Adapting Oil Palm Best Management Practices to Ghana: Opportunities for Production Intensification

By T. Rhebergen, T. Fairhurst, S. Zingore, M. Fisher, T. Oberthür, and A. Whitbread

An increasing global demand for palm oil, and limited availability of agricultural land in Southeast Asia, has driven a rapid expansion of new oil palm plantings in West Africa.

Sub-optimal climate conditions and generally low yields in West Africa, combined with highly fragmented land holdings limit the potential for expansion of large-scale plantings.

Research conducted in Ghana indicates that production increases can alternatively be sought by applying best management practices to land already planted with oil palm.

The large demand for palm oil has resulted in a rapid expansion of global oil palm cultivation. Most of the current expansion is taking place in Sub-Saharan Africa and Latin America as land available for new oil palm planting is limited in Southeast Asia. As a result, oil palm production in many West African (WA) countries has increased in the past decade. However, compared with the major producing countries in Southeast Asia and Latin America, average bunch yields in WA are very low (**Table 1**).

Table 1. Area planted, fruit bunch production and yields in the main producer countries in oil palm production regions worldwide in 2013 (FAO, 2015).

Region	Country	Production, '000 t fruit bunches	Mature area, '000 ha	Bunch yield, t/ha
S.E. Asia	Indonesia	120,000	7,080	16.9
	Malaysia	100,000	4,550	22.0
	Papua New Guinea	2,100	150	14.0
	Thailand	12,812	626	20.5
Total		234,912	12,406	18.9
Lat. America	Colombia	4,991	250	20.0
	Ecuador	2,317	219	10.6
	Guatemala	1,480	65	22.8
Total		8,788	534	16.5
W. Africa	Cameroon	2,450	135	18.1
	Ghana	2,100	360	5.8
	Liberia	176	17	10.4
	Nigeria	5,000	2,000	2.5
	Sierra Leone	210	28	7.5
Total		9,936	2,540	3.9

Smaller yields in WA are partly the result of sub-optimal climate conditions and poor management practices. Water stress is the main yield-determining factor outside management control in WA. In order to guide government policy makers and investors, it is essential to know where the most suitable conditions for the expansion of oil palm production in WA exists. Using Ghana as a case study, we describe a framework for evaluating areas that are both suitable and available for oil palm production based upon land suitability evaluation (LSE) methods and GIS techniques. We conclude by providing recommendations for the sustainable development of the oil palm sector in Ghana.

Land Suitability Evaluation (LSE) and Data Analysis

We conducted the LSE in three-steps. First, we defined climatically suitable areas for oil palm based upon climate and soil data obtained from WorldClim (www.worldclim.org), the ISRIC/WDC (https://soilgrids.org), and the FAO (http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/) soil databases, respectively. Four climatic zones (CZs) with varying suitability for oil palm were delineated in Ghana, based upon water deficits calculated using the method of Surre (1968). These CZs were grouped according to mean annual water deficit (mm/year), which integrates relevant climate (i.e., rainfall amount and distribution) and soil properties (i.e., water holding capacity) in a single parameter that delineates areas similar in terms of oil palm productivity (Olivin, 1968; van der Vossen, 1969). We defined four CZs:

1. **Optimal:** areas with a mean annual water deficit <150 mm;
2. **Favorable:** areas with a mean annual water deficit <250 mm;
3. **Suitable:** areas with a mean annual water deficit <400 mm; and
4. **Unsuitable:** areas with a mean annual water deficit >400 mm.

Areas that were climatically suitable were overlaid with biophysical and topographic constraints categorized as either 'suitable' or 'not suitable' (**Table 2**). Solar radiation, temperature, and slope were included because, after water deficit (WD), they are the most important factors that affect the growth and performance of oil palm (Paramananthan, 2003).

Table 2. Suitability for oil palm production based on climate and topography parameters (Paramananthan, 2003).

Limitation	Units	Suitable	Unsuitable
Climate			
Solar radiation	MJ/m^2	7 to 21	<7 or >21
Temperature	°C	18 to 37	<18 or >37
Topography			
Slope	°	<20	>20

In the final step, we excluded the most current land-use information, including protected areas defined by IUCN (Dudley, 2008), and urban settlements (Balk et al., 2006; CIESIN et al., 2011). Data on protected areas and urban settlements were obtained from the World Database on Protected Areas (http://protectedplanet.net) (IUCN and UNEP-WCMC, 2014) and the Socioeconomic Data and Applications Center (SEDAC) (http://sedac.ciesin.columbia.edu/data/set/grump-v1-urban-extents/data-download) (CIESIN et al., 2011).

Areas Suitable and Available for Oil Palm Production in Ghana

Suitable areas for oil palm production (WD <400 mm/year) are found in the wetter southern parts of Ghana, and are estimated at 73,500 km^2 or 31% of the total land area. Unsuitable areas for oil palm production (WD >400 mm/year) are 165,000 km^2 and occur in the northern regions characterized by a hot and dry climate. Optimal areas for oil palm (WD <150 mm/year) are estimated at 5,800 km^2 and occur in the south of the Western Region and a smaller area west of Koforidua in the Eastern Region (**Figure 1**). Suitable areas for oil palm production were reduced by 9% to 67,200 km^2 after excluding biophysical/topographical constraints, and urban settlements and protected areas. The reduction was greatest in the optimal production zone (-30%), where large areas of forest reserve and urban settlements occur. Few large, contiguous tracts of land remain available for oil palm within this zone (**Figure 1**).

The Effect of Climate Change on Oil Palm Production in Ghana

Compared to a previous suitability assessment (van der Vossen, 1969), our methodology shows a larger suitable area (+20%) for oil palm production in Ghana. The difference is likely the result of different methods used to determine suitability, but also because of a changing climate. Meteorological observations show that the climate in the oil palm belt has changed between 1960 and 2000. In particular, temperatures increased and there was less, but more variable rainfall. These climate trends are projected to continue to 2050 (EPA and Ministry of Environment, 2011), suggesting a more favorable water balance and growing

Abbreviations and notes: IPNI Project GBL-53

Field evaluations are carried out to pinpoint deficiencies in management practices that contribute to yield gaps. Site-specific best management practices are then developed and proposed as remedial action.

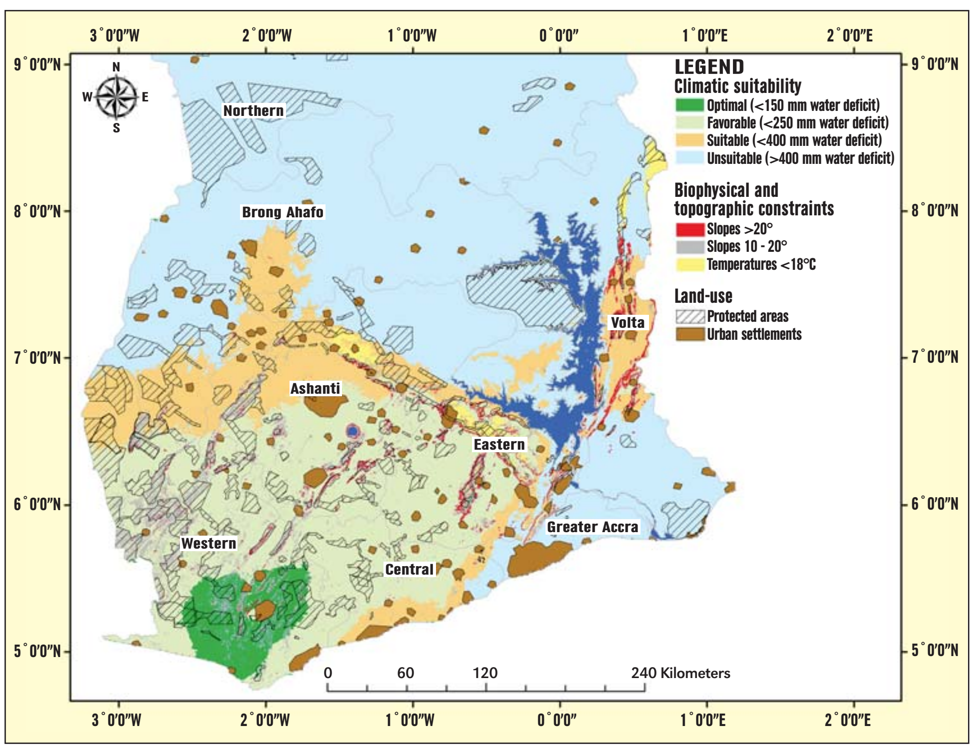

Figure 1. Map of southern Ghana showing suitable and available areas with potential for expansion in oil palm production, after excluding biophysical and topographical constraints and urban settlements and protected areas.

Table 3. Impact of yield intensification assuming moderate to full impact of best management practice (BMP) implementation across Ghana.

Area, ha	Current status: Bunch production, M t	Current status: Yield, t/ha	Current status: Economic value*, US$/yr	Potential yield increase with BMP, %	Yield intensification with BMP: Bunch production, M t	Yield intensification with BMP: Yield, t/ha	Yield intensification with BMP: Economic value*, US$/yr
330,000	1.9	5.8	402 M	25	2.4	7.3	502 M
				50	2.9	8.7	603 M
				75	3.3	10.2	703 M
				100	3.8	11.6	804 M

* Assuming an Oil Extraction Rate (OER) of 21% and a Crude Palm Oil (CPO) price of US$1,000/t.

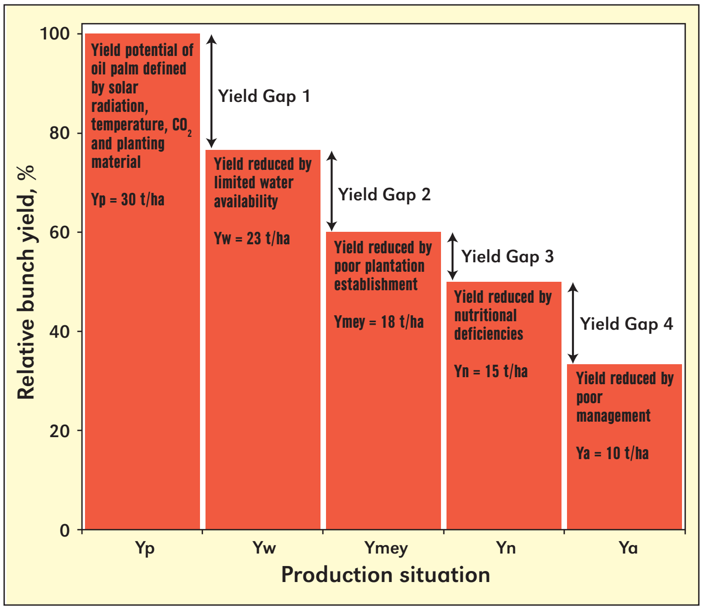

Figure 2. Yield gap model with various production situations and its associated yield gaps. When analyzing yield gaps in Ghana, water limited yield (Yw) is the most relevant benchmark because of the countries' rainfed conditions and sub-optimal climate.

conditions for oil palm in Ghana in the future. Alternatively, temperature increases will most likely increase evapotranspiration and aggravate soil-moisture conditions during periods of drought. This could lead to higher water deficits, and adversely affect oil palm production.

Key Constraints to the Production of Oil Palm in Ghana

The suboptimal amount and distribution of rainfall (water deficit) is the main constraint limiting oil palm production in WA. An almost linear inverse relationship between bunch yield and water deficit has been found in several studies in WA and Ghana (Danso et al., 2008; Olivin, 1968). Each 100 mm increase in water deficit reduces bunch yields by 10 to 15% (Corley and Tinker, 2003; Olivin, 1968), and 40 to 50% if the palms were subjected to severe water stress in the preceding year as well (Caliman et al., 1998). Soils with a high water storage capacity are desirable to cope with WA's climate, and represent a significant resource for oil palm development in Ghana. These results emphasize the need to explore the frequency and intensity of water deficits, and the occurrence of drought as prerequisites to planning future expansion of the area of oil palm (Caliman, 1992).

Restrictions to Area Expansion in Ghana

The annual shortage in crude palm oil (CPO) will increase from 35,000 t to 127,000 t by 2024 (MASDAR, 2011) if current production levels are maintained. To meet the projected oil demand in Ghana, suitability mapping identifies opportunities for area expansion into the most suitable lands for higher yields. Whilst area expansion is possible, fragmentation of suitable and available land largely hinders the establishment of large-scale plantations. This is exacerbated by other land-use types that were not part of the assessment, such as land under cocoa and rubber production, annual cropping, mining, high conservation value (HCV) areas, and fallow land that is part of slash and burn agriculture. Moreover, land acquisition is further complicated by complex land tenure arrangements that prevail in southern Ghana that make it difficult for investors to acquire land for the development of large-scale plantations (Ahiable, personal communication).

Opportunities to Increase Oil Palm Production in Ghana with Best Management Practices

Alternatively, production in Ghana can be increased by improving productivity (Rhebergen et al., 2014). To identify entry points in improving yields, yield gap analysis (YGA) is a useful tool. YGA partitions yield gaps between different causes, such as environment and management, thus providing a systematic process to assess opportunities in increasing yields (**Figure 2**).

Under satisfactory climatic conditions in Ghana, the maximum average attainable bunch yield is estimated at 25 t/ha (Rhebergen et al., 2014). With a country average bunch yield of 5.8 t/ha, current yield gaps are mostly the result of inadequate crop agronomic management, poor crop recovery, and soil fertility constraints that have not yet been sufficiently addressed. Opportunities for increasing production can therefore be sought by improving current management practices. Yield intensification on land already planted to oil palm may be an important policy for sustainable oil palm development in Ghana and WA. Adapting BMPs to local conditions can identity the management practices that are responsible for yield gaps (Donough et al., 2010). Improving agronomic management of existing palm stands shows considerable scope for yield intensification in Ghana, which can alleviate pressure for further land clearing for new plantations and greatly increase profitability for investors and farmers alike (**Table 3**).

Conclusions

The suitability assessment shows that highly fragmented suitable areas for oil palm production in Ghana are limiting the expansion of large-scale plantings. Therefore, a feasible strategy for expansion of smallholder production is needed, provided there are enough and efficient milling facilities to process the fruit. Alternatively, research conducted in Southeast Asia and Ghana indicate that production increases can be sought by applying BMPs to land already planted with oil palm. Closing yield gaps in Ghana could make a significant contribution to the national CPO supply and could lead to an increased profitability for investors and farmers alike. Moreover, increasing productivity in already existing palm stands reduces the need to clear land for new plantations. BC

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References

Balk, D.L. and U. Deichmann, G. Yetman, F. Pozzi, S.I. Hay, and A. Nelson. 2006. Adv. Parasitol 62:119-156.

Caliman, J.P. 1992. Oléagineux 47:205-216.

Caliman, J.P. and A. Southworth. 1998. IOPRI/GAPKI, Bali, Indonesia, pp. 250-274.

CIESIN, IFPRI, World Bank, and CIAT. 2011. NASA Socioeconomic Data and Applications Center (SEDAC), Palisades, NY, USA.

Corley, R.H.V. and P.B. Tinker. 2003. World Agriculture Series. Blackwell Science Ltd, Oxford, UK, 562 pp.

Danso, I. B.N. Nuertey, E. Andoh-Mensah, A. Osei-Bonsu, T.E.O. Asamoah. 2008. J. Ghana Sci. Assoc. 10:93-102.

Donough, C., C. Witt, and T.H. Fairhurst. 2010. Indonesian Oil Palm Research Institute (IOPRI), Jogyakarta, Indonesia, pp.1-8.

Dudley, N. 2008. IUCN, Gland, Switzerland, 86 pp.

EPA and Ministry of Environment, S.A.T. 2011. Ministry of Environment, Science and Technology, Accra, Ghana.

FAO, 2015. FAOSTAT Database.

IUCN and UNEP-WCMC. 2014. Cambridge, UK: UNEP-WCMC.

MASDAR, 2011. Ministry of Food and Agriculture (MOFA).

Olivin, J. 1968. Oléagineux, 23:499-504.

Paramananthan, S. 2003. Potash & Phosphate Institute/Potash & Phosphate Institute of Canada (PPI/PPIC) and International Potash Institute (IPI), Singapore, pp.27-58.

Rhebergen, T., M.P. Hoffmann, S. Zingore, T. Oberthür, K. Acheampong, G. Dwumfour, V. Zutah, C. Adu-Frimpong, F. Ohipeni, and T. Fairhurst. 2014. International Oil Palm Conference (IOPC), Bali, Indonesia.

Surre, C., 1968. Calcul du bilan de l'eau et ses applications pratiques. Oléagineux, 23:165-167.

van der Vossen, H.A.M. 1969. Ghana J. Agric. Sci., 2:113-118.

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