

# Mapping Industrial Agriculture in Central Africa

## Democratic Republic of Congo case study

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Figure 1: Distribution of Industrial Agriculture, 2009 (WHRC) and Agriculture (GLC2000) in the forested lands of DRC.

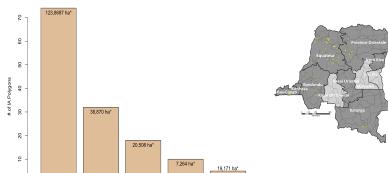
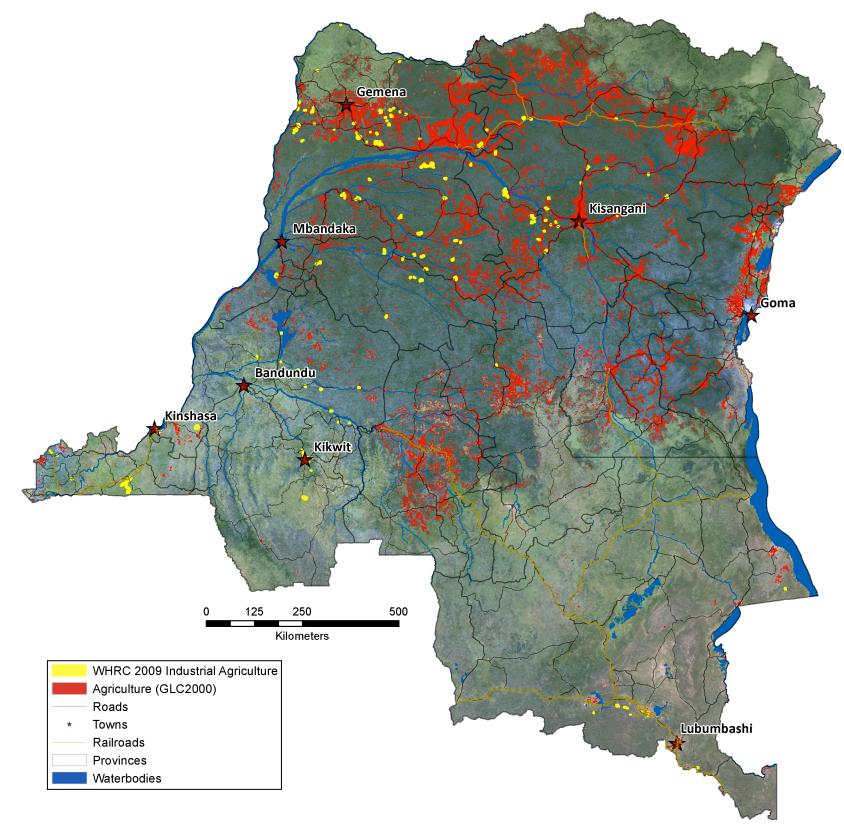


Figure 3: Distribution and Area of Industrial Agriculture (IA) polygons by province. \*Denotes Total Area of IA per province

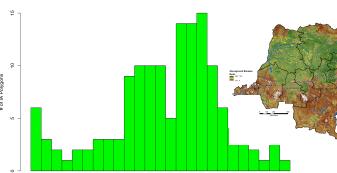


Figure 4: Distribution of Mean Biomass per polygon. Note the multi-modal distribution.

### DISCUSSION/CONCLUSIONS

We compared statistics generated from the Google Earth database with Hansen et al.(2008) 1990-2000 land cover change analysis, the Global Land Cover 2000, and data published by the DRC Ministry of Agriculture.

#### GLC2000

The total land area of all observed IA polygons was 215,913 hectares. Of the total in large-scale industrial agriculture (IA) mapped by this study, a very small percentage (0.75% or 125,281 hectares) of the total is under cultivation, as we approximated according to the 2000 Global Land Cover dataset. This suggests that traditional agriculture (for subsistence and cash crops) accounts for 124,967 (99.25%) of the total area we estimated to be in agriculture (GLC2000) or 7.45% (17,265,900 ha) of the total land area (215,913 ha). However, when compared to our agriculture designation developed from GLC2000, 90,332 ha, were accounted for in other land cover types. This may indicate GLC2000 classification errors, Google Earth georeferencing errors, or differences in the average size of polygon compared to that of a GLC2000 pixel size (1km).

#### Hansen, 2008

When comparing Hansen's (2008) likelihood of forest cover map to our dataset we found that the mean and median forest likelihood of the IA plots was only 22.2% and 19.0%, respectively. This low likelihood of forest cover indicates that most of the IA were already in permanent agriculture during the 1990-2000 period. Furthermore, we can confirm this by checking the rate of deforestation provided by Hansen for the 1990-2000 period, where less than <1% of forest indicated deforestation. Only 0.3% of the total clearing mapped by Hansen from this period occurred within the mapped IA areas of the DRC. This suggests that IA areas were created before the 1990s, as confirmed in reports published by the Ministry of Agriculture.

#### Official Statistics

The main food crops are cassava, maize, rice, and plantains; followed by bananas, beans, and peanuts. Most millets, starches, and fruits are grown locally. Most small farm cultivation is done by women, while more men work in industrial agriculture. Historically, coffee and palm oil have been the major export crops, while the forestry sector contributes only to 0.8% to GDP (Kamu and Mukongo, 2000).

Official national statistics confirm that most of the IA land was converted before 1990, and as we concluded here, the largest areas of forests conversion to IA were in the provinces of Equateur, Province Orientale, and Bandundu (Figure 3).

It was often visually difficult to classify crops in most IA plots, with the exception of oil palm plantations. The official statistics for DRC estimate the total area of palm oil plantations to be 115,524 hectares in Equateur Province, compared to our estimate of 33,122 ha in 2000. This could indicate that 1) many of the plantations have been abandoned (this is reflected in national statistics); 2) that many plantations in the DRC are from small-holders/growers and were not mapped due to their low area extent. In Asia, for example, IA's are categorized for palm oil plantations larger than 500 ha, while independent small-holders have a total area of approximately 40 ha, and small-growers area as 40 and 500ha. In the DRC, we found that the average size of IA mapped was 1,524 ha, with only 1 plot less than 40 ha size and 41 plots between 40 and 500ha; or 3) We underestimated the the extent of industrial agriculture.



### INTRODUCTION

Increasing national, regional and international, often competing, demands for food, fiber, and biofuels driven by growing and increasingly urbanized populations, is likely to put considerable strain on the forests and arable lands of central Africa. In the Democratic Republic of Congo (DRC) the 2009 national GDP in terms was \$21.93 billion (around \$300 per capita). Agriculture currently constitutes around 55% of GDP (CIA, 2010). However this country is in food deficit having to import a large proportion of staple food commodities, and around 55% of household expenditure is on food (WFP, 2008). National reliance on imported foods also contributes to economic vulnerability to international price shocks; in 2009 inflation was around 30% (WB, 2009) with the consumer price index (CPI) running at a 50% year on year increase (WB, 2009). This was mainly driven by the high cost of food (76% of CPI) and thus can be a powerful incentive to trigger land clearance as farmers respond to higher market prices and instability. Agriculture will continue to be a key sector in the stabilization and development of the DRC economy.

After a prolonged recovery from years of crisis and conflicts, an increase in carbon emissions from deforestation is likely to occur if appropriate policies are not put in place to mitigate and monitor land-use changes from burgeoning population and agriculture.

While the discussions of Reduction of Emissions from Deforestation and Degradation (REDD) in UNFCCC negotiations continue, it is important to prepare tropical countries with this new mechanism. For this, baseline information on the extent and distribution of the various land uses needs immediate evaluation as part of the development of MRE systems. While some estimates of the total extent of agriculture (both industrial and subsistence agriculture) in central Africa exists (Laporte et al. 1998, GLC2000), no studies differentiate the spatial distribution of industrial agriculture (IA) from traditional agriculture. For example, Industrial Agriculture would be large-scale palm oil production or rice cultivation; and subsistence agriculture would be growing of cassava and millet usually done in much smaller plots.

In the framework of implementing a national strategy for REDD, not only is information on forest and biomass extent necessary, but information on the agricultural sector is crucial as well. To narrow this knowledge gap, we used freely-available imagery and GIS software to report a first baseline of the historical extent of industrial agriculture in the Democratic Republic of Congo (55% of central Africa). This information, combined with the distribution of carbon stocks, is an important component for priming various policy scenarios/models of reducing emissions and rural development in the DRC. These scenarios should help decision makers to identify the most effective policies for minimizing deforestation and carbon emissions from land conversion, while optimizing forest conservation and improving rural livelihoods. Such models are necessary to guide REDD policies by integrating the forest, agricultural, and energy sectors.

### METHOD & DATASETS

Most of the central African countries, including DRC, have limited access and resources devoted to remote sensing technologies and satellite imagery. Consequently, proposed methods need to have low implementation costs and be easy to implement with minimal capacity. The method developed here focuses on mapping industrial agriculture (IA) and relies on freely-available imagery from Google Earth and Bing Maps, as reference, for manually digitizing the extent of IA in the DRC. To systematically scan the landscape for areas of IA, a vector grid is overlaid across central African countries. For each grid cell, imagery from Google Earth/Bing, TerraMetrics, Digital Globe, CNES/SPOT image and 2009 GeoEye for 2009 were utilized at a constant altitude of observation(10km) to carefully digitize IA plots, before moving to the next cell. Because the Google Earth interface did not allow access to time series of imagery, the exact age of the IA plots is largely unknown. But we do know that most plots were put into place before 2009. Furthermore, the rate of change could not be extracted from these data. However, Google.org will soon be providing free historical Landsat data sets. This will allow for image processing of land cover and land-use change at relatively low cost in most tropical countries (see Google Earth Engine, COP16).

### RESULTS

The digitizing process allowed us to identify 143 polygons of industrial agriculture (IA) in the DRC for a total land area of 215,913 hectares (Figure 1). Figure 2 illustrates two of these IA polygons. Note the traditional shifting agriculture at the edge of the IA fields. Traditional agriculture does not show the regular geometric pattern of IA and is systematically more difficult to map than IA.



Figure 2: Illustration of digitized IA near Bonsu, Equateur province . Note the areas of small-holder subsistence agriculture at the edge of each polygon. (Image: Google Earth)

The mean area of all IA polygons was 1,524 ha. The largest plot was identified in the Bas-Congo Province with an area of 18,440 ha. However, most of the observed industrial agriculture polygons were less than 2,000 ha. The largest number of polygons (74) were observed in the Equateur Province, then in the Province Orientale (32) and Bandundu (18) (Figure 2).

Although not an entirely accurate comparison the mean above-ground biomass biomass (Baccini et al., 2008) for all IA polygons was 131.5 Mg/ha. Positive identification of the land-use type in Google Earth is difficult, however, in Figure 3, the multi-modal distribution of mean biomass per polygon could potentially indicate underlying land-use.

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