Soil Survey in DR Congo – from 1935 until today*

by

G. BAERT[**,***], E. VAN RANST[***], M. NGONGO[*****] & A. VERDOODT[****]

Keywords. - DR Congo, INEAC, soil survey, agriculture.
Summary. - Given the economic importance of agriculture in Belgian Congo, there was a great need for soil information. The first soil surveys conducted by J. Baeyens in 1935 (KU Leuven) were the start of a vast soil survey program carried out by INEAC (National Institute for Agricultural Research in Belgian Congo) during the period 1945-1960. This survey programme was coordinated by the INEAC principal station in Yangambi, where soil laboratories were present. When this program was stopped at independence in 1960, around 15 % of the territory was mapped, spread over the different agro-ecological zones of the country. After 1960, most of the soil surveys in DR Congo were conducted by the Laboratory for Soil Science – UGent, both semi-detailed mapping for industrial agriculture, as systematic reconnaissance surveys for general agricultural development (Lower Congo and Plain of the Ruzizi). To prevent loss of the existing soil data, soil maps, exploratory texts and technical reports were stored in a digital soil database (VlIR-project) and as such made available for Congolese researchers and others. In 2006-2007, also a SOTER (**SO**il and **TER**rain) database was produced for Central Africa in the frame of an ISRIC-UGent-FAO project.

Samenvatting. – *Bodemkartering in DR Congo – van 1935 tot op heden.* - Gezien het economisch belang van landbouw in Belgisch Congo was er grote nood aan bodeminformatie. De eerste bodemkarteringen uitgevoerd in 1935 door J. Baeyens (KU Leuven) waren de start van een uitgebreid bodemkarteringsprogramma uitgevoerd door het NILCO (Nationaal Instituut voor Landbouwwetenschappen in Belgisch Kongo), tijdens de periode 1945-1960. Dit karteringsprogramma werd gecoördineerd vanuit het hoofdstation van het NILCO in Yangambi, waar tevens bodemlaboratoria aanwezig waren. Wanneer dit programma bij de onafhankelijkheid (1960) werd stopgezet, was +/- 15 % van het grondgebied gekarteerd, gespreid over de verschillende agro-ecologische zones van het land. Na 1960 werden de meeste bodemkarteringen in DR Congo uitgevoerd door het Laboratorium voor Bodemkunde - UGent, dit zowel in semi-detail voor industriële landbouw, als systematische verkenningskarteringen voor algemene landbouwontwikkeling (Neder-Congo en Vlakte van de Ruzizi). Om te vermijden dat de bestaande bodemgegevens zouden verloren gaan, werden bodemkaarten, verklarende teksten en technische rapporten digitaal verwerkt (VlIR project) en beschikbaar gesteld voor Congolese onderzoekers en anderen. Tevens werd in 2006-2007 een SOTER (**SO**il and **TER**rain) database opgemaakt voor Centraal Afrika in het kader van een ISRIC-UGent-FAO project.

Résumé. – *La cartographie des sols en RD Congo – de 1935 jusqu'aujourd'hui*. - Vue l'importance économique de l'agriculture au Congo Belge, il y avait un grand besoin en information pédologique. Les premières cartographies de sol effectuées en 1935 par J. Baeyens (KU Leuven) ont constitué un point de départ du vaste programme de cartographie pédologique que mènera l'INEAC (Institut National pour l'Etude Agronomique du Congo Belge) durant la période 1945-1960. Ce programme de cartographie des sols était coordonnée à partir de la station principale de l'INEAC à Yangambi, qui comptait en son sein des laboratoires d' analyses du sol. Quand ce programme fût arrêté à l'indépendance (1960), +/- 15 % du territoire, réparti dans le différents zones agro-écologiques du pays, était

cartographié. Après 1960, la plupart des prospections pédologiques en RD Congo ont été exécutées par le Laboratoire de Science du Sol – UGent, aussi bien en semi-détail pour l'agriculture industrielle, que des cartographies de prospection systématiques pour le développement agricole générale (Bas-Congo, Plaine de la Ruzizi). Pour éviter la perte des données pédologiques existantes, toutes les cartes de sol, notices explicatifs et rapports techniques ont été numérisés (projet VlIR) et mis à la disposition des chercheurs congolais et autres. En plus, une base de données SOTER (**SO**il and **TER**rain) pour l'Afrique Centrale a été élaborée en 2006-2007 dans le cadre d'un projet ISRIC-UGent-FAO.

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** Department of Plant Production, University College Ghent, Schoonmeersstraat 52, B-9000 Gent, Belgium
***Laboratory of Soil Science, Department of Geology and Soil Science (WE13), Faculty of Sciences, Ghent University, Krijgslaan 281/S8, B-9000 Gent, Belgium
**** Research Unit of Soil Degradation and Soil Conservation, Department of Soil Management & Soil Care, Ghent university, Coupure Link 653, B-9000, Gent, Belgium
***** Laboratory of Soil Science, Faculty of Agriculture, University of Lubumbashi, DR Congo

Introduction

DR Congo is a very large country with a total surface of 2,345,408 km^2, *i.e*. the largest country in Sub-Saharan Africa. The country was colonized by Belgium from 1908 till 1960 (Belgian Congo); from 1877 till 1908, it was the so called 'Congo Free State' ruled by Leopold II, King of Belgium. After independence, the country was renamed several times - from 1960 onwards - as Congo-Léopoldville, Congo-Kinshasa, Zaire and finally the Democratic Republic of Congo (DR Congo).

At its independence in 1960, DR Congo was one of the most industrialized countries in Africa; its economy was mainly based on mining and agriculture. During colonial times, agriculture mainly comprised the production of industrial crops through plantation agriculture (mostly oil palm, rubber, coffee, cocoa, sugarcane) or as compulsory crops (*e.g*. cotton, groundnuts), and food crops *(e.g*. cassava, maize, bananas).

The first rubber, oil palm, cocoa and coffee trees were planted late 19th century in the Mayumbe region, Lower Congo (Groupement Agrer – Earth Gedif 200, CLARENCE-SMITH 2011, KALONJI-MBUYI *et al*. 2009), and some years later throughout the whole Belgian Congo. When Belgium annexed Congo as a Belgian colony, plantation agriculture was encouraged by the colonial authorities and large concessions were assigned to investors. As such, UNILEVER received in 1911 concessions of 750,000 hectares for the exploitation of natural palm trees and for the development of industrial oil palm plantations (JEWSIEWICKI 1986), the latter totaling 47,000 ha in 1960 (DRACHOUSSOFF *et al*. 1991). Exports of agricultural products increased steadily, and by 1958 Belgian Congo was among the major producers of perennial crops, mostly by European-owned enterprises, ranging from large industrial plantations to small family plantations (European settlers), but also by Congolese smallholders and 'paysannats' (permanent settlements of African farmers) (tab. 1). Congolese farmers were engaged primarily in the production of subsistence crops, however, they

produced all of the cotton (compulsory) and about 65 % of the palm oil. The area under European plantations increased from 240,000 hectares in 1950 to 370,000 hectares in 1958 (International Bank for Reconstruction and Development 1960).

Table 1
Production of perennial crops in Congo in 1958

Crop	Production (tons)			Export (tons)	% of value of total export
	Industrial	Smallholder	Total		
Rubber	33,279	3,576	36,855	35,855	4.13
Palm oil	74,680	11,337	222,879[2]	164,513	12.51[3]
Cocoa	4,782	19	4,801	4,878	0.98
Coffee robusta	38,779	6,608	45,387	43,580	8.20
Coffee arabica[1]	7,281	19,166	26,447	26,579	5.47
Tea	2,523	9	2,532	2,465	0.39

[1] including Rwanda and Urundi
[2] including the gathering of fruits of natural palm trees
[3] including the palm fruit and kernel oil
Source: VAN DE WALLE 1960 (in TOLLENS 2004).

Since independence in 1960, DR Congo has suffered from chaotic political and economic instability (several wars, lootings, nationalization of foreign owned companies, …), leading to a nearly complete collapse of the plantation agriculture and an enormous decline in crop outputs. Most industrial plantations operated poorly in a very difficult context (SHAPIRO & TOLLENS 1992) and were abandoned; many fields of crops imposed or encouraged by the colonizers returned to bush (CLARENCE-SMITH 2011). As an example: in 2002, the production of palm oil (including the kernel oil) was only about 5,500 tons (Groupement Agrer – Earth Gedif 2006), only a fraction of the production before independence (tab. 1).

To support the agricultural development during and after colonization of DR Congo, research institutes (*e.g.* INEAC) were created and many soil surveys have been undertaken. This paper gives a review of the history of the soil survey in DR Congo from 1935 until present, and of the different institutions involved in the soil prospection. The soil prospection in Congo can be separated in different distinct periods of activities and methodologies, related to some major important national or international events. A large number of soil surveys were conducted in DR Congo. It is impossible to mention all surveys in the text below; a complete list of references of soil surveys carried out in DR Congo is given in BAERT *et al*. 2009.

Soil survey in DR Congo

BEFORE 1945

Due to the high expansion of plantation agriculture since 1910, E. Leplae, Director General of Agriculture at the Belgian Ministry of Colonies, emphasized in 1914 the urgent need for systematic soil prospection for plantation and smallholder agriculture. In 1926 the 'Régie des Plantations de la Colonie' (REPCO) was set up by the Ministry of Colonies, mainly to support

the plantation agriculture. In 1933, the 'National Institute for Agronomy in Belgian Congo' (INEAC) was established as a successor of REPCO (DRACHOUSSOFF *et al*. 1991). INEAC was a very large research institution, specialized in all aspects of agriculture, and thus of major importance for agricultural development of the colony. The principal research station was installed in Yangambi, and many small research centers were gradually created all-over the territory (mostly after 1945, see further).

Before 1945, as elsewhere in tropical Africa, soil survey was very limited in Belgian Congo because of the disastrous impact of World War I, the Great Depression (early 1930s) and World War II. As such, only some general soil prospections for plantation agriculture (*e.g*. soil fertility for banana cultivation in Lower Congo, soil prospection of coffee plantations in Ituri) and for the location of INEAC stations were organized. The first published study on soils of Central Africa was the reconnaissance soil survey of the Lower Congo (BAEYENS 1938), based on some general soil prospections done in the period 1934-1936. The study was conducted mainly for soil fertility characterization (6,000 soil samples were send to KU Leuven for physico-chemical analysis), resulting in a soil suitability scale for different tropical crops as oil palm, cocoa, coffee, sugar cane, rubber, … (DUDAL 2003). The survey resulted in a very general soil map of the Lower Congo, as presented in figure 1 (soil map of the Mayumbe region, western part of the Lower Congo province). Soil units were distinguished based on parent material, soil texture and soil depth.

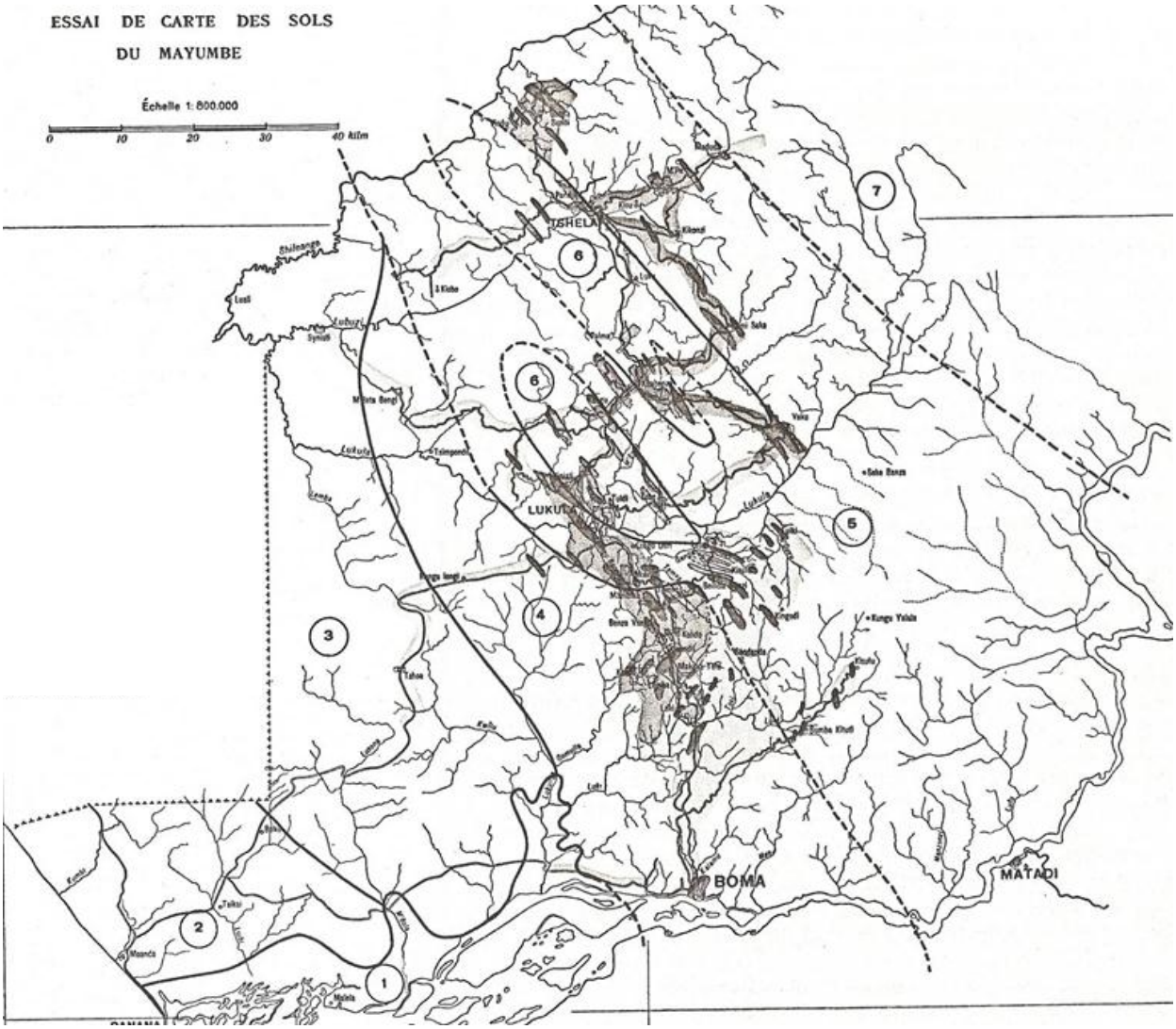


Fig. 1. - Soil map of the Mayumbe region, Lower Congo (Source: Baeyens, 1938): 1. Holocene Holocene sandy and clayey deposits; 2. Littoral zone – sands and sandstones; 3. Sub-littoral zone – sandstones; 4. Zone of gneiss, amphibolites and granites; 5. Zone of micaschists and other metamorphic schists; 6. Synclinals of graphite schists, quartzites and quartzitic phyllades; 7. Quartzites, arkoses, schistes.

1945-1960

The real soil survey activities in Congo started after World War II, mainly by the INEAC soil survey team, but also to a minor extent by other institutions generally in collaboration or under supervision of the INEAC soil survey team. This expansion of the soil surveys after World War II was also the case in other colonies in Africa, mainly French and Portuguese (FELLER *et al*. 200, VAN RANST *et al*. 2010).

From 1945 onwards, INEAC was fully developed, with the principal research station in Yangambi and 31 substations (research stations, experimental stations and plantations, ..) all-over Congo, located in different agro-climatic zones (http://www.inera-rdc.org/). The Yangambi station comprised 19 divisions, covering the different disciplines in agriculture. The 'soil prospection and mapping' unit was part of the Agrology Division, and was supported by a cartographic room, a fully equipped central soil laboratory for routine physico-chemical soil characterization and research laboratories in soil mineralogy, soil chemistry and fertility, and soil microbiology (DRACHOUSSOFF *et al*. 1991). The Agrology Division also hosted the Inter-African Pedological Service (D'HOORE 2003).

The INEAC soil survey team, often in collaboration with the 'Agricultural Service of the Colony', conducted soil surveys all-over the territory (Fig. 2), coordinated by the soil survey leader in Yangambi. The soil survey approach evolved through different phases, resulting in maps at different scales (tab. 2):

- 1945-1950: mainly semi-detailed surveys of INEAC research or experimental stations, e.g. Kaniama (FOCAN & MULLENDER, 1955), M'Vuazi (DENISOFF & DEVRED 1954), Nioka (HOLOWAYCHUK *et al*. 1954), Yangambi (VAN WAMBEKE & EVRARD 1954, GILSON *et al*. 1956 et 1957, VAN WAMBEKE & LIBEN 1957).
- 1950 onwards: systematic soil survey at different scales:
  - pedo-botanical surveys at scale 1:50,000, 3 to 5 soil profiles/10 ha (*e.g*. VAN WAMBEKE & VAN OOSTEN 1956, VAN WAMBEKE 1958, SYS & SCHMITZ 1959, JONGEN *et al.* 1960), among others for the installation of 'paysannats' (*e.g*. FRANKART 1967)
  - general surveys at different scales: reconnaissance, 1 soil profile/km^2; semi-detailed survey of sample areas of +/- 50,000 ha, 3 to 5 profiles/10 ha (*e.g*. VAN WAMBEKE 1959, GILSON & LIBEN 1960, JAMAGNE 1965).
- in 1956: program started for survey at 1:500,000 for the whole territory (*e.g*. DEVRED *et al*. 1958, PECROT & LEONARD 1960, JONGEN & JAMAGNE 1966, GILSON & FRANCOIS 1969).

In collaboration with the INEAC soil survey team, also semi-detailed soil surveys were conducted by other institutes and by consultancy firms, as:

- BOURGUIGNON *et al*. 1960: FULREAC, Lufira plains – Katanga.
- MAE (Mission Anti-Erosive): Ruzizi plain and mountain area Bukavu - South Kivu, not published.

- GER (Groupe d'Economie Rurale): Lower Congo (Kimpangu, Luala plain). The Luala plain was mapped by SOCINCO (1960).
- SOCINCO, 1959a and b: pedological studies of different parts in Lower Congo (Kasi, Mbanza Ngungu), technical reports.
- SOGREAH, 1959: study of Stanley Pool, Kinshasa, technical report.
- ….

In 1960 Yangambi and the INEAC substations were abandoned, and all soil survey activities stopped. At that time, around 15 % (+/- 336,000 km^{2}) of DR Congo was mapped at large-scale (general surveys), 1.5 % (+/- 3,525,000 ha) as semi-detailed pedo-botanical surveys. The non-printed soil maps recovered at independence were published after 1960; however lots of soil data (soil maps, analytical data) were lost.

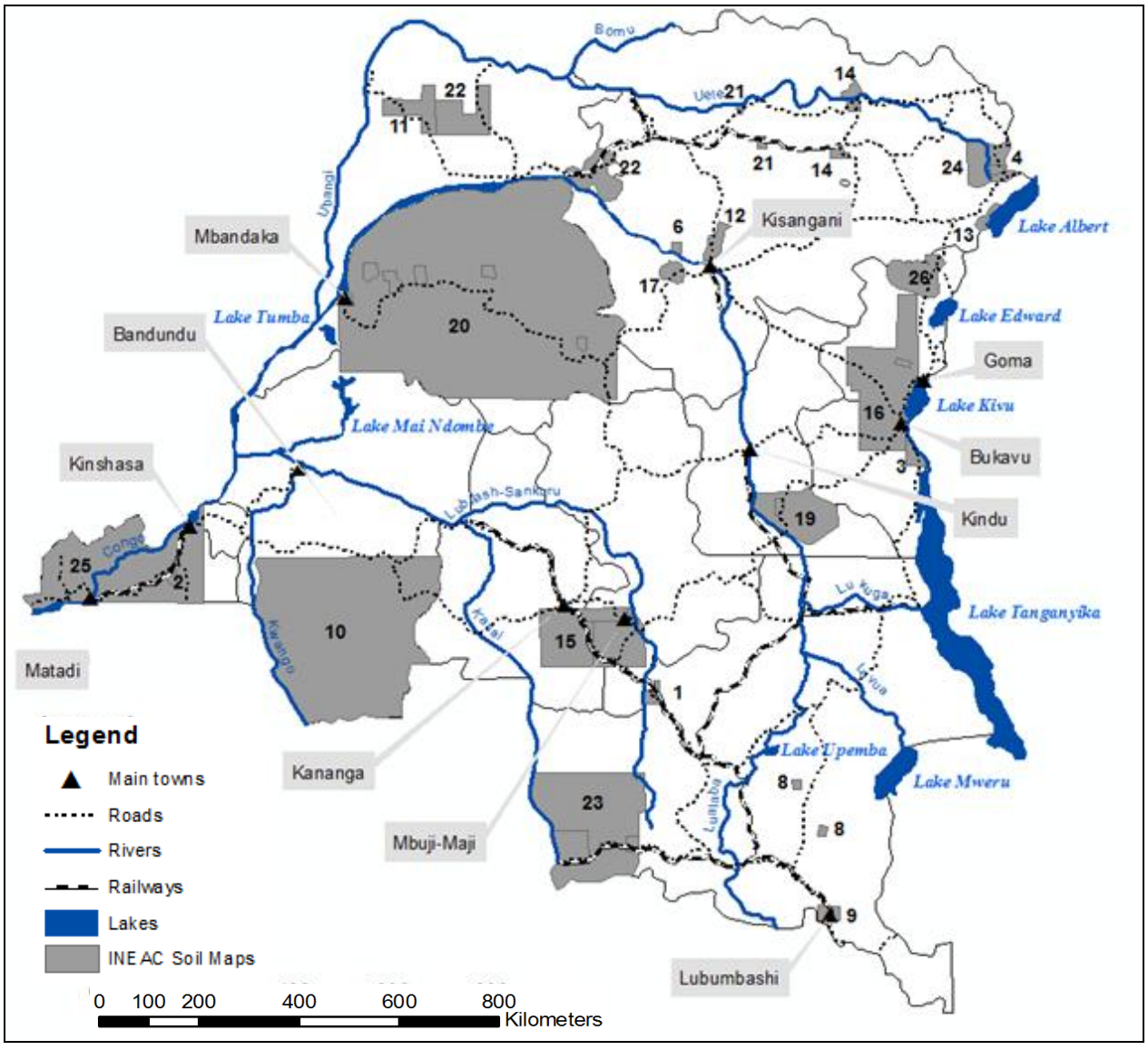


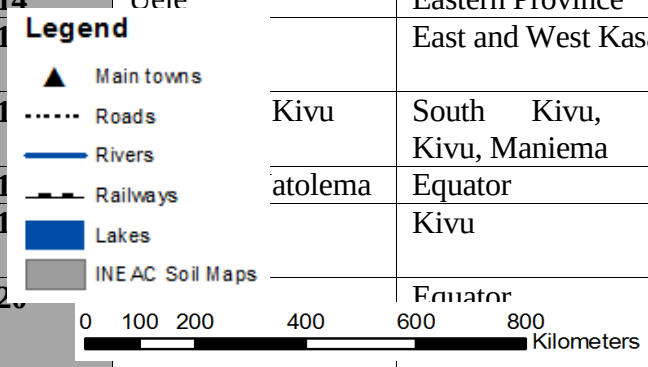
Fig. 2. - Soil maps of INEAC (1945-1960).

Note: The INEAC publication on the Lower Congo (sheet 25) only comprises the vegetation map. Soils of the Lower Congo were only partly mapped before 1960 and not published. The

soil survey was finalized in 1990 (see further). For more information on scale and extent of the different sheets, see table 2.

Table 2
Cartes pédologiques de l'INEAC

Sheet	Region	Province	Scale	Surface (ha)
1	Kaniama	Katanga	1:100,000	100,000
2	M'Vuazi	Lower Congo	1:50,000	30,000
3	Vallée de la Ruzizi	South Kivu	1:50,000 1:20,000*** 1:10,000***	80,000 25,000 5,000
4	Ituri, région de Nioka	Eastern Province	1:50,000	65,000
6	Yangambi	Eastern Province	1:50,000	34,000
8	Vallée de la Lufira	Katanga	1:50,000	
9	Lubumbashi	Katanga	1:50,000	160,000
10	Kwango	Bandundu	1:1,000,000	2,700,000
11	Ubangi	Equator	1:50,000	350,000
12	Bengamissa	Eastern Province	1:50,000	90,000
13	Région du Lac Albert	Eastern Province	1:100,000	50,000
14	Uele	Eastern Province	1:40,000	150,000
1		East and West Kasai	1:200,000 1:50,000	2,000,000 200,000
1	Kivu	South Kivu, North Kivu, Maniema	1:500,000 1:50,000	
1	atolema	Equator	1:100,000	
1		Kivu	1:250,000 1:50,000	1.500,000 45,000
2		Equator	1:250,000 1:100,000 1:50,000	 217,000
21	Uele, Babua	Eastern Province	1:40,000	
22	Ubangi	Equator	1:100,000 1:50,000	 1,050,000
23	Zone de la Haute Lulua	Katanga	1:1,000,000 1:200,000 1:50,000	
24	Mahagi	Eastern Province	1:200,000	
25	Bas Congo and Région de Kinshasa**	Lower Congo and Region of Kinshasa	1:200,000	6,300,000
26	Nord Kivu et Lac Edward	Kivu	1:200,000 1:50,000	70,000 15,000



* all sheets have an exploratory text, with explanation of the soil units, based on morphological and physico-chemical data (soil profiles and analyses, see further)

** only vegetation map published by INEAC. Soil map of the Lower Congo was finalized by project 'Carte Pédologique du Bas Congo' (ABOS-UGent) (BAERT *et al.* 1991a-h), partly based on existing INEAC soil maps

*** additional soil maps of projet 'Etude Hydro-agronomique de plaine de la Ruzizi' (UGent), partly based on INEAC and MAE maps (BAERT *et al*. 1993 a-c)

During the course of the soil prospection, the INEAC soil survey team developed their own soil classification system inspired by the Soil Survey Manual (USDA 1951). Early soil maps, e.g. the soil map of M'Vuazi (DENISOFF & DEVRED 1954), had no soil classification system; the soil units were based on differences in parent material, soil texture, stoniness, drainage and depth. Moreover, no profile descriptions with analytical data were available. Towards the end of the 1950s, the INEAC soil classification system was fully developed and used to designate the soil units on both semi-detailed as well as large-scale reconnaissance soil maps. The system was thus gradually developed and tested in the field, and published by SYS *et al*. (1961), later revised by TAVERNIER & SYS (1965).

The INEAC soil classification system is a morphogenetic system considering 7 categories (Tab. 3); soils are classified according to their soil profile morphology, physico-chemical data and clay mineralogy. The insights of the INEAC soil classification system were at the base of diagnostic horizons adopted in the soil classification systems USDA-Soil Taxonomy, FAO and WRB to accommodate soils of the tropics (DECKERS *et al*. 2003).

Table 3
INEAC Soil Classification System

Categorie	**Criteria**	**Example for soil in kaolinitic materials***
Order	major differences in weathering of parent materials and in kind & sequence of diagnostic horizons	Kaolisols
Suborder	major differences in degree of gleying, soil moisture regime (≈ Aquic, Udic, Ustic)	Hygro-Xero Kaolisols (HX)
Great soil group	succession of diagnostic horizons	HX Ferralsol (Ferralitic horizon)
Little soil group	intergrades between higher categories	HX Ferralsol intergrade Ferrisol
Great family	kind of parent rock	HX Ferralsol intergrade Ferrisol on basic rock
Little family	geomorphological position	HX Ferralsol intergrade Ferrisol on basic rock on recent erosion surface
Soil series	texture, color, drainage, structure, consistency	HX Ferralsol intergrade Ferrisol on basic rock on recent erosion surface, very clayey, dark red, well drained, weak structure

*dominance 1:1 clays with important amounts of Fe oxides, CEC-clay < 25 cmol(+)/kg clay, coarse fragments of fresh and partly weathered rock in upper 50 cm < 15 vol %

AFTER 1960

After 1960, the systematic soil survey, as was done by INEAC, stopped. Between 1960 and 1985, soil prospections were mainly conducted for plantation agriculture, to a lesser extent for general agricultural development. Some examples (fig. 3):

- Kaniama-Kasese (Katanga) : evaluation for maize (SYS 1974, 1979; EMBRECHTS 1975)
- Lubilashi (Katanga), Fiwa (Equator), Mushie Pentane (Bandundu) and Luiza (East Kasai): evaluation for sugarcane (SYS 1970; SYS *et al*. 1978; SYS & VERCRUYSSE 1978a, b)
- Katale (North Kivu) : evaluation for coffee (KANYANKOGOTE & SYS 1981)
- Lower Congo & Kinshasa: general agricultural development, forestry (SOGREAH – SOCINCO 1964, USAID 1969, IFAGRARIA 197, ULG 1985)
- Befale (Equator), Kindu (Maniema): evaluation for cocoa (BOEDT 1980, 1981).
- Nyantja estate, Bukavu (South Kivu): evaluation for tea (HARTEMINK 1991).

The last systematic soil surveys in DR Congo for general agricultural development were conducted by the Laboratory of Soil Science – UGent (tab. 2):

- reconnaissance soil survey at scale 1:200,000 of the Lower Congo province and the region of Kinshasa (1988 - 1990) partly based on former INEAC soil surveys (BAERT *et al*. 1991a-h), through funding of the former GADC (General Administration for Development Cooperation).
- semi-detailed and detailed surveys (scale 1:50,000 to 1:10,000) of various parts of the Ruzizi plain, South Kivu (1992-1993) (BAERT *et al*. 1993 a-c), funding by the African Development Bank.

With the suspension of the Belgian aid to DR Congo in 1990 (related to the killing of students at the University of Lubumbashi), and the genocide in Rwanda (1994) which was the start of a long period of instability and war, international aid was suspended and all survey activities stopped.

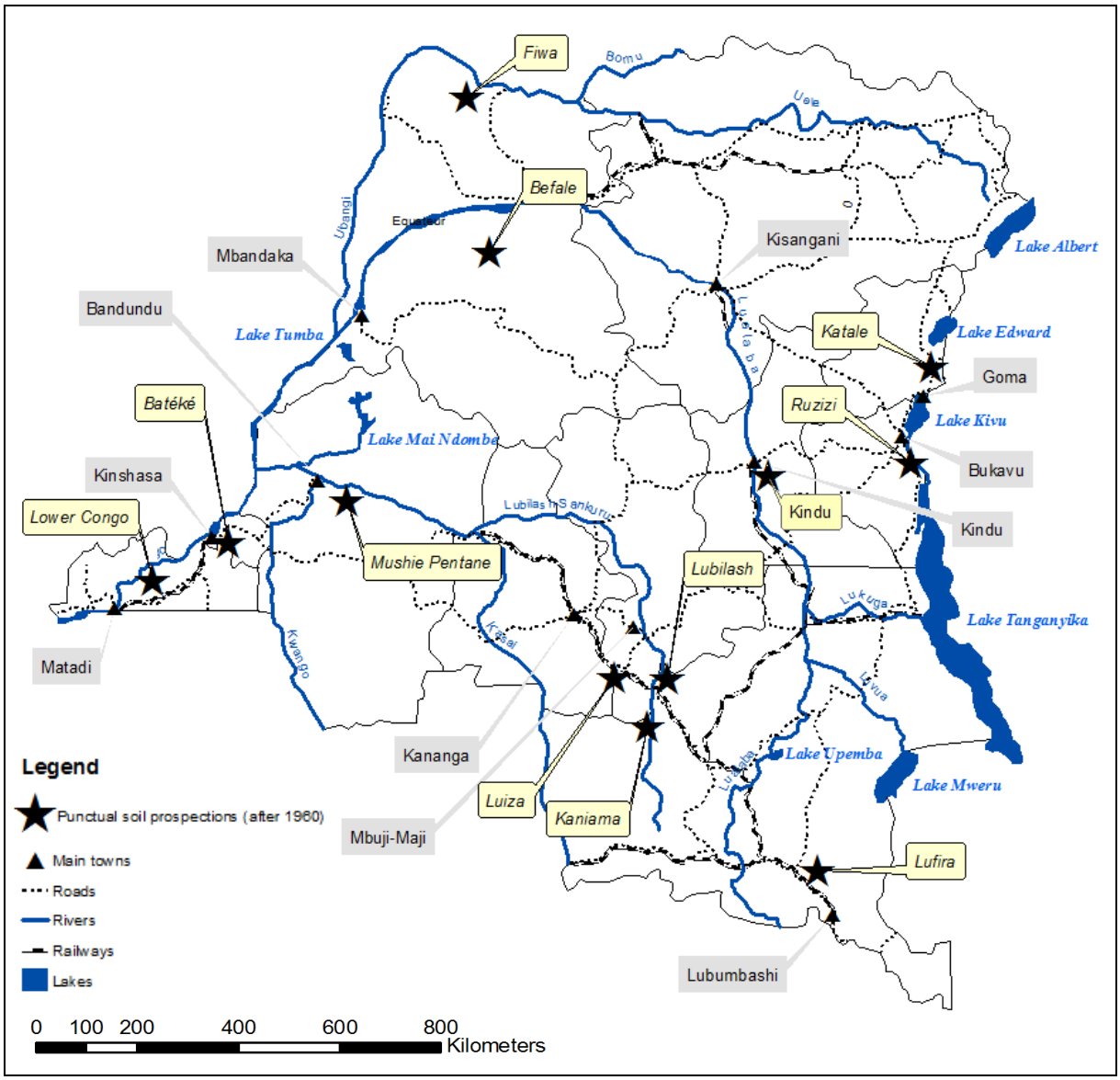


Fig. 3. - Punctual soil prospection (after 1960).

Digital storage of soil data

SOIL MAPS

As described above, a large number of soil surveys were conducted in DR Congo, particularly by INEAC during colonial times and by the Laboratory for Soil Science of the Ghent University. However, since 1960, during the major events and subsequent periods of instability that took place in DR Congo, a major part of soil data was lost in DR Congo. Other datasets, such as the unpublished soil reports and maps conducted by consultancy firms, were not available.

In order to make soil data more accessible primarily to Congolese scientists, soil maps were digitized (ArcView) at the Universities of Lubumbashi and Kinshasa and stored in a digital database, in collaboration with the Ghent University and the University College Ghent (VlIR-funding). A similar methodology as for the Rwanda soil database (IMERZOUKENE & VAN

RANST 2001, VAN RANST *et al.* 2002, VERDOODT & VAN RANST 2006) was adopted for the elaboration of the DR Congo database. Ninety published (INEAC) and non-published soil maps were stored in the database. The soil units were digitized as a polygon theme, representing the soil mapping units on the original soil maps. Most digitized soil maps were geo-referenced. As already mentioned above, INEAC gradually developed their own soil classification system during the course of the INEAC soil survey, and soil maps had different legends. A major challenge was thus the development of a uniform soil legend, applicable for the whole territory of DR Congo. This legend was largely based on the soil legend of Rwanda. In the attribute table of the vectorized soil units, both the original code of the soil maps (link to soil reports, also available in digital format), as the code of the adapted legend are indicated. The colour palette was somewhat different as more parent materials were distinguished on the soils maps of DR Congo.

The scanned original maps with exploratory text, as well as the digitized generalized maps are available at the Laboratories of Soil Science of the Universities of Lubumbashi, Kinshasa and Ghent.

ANALYTICAL DATA

The delimitation and characterization of the soil units distinguished on the digitized soil maps are based on thousands of soil profiles and a very large number of soil analyses conducted in specialized soil laboratories. A huge amount of soil samples was analyzed in the central soil laboratory at Yangambi, as evidenced by table 4: around 40,000 soil samples were analyzed between 1956 and 1960 (DRACHOUSSOFF *et al*. 1991). During that period nearly 17,000 physico-chemical routine analyses supported the soil survey, whereas other soil (and plant) analyses were conducted within the frame of the INEAC soil fertility program and to support plantation agriculture. During the soil survey of the Lower Congo (Baert *et al*. 1991a-h) and the Ruzizi Plain (BAERT *et al.* 1993 a-c), around 350 soil profiles were described and analyzed at the Laboratory of Soil Science of the Ghent University (around 2,000 soil samples).

Table 4

Repartition of the analyzed samples at the central soil laboratory (Yangambi)

Type of analysis	**1956**	**1957**	**1958**	**1959**
Public services	*1,608*	*2,875*	*2,652*	*1,653*
Colonisation blocs	*1,378*	*369*	*152*	-
Pedo-botanical survey	*3,185*	*2,584*	*4,066*	*4,112*
Missions with other institutions	*988*	*1,267*	*1,800*	-
Agricultural experiments	*2,977*	*2,878*	*1,815*	*3,736*
Total of soil analyses	***10,136***	***9,973***	***10,485***	***9,501***
Analysis of plant materials	*4,856*	*4,921*	*2,992*	*7,528*

Source: DRACHOUSSOFF et al. 1991.

Reference soil profiles (mostly non geo-referenced) with physico-chemical analyses are presented in most exploratory texts of the published INEAC soil maps (tab. 2) and in the non-published soil survey reports. Analytical data of the geo-referenced soil profiles of the Lower Congo (BAERT *et al*. 1991a-h) were organized in a relational database which contains the analytical data of all horizons.

A number of INEAC reference soil profiles were published by SYS (1972). BAERT *et al*. (2009) published selected reference profiles scattered all-over DR Congo, from INEAC and other soil surveys. Soil profiles are presented per parent material, as presented in figure 4 for the soils developed on cover deposits in DR Congo. For each parent material, soils in different weathering stages were selected. The morphological, mineralogical, physical and chemical properties of the soils in relation to weathering and soil formation are discussed in NGONGO *et al*. (2009).

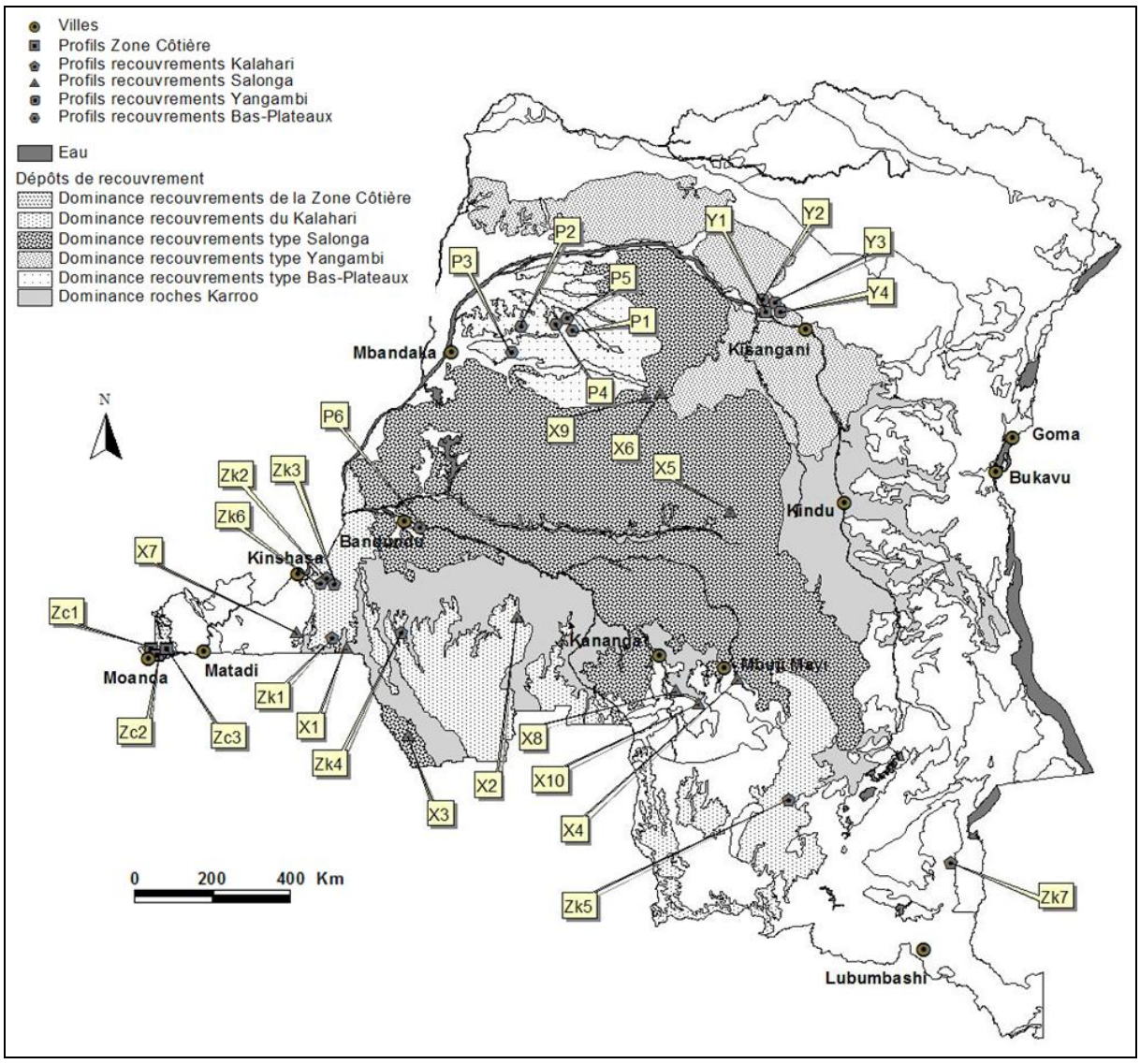


Fig. 4. – Soils on cover deposits (BAERT *et al*. 2009).

GENERAL SOIL MAP OF DR CONGO

Based on the INEAC soil surveys conducted before 1960 in the different agro-ecological zones of DR Congo, Sys (1960) produced a general soil map of the country at scale 1 : 5 M. This map was incorporated in the Soil Map of Africa at scale 1: 5 M published in 1964 (D'HOORE 1964, 2003) and the 1 : 5 M FAO Soil Map of the World (FAO 1971-1981).

As was shown above, lots of additional information on the spatial distribution and properties of the soils of DR Congo was gathered since 1960, enabling the development of a scientifically sound Great Lakes Area SOTER (**SO**il and **TER**rain) database (DR Congo, Rwanda, Burundi). This digital database for Central Africa (SOTERCAF) was produced in 2006-2007 in the frame of an ISRIC-UGent-FAO project (VAN ENGELEN *et al*. 2006, GOYENS *et al*. 2007). For the development of this database, available information on terrain (landform, slope), lithology (derived from geological maps), and soils was used (VAN RANST *et al*. 2010), enabling the distinction of 147 unique SOTER units for DR Congo, most of which are characterized by reference soil profiles derived from soil survey reports (GOYENS et al. 2007). The SOTERCAF database can be downloaded from the ISRIC website: http://www.isric.org/projects/soter-central-africa-sotercaf.

A number of soil parameter estimates for fixed depth intervals of 0.2 m to 1 m depth was derived from SOTERCAF and the ISRIC-WISE soil profile database, using standardized taxonomy-based pedotransfer procedures (BATJES 2007). Most important parameters are organic carbon, total nitrogen, C/N ratio, pH(H_2O), CECsoil, CECclay, base saturation, ECEC, Al-saturation, bulk density, content of sand, silt and clay, content of coarse fragments (> 2 mm), and available water capacity (-33 kPa to -1.5 MPa). These attributes have been identified as being useful for agro-ecological zoning, land evaluation, crop growth simulation, modelling of soil carbon stocks and change (BATJES 2008), and analyses of global environmental change. The data are also available on the ISRIC website: http://www.isric.org/projects/sotwis-central-africa-sotwiscaf.

Conclusions

This paper clearly illustrates the availability of a large amount of soil data, although scattered, of DR Congo, both soil maps and analytical data, which were collected over a long period. The numerous soil surveys, conducted before and after independence in 1960 in different agro-ecological zones of the country, have played an important role in the development of tropical soil science, soil classification, and in determining the land-use potential for agricultural development in tropical regions.

The digital storage of the precious soil data in a soil information system has prevented their loss and made them available to Congolese and other scientists. The database provides inputs in a large number of applications in DR Congo, such as land evaluation for food and industrial crops in different agro-ecological zones, investigation of soil hydraulic properties, and modeling of carbon sequestration.

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