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Ethnopedology of a Quilombola Community in Minas Gerais: Soils, Landscape, and Land Evaluation

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ABSTRACT: *Quilombolas* are Afro-brazilian rural peasants who descended from escaped slaves who tried to carve out territories of autonomy (called *Quilombos*) by collective organization and resistance. Despite many anthropological and ethnopedological studies, little research has been carried out to identify the agricultural practices and the knowledge of people who live in the *Quilombos* (*Quilombolas*). Peasant communities who live from land resources have wide empirical knowledge related to local soils and landscapes. In this respect, ethnopedology focuses on their relationship with local practices, needs, and values. We carried out an ethnopedological evaluation of the soils, landscape and land suitability of the *Malhada Grande Quilombola* Territory, aiming to examine the local criteria involved in land-use decision making, and evaluate the legitimacy of local knowledge. For this purpose, participatory workshops allowed environmental stratification of the *Quilombolas* into landscape units, recognition of soil types, and evaluation of land-use criteria. This approach was combined with conventional soil sampling, description, and analysis. The Brazilian System of Soil Classification and its approximations to the WRB/FAO system and the SAAT land evaluation system were compared with the local classificatory systems, showing several convergences. The *Quilombolas* stratified the local environment into eight landscape units (based on soil, topography, and vegetation) and identified eight soil types with distinct morphological, chemical, and physical attributes. The conventional soil survey identified thirteen soil classes, in the same eight landscape units, organized as soil associations. The apparent contradictions between local knowledge and Pedology were relative since the classification systems were established based on different criteria, goals, and sampling references. Most soils are only suitable for pasture, with restricted agricultural use, due to water or oxygen deficiencies. The current land use was only inconsistent with the technical recommendations when socioecological constraints such as the semiarid climate, land availability, and economic conditions for land management led to overuse of the land. Local knowledge demonstrated its legitimacy and allowed a useful and fruitful exchange of information with the academic view of soil-landscape interplays. Although mostly unknown by the scientific community, local knowledge proved capable of achieving social welfare and food security. In addition, a participatory survey proved to be a core factor for more grounded and detailed data collection on how *Quilombolas* decide land use on a local scale.

Keywords: ethnopedology, *Quilombo*, maroons, participatory methods, local knowledge.

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INTRODUCTION

Mankind developed the ability to manage lands allowing sedentarization circa 10,000 years ago. Since then, despite all technological advances, traditional rural populations have maintained close connections with local resources, focusing on self-sufficiency, totaling about 300 to 500 million indigenous people and 1,300 to 1,600 million smallholder farmers and other groups worldwide (Toledo and Barrera-Bassols, 2009). These communities possess elaborate management techniques and knowledge of local soil resources, which are key components of the terrestrial ecosystem and essential for their survival (Adhikari and Hartemink, 2016). Considering the non-market-oriented but culturally-based productive organization of these communities, they can be understood as territory-based communities, requiring participatory methods aiming at contextualized land-use planning, which considers the local logic of development (Perrot, 2008).

In the northern region of the state of Minas Gerais (MG), Brazil, intense co-evolution and interplay between the local population and the biophysical setting has led to the development of a locally diverse peasantry, formed by traditional communities who are identified according to the specific landscape where they live. Therefore, the *Quilombolas* (Maroons) are recognized as *geraizeiros* (people who live on the top of the Espinhaço mountain), v*azanteiros* (from the rivers plains and terraces), and as *caatingueiros* (since they occupy dry forests known by local communities as *caatinga*) (D'Angelis Filho, 2009).

The largest *Quilombola* territory and community in the state of Minas Gerais is the Gurutuba Territory, located in the *Jayba* region, a place with a native *Tupi* meaning of "bad water and harsh environment" that arose during colonial times when waterlogging and malaria were common features. Since only black people were immune to this disease, this natural condition safeguarded escaped slaves (Costa, 2006). Despite water scarcity, the long-term adaptation of these *Quilombolas* to a harsh environment acquired over three centuries enabled these smallholders to keep their lands, recognize patterns of soil variations, and separate different landscape units to establish various productive strategies (Matos et al., 2014).

This folk ecological knowledge is traditionally connected to the local context and transmitted across generations by sharing experiences, and it is dynamically adapted to socioecological changes that occur in time and space, in a way similar to that indicated by Krasilnikov and Tabor (2003).

The modernization of this region caused expropriation and sharp socioecological changes that threatened the *Quilombola* food security (Costa Filho, 2008). Within this context, traditional forms of rural extension were based on top-down transfer of knowledge and technologies and on the introduction of new agricultural activities linked to the Green Revolution agricultural model. Although this initiative aimed to integrate *Quilombolas* in the market economy, in most cases, it led to greater difficulties. Without recognition of local needs, interests, and vulnerabilities, many families abandoned traditional agricultural activities vital for food security and adopted other productive activities that intensified land degradation, and they eventually left their homelands (Dayrell et al., 2006). As top-down rural extension failed, new approaches, supported by ethnopedology, developed participatory methodologies aiming at ethically committed guidance of land-use planning for smallholder farmers (FAO, 2001; Coelho, 2014).

The importance of local knowledge has been perceived since the late 19th century, when Dokuchaev founded Modern Pedology using the vernacular knowledge of Russian farmers to classify the soils (Krasilnikov and Tabor, 2003). A century later, Williams and Ortiz-Solorio (1981) introduced "ethnopedology" as a science that dialogues with local people, to understand their knowledge of soil and consider this knowledge in land-use planning. Ethnopedology focuses on the human-soil interface, as well as on landscape ethnoecology processes related to it (construction of ecological knowledge, practices, culture, socioecological trade-offs, etc.) (Toledo and Barrera-Bassols, 2009; Johnson and

Hunn, 2010; Vallejo-Rojas et al., 2015). Hence, bottom-up approaches, based on dialogue between science and local knowledge, is a key working tool for agrarian professionals, enabling horizontal relationships with local communities and consideration of the local context in the land-use planning (Almekinders et al., 2009).

Studies done by Barrera-Bassols and Zinck (2003), Vale Júnior et al. (2007), and Araújo et al. (2013) associate local and classical pedological knowledge about soils, highlighting many agreements between them. Nonetheless, they provide little explanation for the differences between the cognitive systems and the importance of integrating them to better understand the criteria involved in the land-use decision-making process. Local knowledge is still little or marginally considered by scientists in land-use planning. This usually results in land degradation and political and economic constraints (Krasilnikov and Tabor, 2003). These gaps express the need for further scientific investigation of local knowledge and land-use decision making to increase scientific recognition of their legitimacy and better understanding of the elements that affect soil management practices.

The hypothesis of this study is that an ethnopedological analysis of a *Quilombola* territory and local knowledge of soils, landscape, and agricultural capability can reveal critical local perception of land-use decision making, and allow the interplay of different factors and enrichment of the technical approach. The ethnopedological study was carried out in the *Malhada Grande Quilombola* Territory (MGQT), part of the larger Gorutuba territory, whose Afro-brazilian population struggles to become more visible to Brazilian society in search of ensuring food security and territorial legitimacy.

MATERIALS AND METHODS

Description of the study area

The MGQT is located in the rural zone of the municipality of Catuti, in the northern region of the state of Minas Gerais (MG), Brazil, and represents one of the 29 groups that compose the Gurutuba *Quilombola* Territory. This Territory is located in the Gorutuba River valley, a tributary of the Verde Grande River, in the São Francisco Depression. Although the *Quilombola* identity of the community has been already legitimated, the territory has not been, as it is not part of the Gorutuba river drainage area (criteria used by the Brazilian government as a reference to demarcate the area of the *Quilombo*). However, the area is very close to the other territories of the *Quilombo* and it was occupied by the community due to territorial invasion the *Quilombo* underwent in the past.

This study area is a regional pediplain with recent pediments and abundant limestone depressions (karst) (Egger, 2006). The geomorphology ranges from flat to gentle rolling at altitudes from 450 to 510 m. Late Cenozoic unconsolidated sediments (sandy to clayey) make up the mid altitudes and slope substrates, whereas late Precambrian limestone and slates of the Bambuí Group form most lowlands. In the High Mountains, the quartzites of the Espinhaço Supergroup (Upper Proterozoic) are associated with nutrient-poor sandy soils that contribute to the soils of the region (Egger, 2006). The climate is Bsh (semiarid), according to the Köppen classification system. Rainfall is variable but is usually around 690 mm and is concentrated in the spring and summer, leading to droughts. Catuti is considered to be a region susceptible to desertification (Brasil, 2010). As the study area is in a transitional region between *Caatinga* (dry forest) and *Cerrado* (savanna) (Ab'Sáber, 2003), it has Semi-deciduous Seasonal Forests and Deciduous Seasonal Forests (Seasonal Dry Forests *strictu sensu* that mix species from different biomes and whose presence is related to carbonates of the Bambuí Group (Arruda et al., 2013). Degraded deciduous forests are denominated *carrascos* (Andrade-Lima, 1981).

The whole region is dominated by cattle raising. The area studied included the *Quilombo* territory and the expropriated lands that were part of their territory in the past, which they cultivate through permission of the official owners. The local population is made up of 30 *Quilombola* families who practice small-scale agriculture for local use and maintain a great diversity of land use (agroforestry orchards, cultivation of medicinal plants, etc.). The *Quilombolas* are politically organized and engaged in projects aimed at increasing food security and soil conservation.

Methods

Initially, preliminary contacts with local leadership were made by means of participation of members of the research team in regional meetings with traditional populations in the state of Minas Gerais (MG). The local leadership opened access to the community and gathered participants for a workshop and interviews. They also supported workshop planning and authorized community participation in the study. This allowed the project to obtain permission from the ethics committee of the Federal University of Viçosa (MG) to deal with traditional knowledge. Contacts with the NGO “Center for Alternative Agriculture of Northern Minas Gerais” (CAA/NM, acronym in Portuguese) were important to assist in field activities.

A map with a schematic distribution of soils was produced, based on previous knowledge of the research team in regard to the area. Key informants were chosen by the local population, considering their deeper knowledge of soils, to more actively participate in the study (Albuquerque et al., 2014). Other informants who live in different landscape units were indicated. Field campaigns were carried out in the dry and rainy seasons to observe seasonal variations. Workshops were conducted for participatory diagnosis and participatory mapping of soils, landscape units, and land-use areas (Coelho, 2014), where local people acted as protagonists, contributing their knowledge and experiences. The research team directed the workshops, creating dialogue groups and motivating people to talk about their history, achievements, and difficulties related to food production. Then, participatory mapping of soils and landscape was conducted through dialogue and questions about what types of soils people recognized and where they were located. The research team addressed the *Quilombolas* in a trustful horizontal relationship (e.g., sitting on the floor with them during production of participatory mapping) to assure the quality of the data collected. This posture is highlighted by Chambers (2007) as very significant in creating openness of the local groups for knowledge exchange. The data from participatory mapping was checked on guided tours, undertaken in the company of key informants, and during semi-structured interviews (Albuquerque et al., 2014). Georeferencing control points were registered during the tours for the mapping of the geoenvironments.

The dialogue and exchange of knowledge between the research team and the *Quilombolas* was based on an ethnographic approach to distinguish the scientist-oriented knowledge (denominated etic system) from the local ecological knowledge (emic system) (Marques, 2001). Therefore, the Brazilian System of Soil Classification (SiBCS, acronym in Portuguese) and the Land Evaluation System (SAAT, acronym in Portuguese) (Ramalho Filho and Beek, 1995) were compared with the criteria involved in land-use decision making to verify the legitimacy of local knowledge.

The landscape sectors identified by the *Quilombolas* were called “ethnoenvironments” (since they express the local criteria used for their stratification). This aimed at differing them from the scientific classification, presented as geoenvironments (Tricart and Kiewitdejonge, 1992; Rodrigues, 2015). The local system of soil classification was systematized based on the soil characteristics most cited by the *Quilombolas* to classify them, whereas the etic classification of the soils was based on the SiBCS (Santos et al., 2013a). However, this classification was approximated to the World Reference Base for Soil Resources of the FAO (IUSS Working Group WRB, 2015) for presentation in an international system. The emic system was decoded considering corresponding items and relations with the etic cognitive system.

The soils were identified and sampled through one representative soil pit, previously identified by the *Quilombolas*, for each landscape unit. Then, they were decoded by scientific knowledge. All soils were described and collected according to Santos et al. (2013b). Diagnostic properties, diagnostic horizons, and other criteria for definition of soil classes were considered (Santos et al., 2013a). Chemical and physical analyses were conducted according to Donagema et al. (2011). The soil particle size composition, clay dispersed in water, and the degree of flocculation were analyzed according to Ruiz (2005). Because the MGQT was in the midst of a time of struggle during the study, it was necessary to optimize the last field visit. Thus, part of the soils representative of the geoenvironments were obtained using soil augers and only their morphology and physical attributes were analyzed (Donagema et al., 2011). Therefore, they were not classified at the same categorical level as the other samples. These soil classes were identified in the field and were induded as associations with others soil classes that are present in the same landscape units.

The agricultural capability of the lands was evaluated based on criteria recommended by the SAAT, considering soil fertility, water deficiency, oxygen deficiency, susceptibility to erosion, limitation to mechanization, and the level of technological management adopted (level A: primitive, based on a low technical level of farming practices; B: undeveloped or medium level; and C: developed or high technological level). The land use was analyzed in each landscape unit. The current land use, local knowledge regarding the suitability of the land, and land-use decision-making criteria were compared with the recommendations from the SAAT to reveal if there are inconsistencies between them and to understand the reasons why inconsistencies occur. Data analysis was performed through comparison between the scientific and etic classification of soils, in which the landscape analysis was performed through an ethno/geoenvironmental identification-key (Petersen, 1996).

The map of soils and geoenvironments was produced using the ArcGIS10 software. Delimitation of the polygons mapped was created using an available cartographic base (IBGE, 2009). The georeferenced and systematized data regarding landscape and soils were overlapped on RapidEye satellite images (with a spatial resolution of 5 m from 28 March 2010). Therefore, the preliminary soil map was adjusted to the data collected. The units that could not be separated in the satellite image were grouped. Finally, a field expedition was conducted to return the data to the *Quilombola* community and perform validation of the maps and identification key, as well as receive their comments.

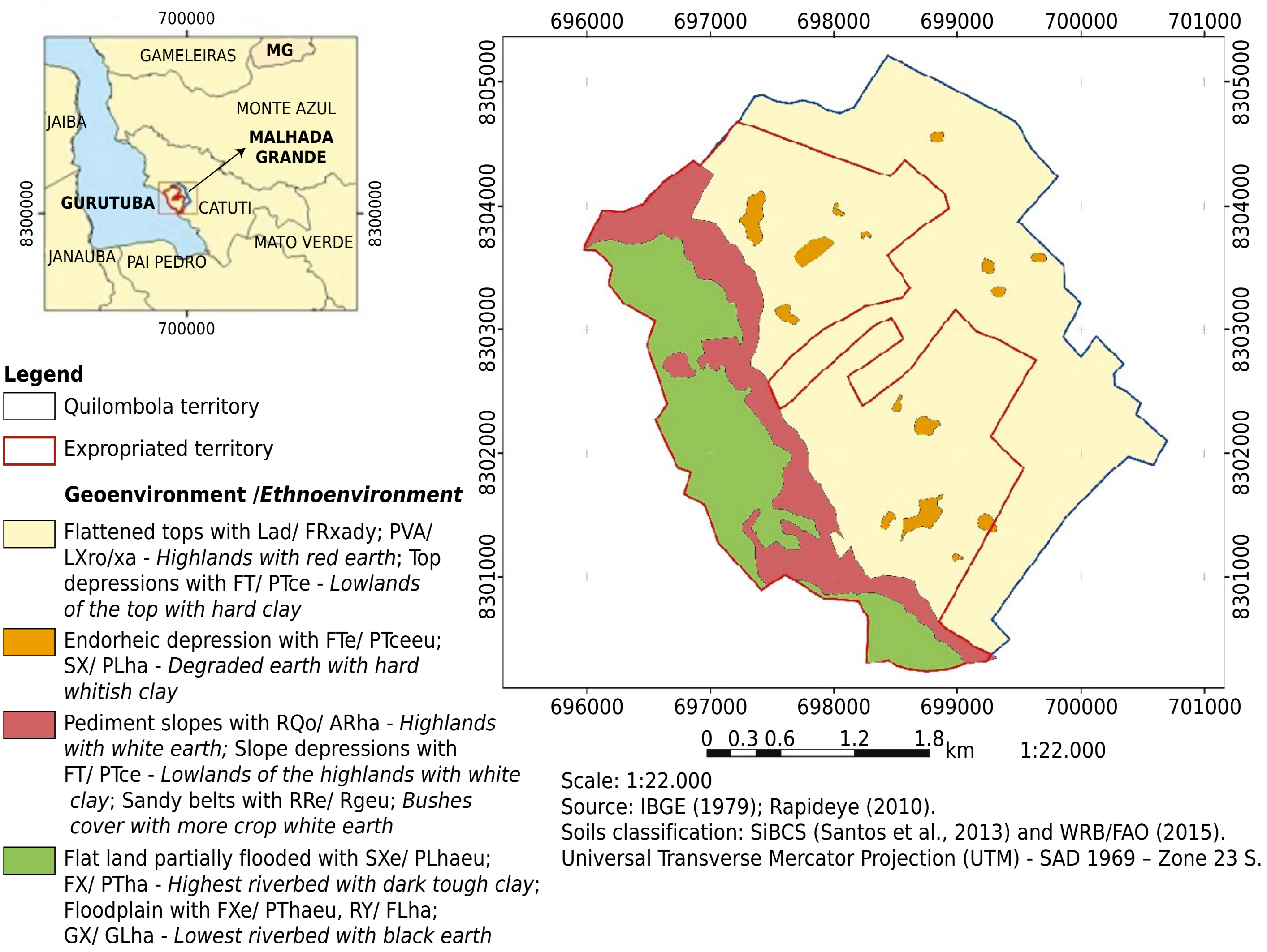
RESULTS AND DISCUSSION

Ethnopedological characterization of geoenvironments and agricultural aptitude of lands

The presence of flattened tops with Dystric Xanthic Ferralsols (Clayic) (FRxady) and Rhodic/Xanthic Lixisols (LXro/xa), locally denominated as “Highlands with red earth” (Figure 1), is associated with a complex of semi-deciduous forest and degraded seasonal deciduous forest (*Carrasco*), corroborating Arruda et al. (2013). This vegetation, commonly found in the semiarid northern region of MG corresponds to secondary forest characterized by assemblying species of dry forest, including *cerrado* (savanna) and *caatinga*. The FR at an altitude of 509 m is dystrophic in the B horizon (BS = 28 %) and acidic (Al saturation = 47 %) (Table 1); it is dark yellowish-brown in the A horizon, has a loamy texture and granular structure (“fine earth”), and is soft and very friable in the ferralic horizon; it is dystrophic (“poor soil”), well-drained, and porous (“difficult to hold water”) (Tables 2 and 3).

The presence of Ferralsols with corresponding semi-deciduous forest formations in this semiarid domain indicates a more humid paleoclimate, which is necessary for the pedogenesis of this deep-weathered soil and associated vegetation (Arruda et al., 2013). The establishment of the semiarid climate in the São Francisco River Depression led these forests to more deciduous formations, culminating in the current distribution pattern. The abundant presence of relict elements, non-active termite mounds (*murundu* fields) and coprolites, in the flattened tops (Figure 2) confirms this previous climate, since groundwater is a necessary condition for termite activity (Ibraimo et al., 2004).

According to the SAAT, the FR are suitable for planted pasture, with restriction by water deficiency, requiring a C level of management (Table 4). Thus, is it not a coincidence that, according to the *Quilombolas*, these were the priority soils acquired by farmers to introduce cattle raising under irrigation after modernization of the region. The uncleared areas where the *carrascos* and semi-deciduous forests remain are used by the *Quilombolas* as natural pasture and for extraction of food and medicinal plants (which are grown on their properties). Most of the FR is on lands of farmers (Figure 1), who allow the *Quilombolas* to continue this use, which is essential for their food security. An interesting practice is "extraction" of soils, which are transported to their home gardens and mixed with the sandy soils of the slopes to support seed germination of plants used in the traditional food system. The *Quilombolas* recognize that the Ferralsols could be the best soils in the MGQT to provide food production due to their good drainage and capacity to store water throughout the year. However, this would require a higher level of management (C) that they cannot afford.



Scale: 1:22.000
Source: IBGE (1979); Rapideye (2010).
Soils classification: SiBCS (Santos et al., 2013) and WRB/FAO (2015).
Universal Transverse Mercator Projection (UTM) - SAD 1969 – Zone 23 S.

SiBCS - WRB/FAO: LAd: *Latossolo Amarelo Distrófico argissólico* - FRxady: Dystric Xanthic Ferralsols (Clayic); PVA: *Argissolo Vermelho-Amarelo* - LXro/xa: Rhodic/Xanthic Lixisols; FT: *Plintossolo Argilúvico* - PTce: Clayic Plinthosols; FTe: *Plintossolo Argilúvico Eutrófico abrúptico* - PTceeu: Eutric Clayic Plinthosols (Abruptic); SX: *Planossolo Háplico* - PLha: Haplic Planosols; RQo: *Neossolo Quartzarênico Órtico típico:* ARha: Haplic Arenosols (Typical); FT: *Plintossolo Argilúvico* - PTCe; RRe: *Neossolo Regolítico Eutrófico típico* - RGeu: Eutric Regosols (Typical); SXe: *Planossolo Háplico Eutrófico solódico* - PLhaeu: Eutric Haplic Planosols (Solodic); FX: *Plintossolo Háplico* - PTha: Haplic Plinthosols; FXe: *Plintossolo Háplico Eutrófico típico* - PThaeu: Eutric Haplic Plinthosols (Typical); RY: *Neossolo Flúvico* - FLha: Haplic Fluvisols; GX: *Gleissolo Háplico* - GLha: Haplic Gleysols.

Figure 1. Ethnopedological map of geoenvironments and ethno-environments of Malhada Grande *Quilombola* Territory (Catuti, MG, Brazil).

Table 1. Chemical properties of soils classified according to the SiBCS and WBR/FAO - Malhada Grande, northern Minas Gerais, Brazil

Pedon	Depth	pH		P	K	Na	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al	SB	CA	T	V	m	NaSat	OM	rem-P	Zn	Fe	Mn	Cu
		H_2O	KCl																			
	m				mg dm^{-3}					cmol$_c$ dm^{-3}					%		dag kg^{-1}	mg L^{-1}		mg dm^{-3}		
P01 - LAd - FRxady																						
A	0.0-0.15	5.94	4.92	3.0	92.0	0.0	2.1	0.5	0.0	2.3	3.0	30.6	5.2	56	0.0	0.0	1.6	54.1	0.6	11.0	28.0	0.2
Bw	0.15-0.80	4.68	4.07	1.0	27.0	0.0	0.9	0.3	1.1	3.1	1.2	16.5	4.3	28	47.0	0.0	0.5	36.6	0.1	9.3	15.0	0.4
P02 - FTe – Ptceeu – Eutric Clayic Plinthosols (Abruptic)																						
A	0.0-0.20	6.55	5.75	3.0	72.0	1.1	1.4	0.3	0.0	2.1	2.0	50.0	4.0	48	0.0	0.3	0.5	60.0	0.1	49.0	7.1	0.3
E	0.20-0.40	7.02	5.57	1.0	64.0	4.1	0.9	0.3	0.0	2.1	1.4	58.3	3.5	40	0.0	1.3	0.0	60.0	0.0	44.0	12.0	0.7
EB	0.40-0.50	6.22	4.75	1.0	156.0	4.1	3.2	1.0	0.0	2.1	4.5	26.8	6.7	68	0.0	0.4	0.1	58.4	0.0	38.0	17.0	0.4
Bf	0.50-0.80	5.87	4.79	1.0	135.0	11	5.0	1.8	0.0	2.6	7.2	22.3	9.8	73	0.0	0.7	0.1	39.3	0.2	21.0	3.0	0.0
P03 - RQo - RGeu																						
A	0.0-0.10	7.12	6.08	5.0	114.0	0.0	2.1	0.3	0.0	0.6	2.7	110.0	3.3	82	0.0	0.0	1.2	60.0	1.5	2.8	41.0	0.0
C_1	0.10-0.20	7.39	6.23	2.0	52.0	0.0	1.5	0.3	0.0	0.5	2.0	83.3	2.5	80	0.0	0.0	0.5	60.0	0.3	3.0	15.0	0.0
C_2	0.20-0.50	6.23	5.48	2.0	42.0	0.0	1.4	0.3	0.0	1.0	1.9	56.0	2.8	65	0.0	0.0	0.5	60.0	0.3	3.0	15.0	0.0
C_3	0.50-0.70	6.53	5.5	1.0	44.0	0.0	1.1	0.2	0.0	0.3	1.4	42.5	1.7	82	0.0	0.0	0.3	60.0	0.1	19.0	6.8	0.1
C_4	0.70-0.80	6.42	4.84	1.0	43.0	0.0	0.5	0.2	0.0	0.5	0.8	65.0	1.3	62	0.0	0.0	0.1	60.0	0.0	14.0	3.3	0.1
P04 - RRe - ARha																						
A	0.0-0.12	5.92	4.83	4.6	57.0	0.0	1.2	0.3	0.0	1.6	1.7	55.0	3.3	50.8	0.0	0.0	1.1	60.0	0.8	44.8	18.0	0.1
C_1	0.12-0.40	5.51	4.3	1.3	49.0	0.0	0.7	0.2	0.2	1.9	1.0	41.4	2.9	34.3	17.0	0.0	0.7	60.0	0.1	80.2	4.3	0.0
C_2	0.40-0.70	5.09	4.15	1.4	38.0	0.0	0.6	0.1	0.7	2.1	0.8	36.3	2.9	27.3	46.0	0.0	0.5	60.0	0.1	99.5	1.9	0.0
P05 - SXe - Lhaeu																						
A	0.0-0.10	5.99	4.73	4.0	37.0	30.0	1.8	0.5	0.0	2.1	2.5	65.7	4.6	54	0.0	5.2	1.71	60.0	0.8	195.0	41.0	0.4
E	0.10-0.17	7.06	4.94	2.0	29.0	117.0	1.7	0.7	0.0	0.8	2.9	37.0	3.7	79	0.0	17.2	0.7	60.0	0.2	128.0	35.0	0.3
B	0.17-0.50	8.43	6.23	6.0	22.0	458.0	8.4	3.3	0.0	0.6	14.0	52.5	14.7	96	0.0	14.6	0.4	57.3	0.0	37.0	29.0	0.2
P06 - FXe - PThaeu																						
A	0.0-0.8	5.3	4.32	5.7	71.0	22.3	2.5	0.7	0.3	5.6	3.5	30.3	9.1	38	8.0	2.6	2.8	20.2	1.9	152.0	30.0	0.6
AB	0.8-0.18	5.58	4.36	4.3	52.0	24.3	2.3	0.8	0.1	4.0	3.3	26.1	7.3	45	3.0	3.1	1.6	20.4	1.5	83.5	25.0	0.6
B	0.18-0.47	5.6	4.3	2.0	52.0	14.3	2.1	1.0	0.1	2.0	3.3	19.6	5.3	62	3.0	1.8	0.5	30.7	0.5	76.7	15.0	0.4
BC	0.47-0.60	5.69	4.5	2.0	25.0	19.3	2.2	1.4	0.0	1.7	3.7	20.4	5.3	70	0.0	2.3	0.3	32.1	0.2	55.1	9.8	0.4
C	0.60-0.77	5.76	3.98	1.3	24.0	44.4	2.3	2.2	0.3	2.0	4.8	25.2	6.8	70	6.0	3.8	0.1	39.8	0.1	43.4	12.0	0.6

(1) Soil classification [SiBCS - Santos et al. (2013) and WRB/FAO (2015)]: LAd: *Latossolo Amarelo Distrófico argissólico* - FRxady: Dystric Xanthic Ferralsols (Clayic); FTe: *Plintossolo Argilúvico Eutrófico abrúptico* - PTceeu: Eutric Clayic Plinthosols (Abruptic); RQo: *Neossolo Quartzarênico Órtico típico*: ARha: Haplic Arenosols (Typical); RQo: *Neossolo Quartzarênico Órtico típico*: ARha: Haplic Arenosols (Typical); RRe: *Neossolo Regolítico Eutrófico típico* - RGeu: Eutric Regosols (Typical); SXe: *Planossolo Háplico Eutrófico solódico* - PLhaeu: Eutric Haplic Planosols (Solodic); FXe: *Plintossolo Háplico Eutrófico típico* - PThaeu: Eutric Haplic Plinthosols (Typical). SB: sum of bases; CA: clay activity (T/clay content × 1000); T: cation exchange capacity at pH7.0; V: base saturation; m: Al saturation; NaSat: Na saturation; OM: organic matter, total C analysis; pH in water and 1 mol L^{-1} KCl solution; P, K, Na, Zn, Fe, Mn, Cu: Mehlich-1 extractor; Ca^{2+}, Mg^{2+}, Al^{3+}: extractor 1 mol L^{-1} KCl; H+Al: acidity potential, calcium acetate 0.5 mol L^{-1}; Rem-P: remaining phosphorus.

The LX occurs in association with FR in the transition between the flattened tops and the top depressions, at an altitude of 490 m. The LX is light reddish-brown, is slightly hard and firm and has a clay texture at the argillic horizon (“sticky”) and easily weathered primary minerals such as feldspar and mica. These soils have similar morphologic characteristics and receive the same use by the *Quilombolas* (natural grazing and extractivism). Thus, they are also considered the “red earth” of the highlands.

The top depressions with Clayic Plinthosols (PTce) (Figure 2) are identified by the *Quilombolas* as “Lowlands of the top with hard clay”. This soil occurs at an altitude of 487 m, associated with sparse seasonal deciduous forest, and reflects the shallow depth, hardness, and poor drainage of the PT (Table 3). The morphologic description of this soil reveals that it has an yellowish-brown B1 horizon (“white tough clay”), with a clayey texture, soft and friable, changing to a plinthic B2 horizon with reddish mottling and Fe-Mn concretions, which are called “slate” and “flagstones”, by the *Quilombolas* (Table 3). The top depressions, as well as the pools of the Endorheic depression, have

Table 2. Physical properties of soils classified according to the SiBCS(1) and WRB/FAO - Malhada Grande, northern Minas Gerais, Brazil

Pedon	Depth	Coarse sand	Fine sand	Silt	Clay	DC	F	S/C
	m	g kg^{-1}					%	
				P01 - Lad - FRxady				
A	0.00-0.15	330	420	80	170	40	77	0.47
Bw	0.15-0.80	230	400	110	260	40	85	0.42
				P02 - FTe - PTceeu				
A	0.00-0.20	320	500	100	80	20	75	1.3
E	0.20-0.40	290	500	150	60	30	50	2.5
EB	0.40-0.50	280	350	120	250	110	16	0.5
Bf	0.50-0.80	210	250	100	440	120	73	0.2
				P03 - RQo - RGeu				
A	0.00-0.10	310	510	150	30	0	100	5.0
C_1	0.10-0.20	300	530	140	30	0	100	4.7
C_2	0.20-0.50	380	430	140	50	10	80	2.8
C_3	0.50-0.70	270	570	120	40	10	75	3.0
C_4	0.70-0.80	330	510	140	20	10	50	7.0
				P04 - RRe - ARha				
A	0.00-0.12	140	660	140	60	10	83	2.3
C_1	0.12-0.40	180	610	140	70	20	71	2.0
C_2	0.40-0.70	150	610	160	80	20	75	2.0
				P05 - SXe - Lhaeu				
A	0.00-0.10	170	470	290	70	10	86	4.1
E	0.10-0.17	210	370	320	100	20	80	3.2
B	0.17-0.50	120	220	380	280	200	29	1.4
				P06 - FXe - PThaeu				
A	0.00-0.08	60	370	270	300	30	90	0.9
AB	0.08-0.18	60	400	260	280	10	97	0.9
B	0.18-0.47	50	440	240	270	40	85	0.9
BC	0.47-0.60	70	490	180	260	30	89	0.7
C	0.60-0.77	120	420	190	270	60	78	0.7

(1) SiBCS (Santos et al., 2013a) – WRB/FAO (2015): LAd: *Latossolo Amarelo Distrófico argissólico* - FRxady: Dystric Xanthic Ferralsols (Typical); FTe: *Plintossolo Argilúvico Eutrófico abrúptico* - PTceeu: Eutric Clayic Plinthosols (Abruptic); RQo: *Neossolo Quartzarênico Órtico típico* - ARha: Haplic Arenosols (Typical); RRe: *Neossolo Regolítico Eutrófico típico* - RGeu: Eutric Regosols (Typical); SXe: *Planossolo Háplico Eutrófico solódico* - PLhaeu - Eutric Haplic Planosols (Solodic); FXe: *Plintossolo Háplico Eutrófico típico* - PThaeu: Eutric Haplic Plinthosols (Typical). DC: dispersed clay; F: flocculation; S/C: silt/clay ratio. Coarse sand, fine sand, silt, clay: particle size analysis (pipette method).

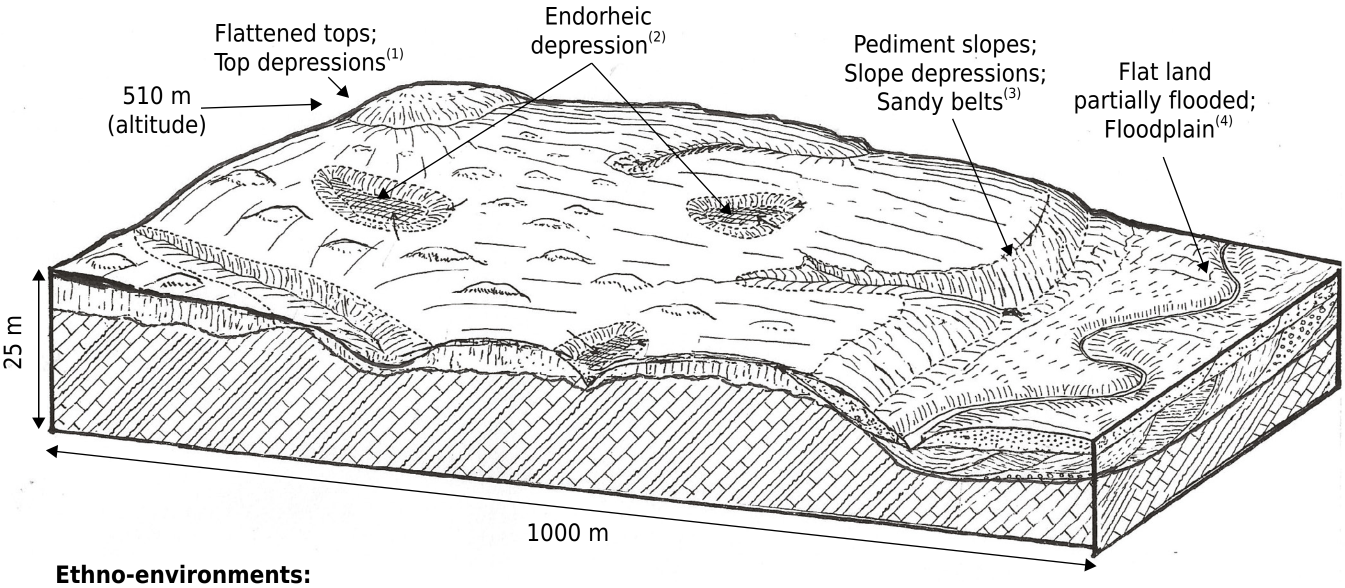
Table 3. Identification-key of local knowledge and pedological knowledge about soils and landscape - Malhada Grande, northern Minas Gerais, Brazil

Geoenvironment Ethno-environment[1]	Characterization of the environments[2]	Soil classification		Soil characterization[5]
		Local[1]	SiBCS - WRB/FAO[3]	
Flattened tops with Lad/ FRxady; PVA/LXro/xa/ *Highlands with red earth*	Top of the landscape; complex of semi-deciduous and degraded seasonal deciduous forest/ *Top with flattened earth and carrasco*	*Red earth*	LAd - FRxady, PVA - LXro/xa[4]	FRxady: dark yellowish-brown in A horizon (*red*), loam texture, granular structure (*fine earth*), soft, very friable in ferralic horizon; dystrophic (*poor soil*), well-drained and porous (*hold water*). LXro/xa: light reddish-brown, clay texture, slightly hard and firm in argillic horizon (*sticky*)
Top depressions with FT/PTce/ *Lowlands of the top with hard clay*	Depressions with sparse seasonal deciduous forest/ *Lowland with low, dry and sparse vegetation*	*White hard clay*	FT – Ptce	Yellowish-brown in B1 horizon (*white*), clay texture, soft, friable, poorly drained, with reddish mottling and Fe-Mn concretions in plinthic horizon (*slate and flagstones*)
Endorheic depression with FTe/PTceeu; SX/PLha/ *Degraded earth with hard whitish clay*	Depressions formed by morphogenetic endokarst process/ *Low wetlands of the top that retain water*	*White harder clay*	FTe - PTceeu, SX – Plha	FTceeu: dark grayish in A horizon (*white*), clay texture, hard/very hard, firm/very firm consistency (*harder*), eutrophic, base saturation = 73 % (*more crop*), mottling and concretions (*slate and flagstones*) in plinthic horizon, blocky structure (*lump of soil*). PLha: yellowish-brown, medium texture and very hard, firm consistency in albic horizon
Pediment slopes with RQo/ ARha/ *Highlands with white earth*	Slope that receives concentrated sandy material from the top; sparse seasonal deciduous forest/ *Difficult to hold water*	*White earth*	RQo - ARha	Yellowish-red in C1 horizon (*white*), sandy loam texture, soft and friable consistency (*loose earth*), pronounced drainage (*difficult to hold water*), dystrophic (*poor soil*)
Slope depressions with FT/ PTce/ *Lowlands of the highlands with white clay*	Slope depressions/ *White lowlands*	*White clay*	FT – Ptce	Brown, sandy clay loam, very hard, very firm (*hard*), moderate drainage, mottling and Fe-Mn concretions (*slate and flagstones*), blocky structure (*lump of soil*) in plinthic horizon.
Sandy belts with RRe/ Rgeu/ *Bush cover with more crop white earth*	Sandy belts with remaining seasonal deciduous forest/ *More productive highlands with white earth, areas that conserve bush cover* (secondary forest)*More productive highlands with white earth, areas that conserve bush cover* (secondary forest)	*More crop white earth*	RRe - RGeu	RGeu: grayish (*white*), sandy loam, soft, friable (*loose earth*), accentuated drainage (*difficult to hold water*), eutrophic, base saturation = 80 % (*more crop*) in C1 horizon, presence of easily weathered minerals
Flat land partially flooded with SXe/ PLhaeu; FX/ PTha *-Highest riverbed with dark tough clay;*	Poor drainage areas, colmatation sediments; highest riverbed turning fluvial terrace; seasonally flooded marsh fields / *Earth that only gives grass*	*Dark clay*	SXe - PLhaeu, FX - PTha	PLhaeu: light grayish, clay loam, very hard, firm consistency (*clay*), very poor drainage, prismatic (*long lump of soil*, *cracking soil while dry*), eutrophic, base saturation = 96 % in albic horizon. PTha: brown, clay loam, very hard, friable (*sticky*), poor drainage in plinthic horizon. Mottling in PL and PT and petroplinthite (*slate and flagstones*)
Floodplain with FXe/ PThaeu, RY/ FLha; GX/ GLha/ *Lowest riverbed with Black Earth*	Highest riverbed area that receives colluvial-alluvial sediments; seasonal semi-deciduous riparian forest/ *Areas where there are bush at river's edge*	*Dark earth*	FXe - PThaeu, RY – Flha, GX – Glha	PTha: yellow-brown, clay texture, soft, friable (*loose earth when dry*), poor drainage, eutrophic in plinthic horizon (*more crop*). FLha: dark brown, loam texture, slightly hard, friable/firm, moderate drainage in C1 horizon. GLha: grayish-brown, loam texture, soft, friable, poor drainage in C1 horizon. Different presence of mottling and concretions (*slate and flagstones*) in these soils

[1] Etic pedological and corresponding emic knowledge (italicized). [2] Ethno-environment separated by vegetation. [3] Soil classification [SiBCS - Santos et al. (2013) and WRB/FAO (2015)]: LAd: *Latossolo Amarelo Distrófico argissólico* - FRxady: Dystric Xanthic Ferralsols (Clayic); FTe: *Plintossolo Argilúvico Eutrófico abrúptico* - PTceeu: Eutric Clayic Plinthosols (Abruptic); RQo: *Neossolo Quartzarênico Órtico típico*: ARha: Haplic Arenosols (Typical); RQo: *Neossolo Quartzarênico Órtico típico*: ARha: Haplic Arenosols (Typical); RRe: *Neossolo Regolítico Eutrófico típico* - RGeu: Eutric Regosols (Typical); SXe: *Planossolo Háplico Eutrófico solódico* - PLhaeu: Eutric Haplic Planosols (Solodic); FXe: *Plintossolo Háplico Eutrófico típico* - PThaeu: Eutric Haplic Plinthosols (Typical). [4] Samples obtained from augering. Morphological description only.

an endokarstic origin associated with the Bambuí Group, which corroborates D'Angelis Filho (2009) and Matos et al. (2014). However, the top depressions have a lower level of morphogenetic karstic evolution. These transitions and associated changes in the soils were reported by the *Quilombolas*. According to them, this environment was used in the past for planted pastures. However, the soil toughness restricted land use to natural pasture. In accordance with the observations in the field and the Quilombolas perception, the use of the PT is limited because of water deficiency and the soil consistency.

The Endorheic depression with Eutric Clayic Plinthosols (Abruptic) (PTceeu) and Haplic Planosols (PLha) is classified by the Quilombolas as "Degraded earth with hard whitish clay" (Figure 1). Dolines, originating from dissolution of the Bambuí limestone (Figure 2), promote groundwater flow and undermining of the surface and are associated with sandy detritus covers of the Espinhaço Supergroup. The seasonal deciduous forest reflects the poor drainage condition of the soils (Table 3). The PT is located at an altitude of 484 m; has light color (yellowish-brown) influenced by the reducing environment (Alleoni and Melo, 2009); is dark grayish in the A horizon ("white harder clay"); has clay texture, hard/very hard and firm/very firm consistency ("harder"), eutrophy, base saturation = 73 % ("better harvest"), mottling and concretions ("slate and flagstones") in the plinthic horizon, and blocky structure ("lump of soil"). The morphologic description of the PL reveals that it is yellowish-brown and has medium texture and very hard/firm consistency in the albic horizon (Table 3). The *Quilombolas* characterize the soils of this landscape sector as *sticky*, with a *lump* structure rich in nutrients. They also pointed out that most of them have mottling and concretions. This soil is located at 480 m of altitude. When compared to the FR, it shows how much the soil characteristics vary across a small altitudinal difference. Although the PL does not show the presence of plinthization, the horizons are clayey (Table 3), and both soils serve for natural grazing and are classified as "white harder clay".



Ethno-environments:
(1) *Highlands with red earth; Lowlands of the top with hard clay;*
(2) *Degraded earth with hard whitish clay;*
(3) *Highlands with white earth; Lowlands of the highlands with white clay; Bushes cover with more crop white earth;*
(4) *Highest riverbed with dark tough clay; Lowest riverbed with black earth.*

Figure 2. Block-diagram of the Malhada Grande *Quilombola* Territory (Catuti, MG, Brazil) showing the general landscape developed on alternating slates and limestone of the Bambuí Group (Late Precambrian) covered by Quaternary colluvial (hills and tablelands) and alluvial sediments (floodplain). The Termite Mounds (*Murundus*) are found on the top surface.

Table 4. Agricultural suitability evaluation and classification of land use - Malhada Grande, northern Minas Gerais, Brazil

Soil classification[1]	Relief	Climate	Vegetation	Limitation level of the land use per level of management					Class of agricultural aptitude	Land use
				FD A B C	WD A B C	OD A B C	SE A B C	IM A B C		
LAd - FRxady	Plain	Bsh	Degraded seasonal deciduous forest (*Carrasco*)	M/F M M1	S S S	N N N	N N N	N N N	4P	Natural grazing and extractivism
FTe - PTceeu	Plain/ Moderate slope	Bsh	Seasonal deciduous forest	N N N	S S S	M M M	L L L	M M M	4P	Natural grazing
RQo - ARha	Plain	Bsh	Sparse seasonal deciduous forest	M/F M1 M1	S S S	N N N	N N N	L L L	4(p)	Houses, annual crops, and natural grazing
RRe - RGeu	Plain/ Moderate slope	Bsh	Seasonal deciduous forest	N/L1 N N	F F F	N N N	N N N	L L L	4(p)	Environmental preservation area
SXe - PLhaeu	Moderate slope	Bsh	Flatland partially flooded	M M M	L L L	M/S M/S M/S	L L L	M M M	5n	No agricultural aptitude
FXe - PThaeu	Plain	Bsh	Seasonal semi-deciduous riparian forest	L L L	M M M	S S S	N N N	M M M	3(a)	Planted pasture, cultivation of rice and sugarcane, and riparian forest

[1] SiBCS (Santos et al., 2013a) – WRB/FAO (2015): LAd: *Latossolo Amarelo Distrófico argissólico* - FRxady: Dystric Xanthic Ferralsols (Typical); FTe: *Plintossolo Argilúvico Eutrófico abrúptico* - PTceeu: Eutric Clayic Plinthosols (Abruptic); RQo: *Neossolo Quartzarênico Órtico típico* - ARha: Haplic Arenosols (Typical); RRe: *Neossolo Regolítico Eutrófico típico* - RGeu: Eutric Regosols (Typical); SXe: *Planossolo Háplico Eutrófico solódico* - PLhaeu - Eutric Haplic Planosols (Solodic); FXe: *Plintossolo Háplico Eutrófico típico* - PThaeu: Eutric Haplic Plinthosols (Typical). SAAT land evaluation system (Ramalho Filho and Beek, 1995). Criteria of classification: Bsh: semiarid. 4P: good for planted pasture; 4(p): restricted to natural grazing; 3: restricted for crop; 5n: no agricultural aptitude; A: A-level management; 5n: - no level management; p: P-level management. Degrees of limitation: N: 0 (null); 1 (light); 2 (moderate); 3 (strong); 4 (very strong). FD: fertility deficiency; WD: water deficiency; OD: oxygen deficiency; SE: susceptibility to erosion; IM: impediment to mechanization.

According to the SAAT and local knowledge, the PT is suitable for natural grazing and is constrained by water deficiency (Table 4). The use of the Endorheic depression is consistent with the SAAT. Nevertheless, this geoenvironment and the depressions of the top and slope had the largest water reserves and were used for planted pasture and agriculture in the past. This physiographic condition changed with the advance of detritus deposition over the lowlands, river silting, the karstic process, and intensification of drought. In addition, social forces, such as building dams around the headwaters of the river, decreased the water supply downstream, intensifying this change. Therefore, the base level of the local river was reduced, the dolines no longer had a direct connection with the river during the rainy season, and most of the pools disappeared. It is noteworthy that the possibility of climate change indicated by the *Quilombolas*, expressed in intensification of droughts, was based on observation of this process for more than 30 years. However, further studies are required to confirm this.

These environmental problems were intensified by social changes in the context of modernization in the North of MG. The adoption of arboreal cotton cultivation, stimulated by the Technical Assistance and Rural Extension Company of Minas Gerais (Emater-MG, acronym in Portuguese), introduced the technological package of the Green Revolution in the MGQT, with genetically modified seeds, agricultural inputs (pesticides and fertilizers), and machinery (Costa Filho, 2008). Nevertheless, they soon lost their crops because of a pest they could not combat. Without receiving governmental support to overcome this pest, the *Quilombolas* halted this activity, became indebted, and adopted charcoal production (activity already abandoned). According to the *Quilombolas*, this led to deforestation and land degradation (erosion, impermeability and sealing of the soils, reduction in water storage capacity, etc.) and threatened the subsistence agriculture. Because of that, many families sold their lands and the *Quilombolas* became dependent on temporary migration to sell their labor to land owners of distant regions (where the climate allows monocultures and demands hiring of laborers) to supplement their families' food security.

The pediment slopes with Haplic Arenosols (Typical) (ARha), classified by the *Quilombolas* as "Highlands with white earth" (Figure 1), originated from the concentrated flow of sandy materials from the flattened top. They occur at an altitude of 482 m, associated with the sparse seasonal deciduous forest, which was cut to supply charcoal production. The ARha is yellowish-red at the C1 horizon ("white earth"), has sandy loam texture, soft/friable consistency ("loose earth"), pronounced drainage ("difficult to hold water"), and is dystrophic ("poor soil") (Tables 1 and 3). The agricultural aptitude of the AR is restricted to natural grazing, due to water deficiency (Table 4). Nevertheless, this soil is used for residences, home gardens (which contain agroforestry orchards where fruits, vegetables, and medicinal plants are cultivated, and pigs and chickens are raised), annual crops (corn, beans, watermelon, cotton, sorghum, cassava, etc.), and natural grazing (Table 4). Although it exceeds the SAAT recommendation, because land use prevails, this landscape sector is a strategic area for providing food security since it is closer to the river and not flooded during the rainy season (Figure 2). The same importance of the slopes for the food supply of the traditional communities of the Verde Grande River was reported by Costa Filho (2008) and Matos et al. (2014). The *Quilombolas* use level A management and occasionally use machines and fertilizer (level B). As irrigation is not affordable, they extract what is possible from this soil.

The slope depressions with Clayic Plinthosols (PTce), which are located at an altitude of 487 m, are classified by the *Quilombolas* as "Lowlands of the highlands with white clay" and are also areas under karstic influence (Figure 1). This environment underwent massive deforestation during the period of arboreal cotton and charcoal production. For that reason, it is no longer called "bush cover" (area with secondary forest) by the *Quilombolas*. The PT is brown and has sandy clay loam with very firm ("hard") consistency, moderate drainage, mottling, and Fe-Mn concretions ("slate" and "flagstones"), as well as blocky structure ("lump of soil") in the plinthic horizon (Table 3). The whitish appearance is related to the psammitic and kaolinitic source material. Elevated groundwater established the presence of plinthization, expressed by reddish mottling and petroplinthite. Concurring with this, the *Quilombolas* describe the PT as "white", "clayey", and "tough", with the presence of "lump structure", "slate", and "flagstones". According to observations in the field and the *Quilombolas* knowledge, the usefulness of the PT is limited to natural grazing, due to water deficiency and toughness. Accordingly, this soil showed densification and compression. The *Quilombolas* indicated that it would be possible to use this soil for planted pasture by applying subsoiling techniques, as the farmers do. However, as was already mentioned, they cannot implement a C level of management because of economic constraints. Despite that, the *Quilombolas* whose properties do not have Arenosols (AR) use the PT in the same way as the AR, though with lower yield.

The sandy belts with Eutric Regosols (Typical) (RGeu), called "bush cover" (secondary forest), with "better harvest on white earth" (Figure 1) are located at an altitude of 472 m. These soils originated from pediment erosion of the slope oriented to the floodplain (Figure 2). The RG is grayish ("white earth"), has sandy loam and soft/friable consistency ("loose earth"), with base saturation = 80 % ("better harvest"), easy drainage ("not holding water earth"), eutrophyc in the C_1 horizon, and contains easily weathered minerals (feldspar and mica) (Tables 1 and 3). The RG is restricted to natural pasture due to water deficiency. However, the lower acidity of this soil allows agricultural productivity, as the *Quilombolas* achieve in the RG. Since in the RG are widespread Gorutuba River catchment, the soils of the slopes are the most intensively used by the *Quilombolas* because they are located near the river, and unaffected by flooding during the rainy season. As this landscape sector is surrounded by lowlands with poorly drained soils, access to it is seasonally restricted. Thus, it is used for forest conservation and is still recognized as “bush cover”. Although the *Quilombolas* perceive that this soil has characteristics very similar to the AR, except for fertility, they separate this soil class because it serves a different land use.

The AR and RG reflect the geology (with a predominance of thin or sandy texture) (Table 2) and the climate of the region (which promotes low leaching and hence conserves bases in the soil sorptive complex). The PL and RG showed a high silt/clay ratio, indicating low pedogenetic development associated with the geology and climate.

The partially flooded flat land has Eutric Haplic Planosols (Solodic) (PLhaeu) and Haplic Plinthosols (PTha), and is locally classified as “Highest riverbed with dark, tough clay” (Figure 1). This geoenvironment is in the process of becoming a fluvial terrace due to lowering of the local river base level and occurs in association with the seasonally flooded marsh fields (Table 4). The PL is located at an altitude of 470 m and has a high elevated content of Na^+ (458 mg dm^{-3}), solodicity (Na saturation = 14.6 %) (Table 1), has a prismatic structure, high CEC (14.7 $cmol_c$ dm^{-3}), 20 % dispersed clay in the albic horizon (Table 2), and feldspar and mica (which are favored by the climate, sedimentation, and fluctuation of the groundwater, which provides pedogenetic renovation). These characteristic explain why this soil is characterized by the *Quilombolas* as a “cracking soil” (Table 3). The dark color is favored by the accumulation of organic matter, which is also perceived by the *Quilombolas*. This soil is very hard and firm in the diagnostic horizon and is very poorly drained. The eutrophy (Table 1) and solodicity were not identified by the *Quilombolas*, but the soil was described as not usable for any crop because of its toughness. Similar to PT, the PL soil is brown, clay loam with a very hard/friable consistency (“sticky clay”) and poor drainage in the plinthic horizon. Mottling in both, PL and PT, and petroplinthite (“slate” and “flagstones”) were also observed. The local population jointly classifies the PL and PT as “dark tough clay” since they serve the same land use (Table 3).

The PL was classified as having no agricultural aptitude (Table 4). Field observations showed that both PL and PL are used with natural grazing because solodicity, compaction and flooding prevent other uses.

The floodplain, associated with Eutric Haplic Plinthosols (Typical) (PThaeu), Haplic Fluvisols (FLha), and Haplic Gleysols (GLha) is denominated by the *Quilombolas* as “Lowest riverbed with Black Earth” (Figure 1), corresponding to the Salinas-Pacuí riverbed. The *Quilombolas* also call this area *vazante*. This is corroborated by Ab’Sáber (1999), who explains that the inland dry regions of the Brazilian intertropical areas (*sertões*) where the lands bordering rivers are reached by rising water in the rainy season of the year are denominated *vazantes* (floodplain) by the local population. This area receives colluvial-alluvial sediments from the upper portions of the landscape and occurs in association with the seasonal semi-deciduous riparian forest (Table 3). The PT is located at an altitude of 472 m. It is yellow-brown, has a clay texture and soft/friable consistency (“loose clay that doesn’t crack when dry”), poor drainage, and eutrophy in the plinthic horizon (“better harvest”). The FL is located at an altitude of 460 m. It is dark brown, has loamy texture and slightly hard, friable/firm consistency, and moderate drainage in the C_1 horizon. The GL is located at the lowest altitude identified in the soil mapping, at 457 m. This soil is grayish-brown and has loamy texture, soft/friable consistency, and poor drainage in the C_1 horizon (Table 3). Accordingly, these soils are characterized by the Quilombolas as “dark earth” (favored by the accumulation of organic matter), and are clayey, always exhibiting mottling and flagstones. These soils are differentiated from the “partially flooded river plain” mainly due to the lack of cracking during the dry season. According to the SAAT, the PT has restricted use for agriculture under the A level of management because of oxygen deficiency. Nevertheless, it is used with planted pasture, rice, and sugarcane crops as other lands are not available for this practice in the local context of the study area, and these crops are essential for local food security (Table 4).

Field observations showed that the FL and GL also have this restriction and serve the same land use. They are considered the noblest soils for promoting food security in the MGQT because of their texture, fertility, and water storage throughout the year. Although parts of the lowest riverbed constitute environmental preservation areas, there is not conflict of use since they represent consolidated use according to the New Brazilian Forest Code. This area concentrates land use during the dry season, whereas land use shifts to the “high lands” and slope during the rainy season. This seasonal dynamic of land use is vital in providing for local livelihoods in the MGQT.

Overall, the community has tried to strengthen food security and sustainable land use management in the direction of reinvigoration of environmental resilience. Since the experience with the Green Revolution package, the *Quilombolas* have avoided monocultures, external inputs, and genetically modified seeds because they saw the bad effects it brought to soil quality and their health through the use of pesticides. In this sense, the Center for Alternative Agriculture – Northern Minas Gerais (CAA - NM, acronyms in Portuguese) and the engagement of *Quilombolas* in the Association of *Quilombolas* of the Maroon Gurutuba Territory has supported them in implementing these goals.

Counterbalancing etic and emic knowledge to evaluate the legitimacy of local knowledge

Etic and emic stratification of the landscape exhibited the same stratification criteria, topography, and influence of seasonal fluctuation of groundwater, soil, and vegetation, and the same environmental units. However, the *Quilombolas* only used vegetation as a criterion to identify the unit of landscape when it was easily distinguishable (Table 3). Comparing the soil taxonomic systems, the *Quilombolas* indicated 8 soil classes, whereas the SiBCS revealed 13 classes, which were classified as associations and are represented as approximations to the World Reference Base for Soil Resources (IUSS Working Group WRB, 2015). The emic individual classes and etic associations were found at the fattened tops (FR and LX), endorheic depression (PT and PL), partially flooded flat land (PL and PT) and PT, GL and FL, revealing similarities among the soils. The *Quilombolas* perceive the existence of soil associations in these environments. Nevertheless, as previously shown, they do not distinguish them as individual classes when they serve the same land use and have morphologic similarities (Table 3). This data corroborates the ethnopedological study of Vale Júnior et al. (2007) in the Malacacheta Indigenous Territory (Roraima, Brazil), where soils were classified depending on the goals related to the soil use of the local group. Likewise, the authors found that the local taxonomic system followed a hierarchy based on characteristics and properties (morphological, chemical, and physical) that promoted or constrained the intended soil use. Moreover, they identified soil associations that were grouped in individual classes by the indigenous.

Another ethnopedological study was performed in the Brejo dos Crioulos Maroon Territory, and it found very similar landscape stratification (flat tops, karst valleys, and slopes divided in more or less elevated levels and fluvial plains) and also used the topography, soils, vegetation, and water influence as stratifying criteria (Matos et al., 2014). Furthermore, the *Quilombolas* studied by these authors also mainly used color and texture to classify the soils; there was a predominance of Ferralsols and soils that were not deeply weathered in the area, sandy soils on the slopes, and clay soils on the plains with elevated SB. These similarities are explained by the common landscape origin of both areas of the São Francisco depression, where the Bambuí Group geology out crops.

It is notewhorthy that the *Quilombolas* separated the classes in types of earth or clay, which was also observed in other studies (Krasilnikov and Tabor, 2003; Vale Júnior et al., 2007; Matos et al., 2014). The soil classes denominated “earth” were the soils that have higher sand content, more developed structure, and/or soft/friable consistency, whereas the soils that have block or prismatic structure, hard/firm consistency, and higher clay content are called “clay” (Table 3). The main attribute used by the *Quilombolas* of the MGQT for soil classification was color, manifesting a first categorical level. In a second level, they emphasized texture and consistency (highlighted for all soil classes). Furthermore, they sometimes indicated chemical, physical, and other aspects in their taxonomic system (Table 3).

Physical aspects such as drainage and soil porosity were emphasized as very important for water retention and the relevance of the soils for the food security of the community. The *Quilombolas* associated the drainage condition with the soil texture and structure (which conferred specific porosity to the soil) and the position of the soil in the topography (Table 3). They also emphasized that the morphological aspects (texture and structure) were related to soil permeability and capacity to retain nutrients and moisture, which are essential elements for crop cultivation and food security.

Most of the MGQT soils are eutrophic, have high SB, and pH H_2O between 5.8 and 7.0 (Table 1), except for FR, which is a more weathered soil located at the top of the landscape and the RGeu, which is sandy and has accentuated drainage. In accord with that, the soil fertility was very well distinguished by the *Quilombolas* and stood out in their reports regarding the agricultural aptitude of the lands. The different levels of soil sum of bases is interpreted by the *Quilombolas* through observing the size and quality of the crops harvested and pastures. Furthermore, the relationship between organic matter and soil fertility was indicated as a key element for the maintenance of soil moisture and nutrient cycling.

The presence of plinthite and petroplinthite was often reported and associated with drainage restriction of the soil and groundwater seasonal fluctuation in successive dry and rainy seasons, indicating recognition of the plinthization process for the formation of Fe^{3+} microsites (Santos et al., 2013b). They also recognized that longer exposure to this process makes the plinthites become hardened as petroplinthites. Moreover, the addition, removal, and elutriation as pedogenetic processes were indicated, expressed through the loss of nutrients by run-off from highlands surfaces, and further concentration in the lowlands contributing to soil fertility.

The *Quilombola*’s knowledge fulfilled practically all the elements indicated by Barrera-Bassols and Zinck (2003) as relevant and commonly found for the soil class distinctions made by smallholder farmers worldwide (eminently morphological). According to them, the main criteria used in folk knowledge to classify soil are: color (100 %); texture (98 %); consistency (56 %); soil moisture (55 %); organic matter and stoniness, topography, land use, and drainage (from 34 to 48 %); fertility, productivity, structure, soil depth, and temperature (from 2 to 26 %).

Regarding the land evaluation systems, local knowledge takes most criteria used by SAAT into account, but it also considers the need for obtaining food security from the local soils. Thus, some criteria used by these family farmers are not considered by the SAAT recommendations. This data corroborates Correa and Anjos (2007) when comparing local and scientific knowledge about soils in Rio Pardo de Minas (Minas Gerais). The authors expressed that this difference of premise and priorities raises the impression that local knowledge is inconsistent with scientific knowledge. However, elements that are part of local land-use decision making are not taken into account by the scientific knowledge systems. These could be incorporated into the land evaluation systems or by technicians to improve the quality of assistance to and dialogue with local people.

It was observed that SAAT mainly targets large scale farmers who, unlike family farmers, can acquire lands with agricultural potential consistent with the market-oriented activities they intend to conduct. They can also correct chemical deficiencies by applying fertilizers at high investment costs.

Uncritical recommendation of this system may make it too disconnected from integrated land use and the sociocultural and economic context of *Quilombola* (e.g., constraints for machinery use and susceptibility to soil erosion). Moreover, the economic constraints of small farmers are critical for land use planning and are not considered by the system.

It is important to mention the subjectivist character of the etic interpretation of the emic knowledge (Posey, 1986). For example: 1) the Quilombolas mentioned excessive hardness of the PLhaeu (Table 1), but they did not mention the excessive presence of Na^+, a limiting factor for agriculture in this area; 2) there were no comments relating geology to soil formation, although the soil mineralogy was not focused on in the study; 3) the *Quilombolas* showed a three dimensional perception of the soils (Toledo and Barrera-Bassols, 2009), perceiving the soil horizons as “natives”, but this issue was not explored either; 4) some people who were interviewed emphasized the main characteristics of the soils present on their lands, sharing a common knowledge with the other people when guided freely on a general perception of MGQT lands. Regarding the absence of perception regarding the Na^+ of the PLhaeu, Alves et al. (2005), who studied ceramic artisans of the Brazilian state of Paraíba, identified that people whose practice depends on detailed perception of consistency can distinguish soil consistency based on observation of the different taste the soils have when they contain different levels of salt. Thus, the subjectivism may result from the focus of research, sampling, and the intrinsic character of the local practices of land use, as Krasilnikov and Tabor (2003) highlight. However, this does not compromise the value and effectiveness of the ethnoscience (van Koppen and Spaargaren, 2015).

Finally, the local cosmovision of the *Quilombolas* reveals that they feel part of nature because they depend on it and perceive soil responses to their actions. Thus, they realize that nature should be respected and used in a sustainable way, aiming for both food security and resilience of the soil-related ecosystem functions so as to maintain the benefits obtained from the ecosystem services. They show this concern through adoption of diverse land-use practices, lower input of agrochemicals, protection and reforestation of deforested areas, crop rotation, etc. This expresses an ecocentric (van Koppen and Spaargaren, 2015) and conscious perception of the human-soil relation that is common among communities that depend mainly on the natural resources of their territories to survive, here called territory-based communities. The feeling of belonging to the territory and environment of the MGQT explains the struggle of the *Quilombolas* to keep their lands despite socioeconomic and environmental limitations.

CONCLUSIONS

A comparative evaluation of local knowledge and scientific knowledge revealed that both cognitive systems have symbolic, practical, logical, and functional meanings, and distinguish the soils, landscape units, and land suitability in a similar way. The study showed that the local content of soils has a strong influence on the ethnopedological characterization (e.g., FR is considered red by the *Quilombolas*, due to the predominant context of soils derived from carbonate, whereas this soil is considered yellow by the SiBCS). In contrast with Pedology, local ecological knowledge is mainly based on empirical experimentation and visual methods of analysis. Thus, the discourse of local people emphasized more morphological characteristics than chemical and physical ones.

Regarding land use, *Quilombolas* showed a consistent knowledge of the agricultural potential of the lands. Similar to SAAT, the *Quilombolas* indicated deficiency of water and oxygen as the main criteria constraining land use. However, they exhibited a more detailed and contextualized perception of the factors limiting land use and potentialities. Apparently, the adoption of market-oriented crops intensified land degradation. Likewise, the historical expropriation of lands and consequent need for obtaining food security from the limited lands available explained the apparent discord between some land uses and the SAAT recommendations.

Overall, the SAAT is not suitable for family farmers since it does not consider the local land use system as a whole and the local context. In other words, the division made by the system of annual crops, perennial crops, etc. does not take into account the farmers' land use systems as they operate - in an integrated way, with one annual crop dependent on the other and complementary to the other land uses in place in that context. Therefore, this shows the need for development and adaptation of land evaluation systems to traditional populations and family farmers.

Finally, the ethnopedological approach confirmed the legitimacy of local knowledge and its utility for detailed and faster collection of data, accurate mapping, and broad understanding of the criteria involved in land-use decision making. Thus, it enables more contextualized and feasible participatory land-use planning. The MGQT scenario shows that development of interdisciplinary and participatory approaches associated with public policies is extremely pertinent for assisting local food security.

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