map the location of recent charcoal production areas in their region. Since the region cannot be visited at the moment, only experts working in Nairobi could be interviewed. Out of a total of 10 experts coming from Lower Juba, 5 are working with international and national NGO's and 4 with FAO Somalia (in Nairobi), while one charcoal trader was interviewed by phone. All of the interviewees confirmed that taking pictures or GPS locations of charcoal production on the ground is currently impossible and would expose them to personal risk. Based on the interviews, a polygon was drawn with the main charcoal producing area exploited by the Al Shabaab regime (red polygon in Fig. 1). In order to better define the spatial extent of the charcoal exploitation areas broadly defined in the interviews and to restrict it to areas with high tree density, a woody biomass map for Somalia produced by the WISDOM (Woodfuel Integrated Supply/Demand Overview Mapping) project (Drigo, 2005) was used as background layer. Thanks to the interviews and the WISDOM map it was possible to reduce the study area progressively from the whole of Southern and Central

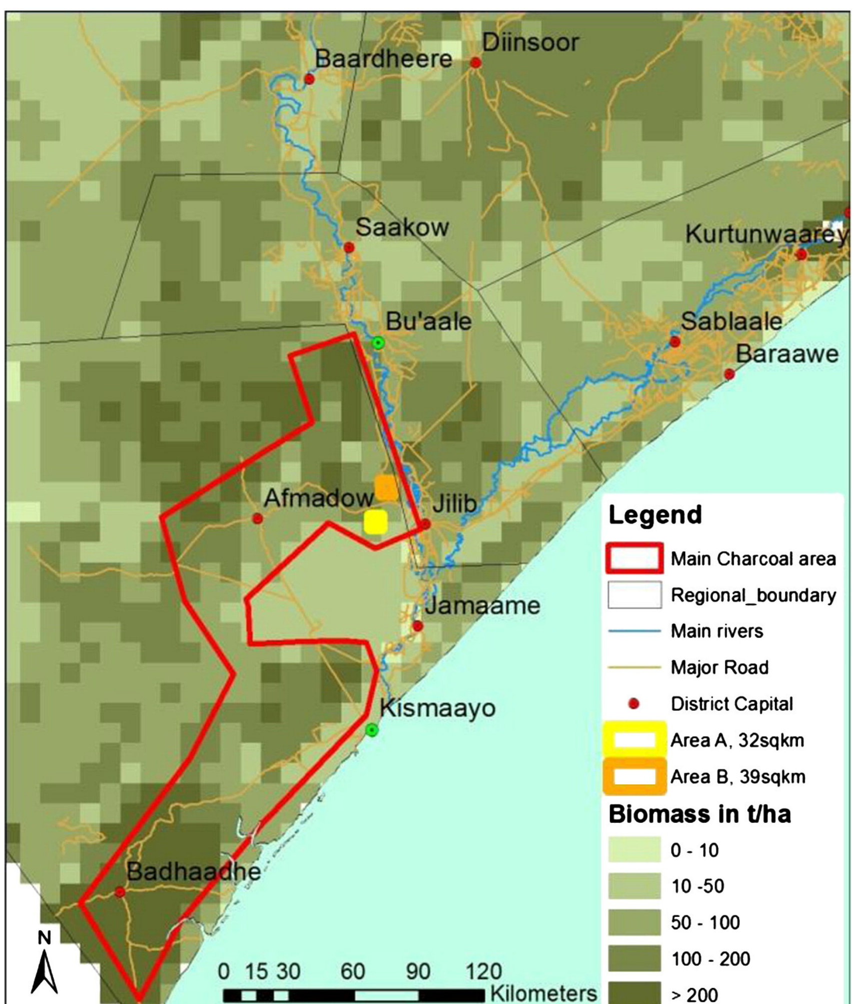

Fig. 1. Map of main charcoal production area in the period 2006–2012 based on expert interviews and woody biomass availability.

Somalia, an area of more than 200,000 km^2, to only woody areas in Lower and Middle Juba, an area of less than 20,000 km^2.

The interviews made it clear that the area with the most rapid and devastating charcoal driven forest degradation during the Al Shabaab period corresponded to a large triangle included between the towns of Jilib, Afmadow and Bu'ale in the Middle and Lower Juba regions. According to the interviewees Al Shabaab supported the construction of new exploitation roads and temporary settlements for charcoal producing teams transferred to the region from the traditional charcoal producing areas in the coastal zones and protected by armed groups. A large belt along the coast of Lower Juba from Badhade to Jamame is also a traditional high intensity charcoal producing area, but has seen a less dramatic increase during the period investigated. Charcoal production intensity is expected to be lower in the northern parts of Lower and Middle Juba due to the higher distance from Kismaayo port.

Following the broad delineation of the main charcoal producing area based on interviews and the woody biomass map, a preliminary analysis was carried out in Google Earth to detect charcoal production activities and tree cover changes within this area. During this work it became clear that charcoal production sites can be identified in a reliable way because of their dark colour, their round shape and typical size of ca. 10–12 m, as found also by Oduori et al. (2011).

Google Earth images allowed the identification of an area of 32 km^2 (area A in Fig. 1), located about 25 km West of Jilib, with a large number of charcoal production sites in 2012 which were not visible on previous satellite coverage in 2002. In 2002 the area was covered by primary forest, while the 2012 image shows a high level of forest degradation (similar to those found later on the VHR images of Fig. 2). Unfortunately in Google Earth only a fraction of the total area is covered by imagery more recent than 2006, while on the other side, the areas with recent images did not have a coverage around the year 2006, making it difficult to detect whether the observed charcoal production activities correspond temporally to the Al Shabaab period. It was therefore decided to acquire more VHR imagery, focussing on data available from 2006 onwards.

For area A, covered by Google Earth images of 2012 and 2002 and located 25 km West of Jilib, VHR satellite images were available for 3 dates: in 2006 (Quickbird), 2011 (WorldView1) and 2012 (Quickbird). A neighbouring area of 39 km^2 (area B in Fig. 1) located ca. 10 km to the North East of this area and with similar dynamics of tree cover change according to the Google Earth analysis, was also covered by the same images in 2011 and 2012. All images were captured during the dry season of February to March, allowing minimum cloud coverage. The Quickbird images were pansharpened (0.65 m resolution), while the WorldView1 image is a panchromatic image with a resolution of 0.5 m.

As compared to the areas investigated in the North Eastern Somalia study (Oduori et al., 2011), where single trees were counted for sampling areas and for different dates, tree coverage in Southern Somalia is generally much denser and the discrimination of single tree crowns in the canopy is difficult. For this reason it was decided to estimate tree losses as a function of the number of charcoal production sites and by knowing the approximate average number of trees burnt by site.

Based on interviews and data from UNEP's report on the state of the Environment in Somalia (UNEP, 2005) it is assumed that 2 bags of charcoal are produced from a single average Acacia tree and that each production site produces an average of 40 bags of charcoal (capacity is 27 kg for each bag). Large trees can clearly produce more than 2 bags of charcoal, but there are sources confirming that the number of large Acacia trees found in Somalia is rapidly decreasing and that 1–2 charcoal bags per tree is a reasonable assumption (AFP, 2012). Therefore we decided to work with the 2 bags per tree hypothesis (equal to 20 trees per production site).

Results

The number of production sites was counted on the satellite images and all sites were mapped for the 3 dates available in area A (2006, 2011 and 2012) and for the 2 dates available for area B (2011 and 2012). As can be seen in the subset in Fig. 2, there was not a single production site visible in area A in 2006 but only minimal traces of human activity such as a small road. In 2011 in the same area 215 production sites were counted (Table 1) and only one year later in 2012, 291 sites were identified. It is also interesting to observe that a number of sites visible in 2011 were already covered by grass in 2012 and were no longer visible. Overall, summing up the 2011 and 2012 production sites, without

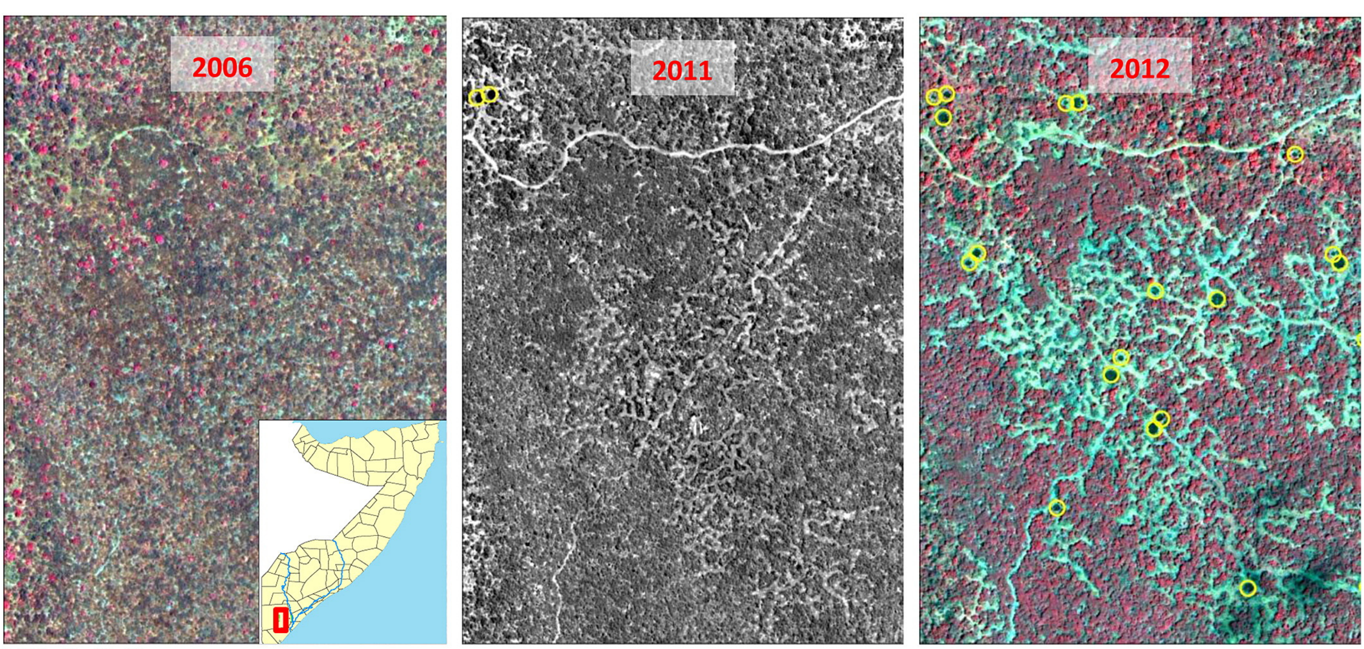

Fig. 2. Subset of area A in 2006 (left), 2011 (centre) and 2012 (right) showing the increase of charcoal production sites (yellow circles) and new roads for charcoal movement. The left and right images from Quickbird are false colour composites (bands 4, 3, 2), while the central image is a panchromatic WorldView1 image.

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Table 1
Charcoal production sites for area A and B in studied area.

	2006	2011	2012	Total no. of sites	Average n. of sites per km^2
Area A (32 km^2) n. of sites	0	215	291	311	10
Area B (39 km^2) n. of sites	Not available	209	471	533	14

double counting, a total of 311 sites were found, which means an average of 10 charcoal production sites for each square kilometre.

For area B very similar dynamics and an even higher density of production sites were observed. As for area A on the Google Earth images of 2002 not a single production site could be detected in the area. Therefore and because of the low distance from area A, it was assumed that tree cutting started between 2006 and 2010 as for area A. The total charcoal production sites mapped in 2011 and 2012 (without double counting) were 533, with an average density of 14 charcoal production sites per square kilometre. In Table 1, the total number of sites includes the sites that were only visible in 2011 and covered by vegetation in 2012. Both areas show a sharp increase in production sites from 2011 to 2012 (in area B they more then doubled), which corresponds to the charcoal export intensification observed also by the UN (UN, 2012b).

The number of charcoal production sites was then used for deriving estimates of the number of trees that were felled/cut for each date and finally to estimate the total tree loss over the observed time period. Based on the assumptions described in the methodology, the tree loss per square kilometre in the two observed areas ranges from 200 to 280. As already mentioned, the initial tree density in the observed areas is too high for an exact tree count in 2006, but still the fraction of canopy coverage can be used to estimate an approximate density. This was done for 10 sites of one hectare area on the 2006 image and the average density was estimated at around 3400 trees per square kilometre. With these numbers, the loss in the 5 year period from 2006 to 2012 would amount to 7.2% of the total trees as average over the observed 71 km^2 (area A + B).

By observing the location of charcoal production sites in Fig. 2 it is clear that the cuttings are not equally distributed over the total area but concentrated in clear patterns following old and new roads. This means that large areas in the observed windows are nearly bare, while some more marginal ones have not been touched yet. On the 2006 (left) image only one small road was visible and no charcoal production sites while in 2011 (centre) the road has expanded and a new one has appeared. The first signs of forest exploitation are also visible in the central portion of the 2011 image, but only 2 production sites (yellow circles) are visible. In the 2012 image (right) numerous roads have been built and many large charcoal production sites are clearly visible again confirming the acceleration of forest degradation in 2011.

In addition it should not be forgotten that the process of burning green trees to produce charcoal involves the use of significant amounts of (dry) grass and other biomass to start the fire (Robinson, 1988). In fact in both areas A and B some spots of herbaceous and shrubs vegetation have been cleared completely and we can assume that this is due to the cutting of grass for firing the charcoal kiln. This practise, also observed in Northern Somalia, contributes to the total loss of biomass in the charcoal production areas.

Conclusions and discussion

By using multidate VHR imagery and auxiliary information it was possible to broadly map the main areas of charcoal driven forest degradation during the main period of the Al Shabaab power between 2006 and 2012 and to estimate the tree loss for 2 sample areas in Southern Somalia. These results represent a substantial contribution to the limited quantitative and spatial knowledge about charcoal driven deforestation in Southern Somalia. First, the analysis gives a clear indication on the origin of the rapidly increasing amount of charcoal produced and exported in this period, shedding some light on the speculations following the discovery of the charcoal piles in the port of Kismaayo in late 2012. Both interviews of Somali experts and the preliminary analysis in Google Earth showed that most of the charcoal produced under Al Shabaab control came from Lower and Middle Juba and in particular from the forest areas west of the Juba River and at a close distance from the main roads to Kismaayo. Second, the counting of charcoal production sites on VHR imagery allows for the estimation of realistic tree loss rates over the observation period and for the understanding of deforestation patterns. The estimated loss rates of 7.2% over the 5 year period are worryingly high, considering also the collateral damage this exploitation has on primary forests, such as the building of new roads and the clearing of herbaceous and shrubs biomass for fuelling the production kilns. This kind of uncontrolled exploitation opens the road to additional small scale charcoal production and for more intensive pastoral use, favouring rapid land degradation in a semi-arid area with soils generally affected by low fertility (Omuto et al., 2009) Also, the preference of charcoal producers for large trees, which play a fundamental role in seed production and soil fertilization means that the speed of forest degradation increases exponentially. In this sense the study confirms warnings that if forest degradation and biomass depletion continue at the same rate, large areas in Southern Somalia can be transformed into a desert in 20 years' time (AFP, 2012).

Some observations can also be made on the location of the main exploitation areas. According to the expert interviews and some rapid checks in Google Earth, only very limited traces of charcoal production could be detected in the forest areas between Jilib and Bu'ale on the Eastern side of the Juba River. This could be linked to a stronger control by communities on that side of the river and to the additional transport problems of the charcoal to Kismaayo port. Little forest degradation could also be seen in very remote areas such as the tiger bush areas in Gedo and Bakool close to the border with Ethiopia. Limited information is available for the forests North of Afmadow, for which the availability of VHR imagery is more limited. The longer distance from Kismaayo and other ports for charcoal shipping makes this area potentially less attractive for exploitation but without proper verification the main charcoal production area could in fact extend more to the North and East as compared to the polygon drawn in Fig. 1. The Bay region has lower woody biomass as compared to the study area in Lower Juba but is mentioned to be the main supplying area of Mogadishu (Robinson, 1988). Land cover degradation in Bay should therefore be monitored closely and more VHR samples should be acquired in larger areas of Lower and Middle Juba.

It also has to be mentioned here that the charcoal production activities are not likely to decrease significantly with the current political situation in Somalia (United Nations Security Council, 2013). There are still large amounts of charcoal transiting Kismaayo and illegal export is practised by small boats from smaller ports (McConnell, 2012). It is important to mention here that the northern part of the charcoal production area shown in Fig. 1 was largely still under Al Shabaab control by March 2013. The Southern part is mainly controlled by the Raskamboni brigades and charcoal production is an important livelihood source in this area too (Anzalone, 2013).

Previous research in Northern Somalia (Oduori et al., 2011) showed that deforestation can be slowed down only by a combination of strengthening policy implementation and control capacity in local administration, by supporting communities and introducing conservation measures. At the same time any strategy to reduce charcoal driven deforestation can only be successful if alternative sources of household income are made available to the population and additional sources of energy are introduced, at least in urban areas. Recent projects proposed by the EU in Puntland (EU, 2013) and by the UN for the whole of Somalia (UN, 2013) are going in this direction but are still at an early stage. The little effect of a large number of bans on charcoal production and export raised by regional and national governments in Somalia over the past

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decade shows the enormous challenges of reducing this lucrative and destructive business and to replace it with more sustainable alternatives.

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