Chapitre 4

Savoirs paysans sur les sols et indicateurs locaux de la fertilité des sols au Lac Alaotra, Madagascar

Typologie de paysage dans le Nord-Est du Lac Alaotra

Chapitre 4. Savoirs paysans sur les sols et indicateurs locaux de la fertilité des sols au Lac Alaotra, Madagascar

Présentation du chapitre

Ce chapitre a été rédigé en anglais en vue d'une prochaine soumission sous forme d'article scientifique (article 1) dans la revue internationale « *Geoderma Regional ».*

L'article cherche à définir les types de sols reconnus par les paysans du Lac Alaotra et à répertorier les indicateurs locaux utilisés par les paysans pour évaluer la fertilité de leurs sols. La méthodologie est basée sur des enquêtes menées auprès de paysans (n=100) grâce à des entretiens ouverts et semi-ouverts. Les types de sols reconnus par les paysans pour les cinq communes d'intervention sont différents. Dans le but d'avoir une gamme de sols représentatifs, la commune d'Ilafy et celle d'Imerimandroso se sont avérées les meilleurs exemples pour présenter les deux typologies paysannes de sol. Les deux communes sont représentatives, car les principaux types de sols pouvant être reconnus par les paysans se retrouvent au moins dans l'une des deux communes. Elles sont également représentatives du fait que les deux cas possibles de successions et d'agencement d'unités morphologiques de nos zones d'intervention y sont observés.

Pour comprendre sur quels critères les agriculteurs évaluent la fertilité de leurs terres, il a été introduit dans le questionnaire une série de questions permettant de recenser, d'identifier et d'avoir des renseignements sur les indicateurs utilisés pour juger les capacités des sols à produire des récoltes.

Article 1

Soil knowledge and soil fertility assessment by farmers in Alaotra lake region, Madagascar

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Abstract

Alaotra Lake region has been privileged since 1950 by government interventions and many agricultural projects to address agricultural problems. However, the incompatibility of the proposed new technical packages with the real environmental and peasant conditions involves particularly a low adoption. Understanding local knowledge can help to better grasp farmers real world conditions and conduct successfully an agricultural development project. This paper aims to take into account local knowledge on soil and determine the main indicators of soil fertility used by farmers in Alaotra Lake region, Madagascar. 100 farmers located in 5 areas were selected and submitted to a survey through a structured questionnaire. The survey revealed that there are two types of local soil classification in our study area. 12 local soil types were identified in the southeast of the lake and 9 local soil types were identified in the northeast. Fertility status of each recognised soil is assessed by 11 main local indicators. They can be categorized in 3 classes : soil physical indicators, biological indicators and productivity indicators. The results showed that farmers in Alaotra Lake are knowledgeable of their soils. Locally recognised soil types are consistent with the technical soil knowledge and local fertility indicators are identical to those used by other farmers in other countries and are scientifically validate as effective.

Keywords : farmer perception; local knowledge; soil fertility; Madagascar highlands, Alaotra lake

Résumé

La région du Lac Alaotra a, depuis 1950, été privilégiée par les interventions de l'État et de nombreux projets de développement dans l'optique de faire face aux problèmes agricoles. Un grand nombre de systèmes de culture innovants ont été proposés, mais la non-compatibilité de ces systèmes aux conditions environnementales et paysannes réelles limite leur adoption. L'analyse des savoirs locaux peut aider à comprendre ces réalités locales et conduire avec succès un projet de recherche ou de développement agricole. Cet article vise à prendre en compte les connaissances locales sur les sols et à déterminer les principaux indicateurs de la fertilité des sols utilisés par les paysans dans la région du Lac Alaotra, Madagascar. 100 paysans localisés dans 5 communes ont été enquêtés à travers un questionnaire structuré. Les résultats ont montré la présence de deux types de classifications paysannes des sols dans la zone d'étude. Au Sud-est du lac, 12 types de sols locaux ont été identifiés et 9 types de sols dans le Nord-est. Les paysans se réfèrent à 11 principaux indicateurs locaux pour évaluer la fertilité de ces sols. Ces indicateurs peuvent être classés en 3 catégories : indicateurs physiques du sol, indicateurs biologiques et indicateurs de productivité. Les types de sols reconnus localement sont conformes aux études pédologiques et les indicateurs locaux de fertilité sont identiques à ceux utilisés par d'autres paysans dans d'autres pays et sont scientifiquement validés efficaces.

Mots clés : perception paysanne ; savoir local ; fertilité des sols; haute terre malgache, Madagascar, Lac Alaotra

4.1 Introduction

Soil knowledge and assessment of soil fertility by farmers constitute the main study object of ethnopedology. It can be defined as the study of soil properties and soil management know-how by people living in a particular environment for some period of time (WinklerPrins, 1999). Understanding farmer knowledge has come to be seen essential as several failures in research and development projects are reccorded in literature because of the lack of consultation towards local community and the denial of their knowledge (Blanchard, 2010). Neglect indigenous knowledge can be as well an hindrance to the success of agricultural development (WinklerPrins, 2003). However, little efforts have been made to understand farmers' knowledge on soil in Alaotra Lake region, were many agricultural projects and several technological issues have been suggested since 1950 (Penot et Garin, 2011).

Intensive rice cultivation with muddy rice fields mechanization, diffusion of robust rice variety and conservation agriculture are among of innovative projects promoted the most in Alaotra lake to address agricultural problems such as decreasing yield generated by demographic and land pressure. But like usual, little minority only applied the set of technology package proposed (Penot et al., 2011). However, the new few techniques adopted are still often modified by farmers to be adapted to their financial possibilities and their needs or to minimize any risks on their plots.

Understanding farmer knowledge is, whereas, essential to grasp farmers real world conditions. Researchers need to take into consideration how do farmers understand their soil to really meet farmers' needs in their local scales in order to solve constraints and value opportunities. The authenticity of soil local knowledge has been proven throughout the world by recent research indicating its conformity, adherence and complementarity with soil scientific understanding (Tamang, 1993; Hirai et al., 2000 ; Birmingham, 2003; Gray and Morant, 2003). Other findings by Steiner, 1998; Barrios et al., 2003 has shown that local knowledge is an effective tool to facilitate soil evaluation and soil survey for agricultural sciences. It could add to scientific understanding and be useful in international agricultural development (Sandor et al., 1996). Local soil knowledge is especially needed in developing countries where most farmers are not able to afford expensive soil analysis. The objectives of this paper are to **study soil local knowledge** and to **determine the main indicators of soil fertility used by the farmers.** Study results may be used as a tool of communication, a beginning of common language between farmers, researchers and agricultural extension workers in Alaotra lake region. Informations provided in this paper can be used to design relevant recommendations for any new agricultural projects in this specific site of Madagascar highlands.

4.2 Materials and methods

4.2.1 Description of study area

The study area, Alaotra lake region, is located in the North East of Madagascar, at approximately 230 km in the North of the capital Antananarivo. The region is located between 17°10 ' and 18 ° latitude the South and 48°10 ' and 48°40 ' longitude (Teyssier, 1994). It is structured of 5 700 km^2 sets of grassy hills and trays, a vast marshy plain of about 130 000 ha on 722 000 ha of watersheds bordering a lake of 200 to 300 km^2 according to seasons (Penot and Garin, 2011).

The climate type is sub-humid tropical, with a rainy season marked by a significant irregularity of precipitations at the rate of 600 to 1500 mm per year from November to March and a long dry season from April to October. The strong inter-annual and intra-annual irregularities of precipitations often expose cultures on *tanety* (hills) to droughts and cultures on rice fields under random flood risk. From 2005 to 2007, for example, precipitation has passed from 617 mm to 1522 mm and was significantly irregularly distributed (Dupin, 2011).

The region is characterized by an important immigration of young pioneers captivated by its dynamism and agricultural potential. This phenomenon, associated with a high birth rate, justifies the annual population growth rate of 4.2% for a national rate around 2.7% (Wilhelm and Ravelomanantsoa, 2006). The land pressure forces farmers to explore more and more hills (*tanety*) with a consequential erosion problem, silting and loss of soil fertility. Many development projects, as BV-Lac project have been committed since 2000 to support local farmers in order to conquer the slopes in an optimal way. The project lasted a decade, with the main objectives to protect watersheds, to secure land tenure and to promote conservation agriculture.

The study area is located in the eastern part of the lake and was conducted in 5 communes : Ilafy, Ambohitsilaozana, Ambatosoratra, Ambarihitsokatra and Imerimandroso, situated respectively at 14 km in the South, 15 km in the North, 40 km in the North and 50 km in the North of Ambantondrazaka, the district headquarter town. 2 distinct methods based on surveys were used.

4.2.2 Study approach for soil local knowledge

The method of local knowledge characterization conceived by Vall et al. in 2006 was adopted. 100 farmers were investigated through the method. It was developed from the fact that to structure their knowledge on real purpose, human being creates classification of objects (entities) and use variables to characterize each created entity (Blanchard, 2010). Three steps were followed to apply this method. The first step was an exploratory survey. It is a matter of carrying out non-directive interviews in order to list entities used by farmers to structure their knowledge background on soil and to identify the main variables used to characterize each recognized soil type. For the second step, investigated through semi-structured interviews are conducted. Responses with individual variants were used to complete the grid of local knowledge characterization drawn from entities and pre-identified variables (table 3). The third step was to hold a restitution workshop with farmers. The aim was to complete and/or correct any errors on the drawn grids in order for validation.

Tableau 3 : Grid of local knowledge characterization

Typology / Variables	Entity 1	Entity 2	…	Entity X…
Quotation	Percentage of farmers citing entity 1	Percentage of farmers citing entity 2	…	Percentage of farmers citing entity X
Description Variables	Description Variable 1 of Entity 1 Description Variable 2 of Entity 1 …	Description Variable 1 of Entity 2 Description Variable 2 of Entity 2 …	…	Description Variable 1 of Entity X Description Variable 2 of Entity X…
Function variables	Function variable 1 of Entity 1 Function variable 2 of Entity 1 …	Function variable 1 of Entity 2 Function variable 2 of Entity 2 …	…	Function variable 1 of Entity X Function variable 2 of Entity X …
Variables of risk	Variable of risk 1 of Entity 1 Variable of risk 2 of Entity 1 …	Variable of risk 1 of Entity 2 Variable of risk 2 of Entity 2 …	…	Variable of risk 1 of Entity X Variable of risk 2 of Entity X …

4.2.3 Study approach for farmer assessment of soil fertility

To understand the criteria used by farmers to evaluate the fertility of each recognized soil, series of questions enabling to list and to identify local soil fertility indicators were introduced in the questionnaire. The same 100 farmers previously surveyed were investigated, with 36, 6, 15, 27 and 16 respondents for the communes of Ilafy, Ambohitsilaozana, Ambatosoratra, Amparihitsokatra and Imerimandroso respectively.

4.2.4 Data processing

Descriptive statistics were used to analyze both data relating to local soil knowledge and data describing farmers' assessment of soil fertility.

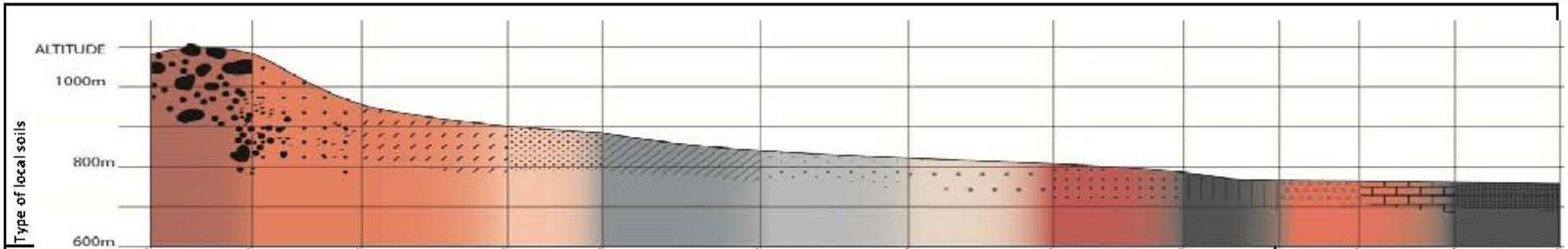
4.3 Results

4.3.1 Soil local knowledge

The results revealed that there is a slight difference on soil types recognized by farmers for the 5 studied communes. Farmers identified 2 soils classifications which are strongly linked to soil's position on toposequence. Ilafy and Imerimandroso fairly represent local soil classifications in the study area with 12 types of soils recognized in south-east (table 1) and 9 in north-east (table 2). Besides position on toposequence, farmers use other variables to characterise each soil type. First, they refer to descriptive variables as soil color, consistency, structure, texture and color. Then, they refer to function variables identified through cultural vocation, fertilizer requirement and working fields perception. And finally, they take into account the risk variables which were particularly related to lack of or too much rain.

The citation or quotation in the 2 tables corresponds (table 5 and 6) to the percentage of farmers having cited the soil type. Thus, for example, for the first row in table 5 for Ilafy Commune, 64% of farmers recognize tanetibe or summit tray's soil as one type of soils. It would be pink, compact, massive, stony and sometimes rocky. This type of soil is located on trays of hills. The risks in case of insufficient rain were extreme drought and and too much rain would generate lavaka[5] formation or a significant erosion.

[5] *Lavaka*: Literaly means « hole »: types of erosion on hill'slope



	Local soil denomination	*tanetibe*	*sompirana*	*taneny marina*	*tany fotsy*	*voditany*	*baiboho-pasika mainty*	*baiboho-pasika fotsy*	*baiboho bedana*	hotsaho-tsaka mainty	hotsaho-tsaka ma- vo mena	tanifotaka mavo mena	tanifotaka mainty
	Soil name translated	summit soil tray	steep hills'soil	low slope hills'soil	white soil	foot hills'soil	black Baiboho	white baiboho	silty baiboho	rainfed black/yellow-red paddy field		flooded, yellow-red/black paddy soil	
	Quotation	64%	64%	100%	6%	61%	56%	11%	100%	36%	50%	94%	50%
Description variables	Color	pink	yellow-red		yellow-white	black trend	black	yellow-white	dark red	black	yellow-red		black
	Structure, consistency	compact, massive	compact to modertly compact, hard to slightly hard, massive to less massive		sticky	lumpy, soft	granular, friable, thinly compact			moderly compact and sticky to thinly compact and soft			
	Texture	stony, occasion-ally rocky	silt, sand, gravel		significant amount of limestone	sand, significant amount of clay	black sand crushed	significant amount of sand	clay, silt, sand	clay, sand	clay, sand covered with silt		clay, sand
	Location	trays of hill	mid-slope	mid-slope	mid-slope	down-slope	low-slope			low-bottom			
Function variables	Cultural vocation	-	types of trees : eucalyptus, grevillea...	rainfed culture: rice, maize, cassava...	culture impracticable	rainfed culture: rice, maize, cassava...	all types of cultures	cassava and sweet potato	all types of cultures except peanut	rice in growing season, vegetables in off-season	rice in growing season, no off-season crop for the majority		
	fertilizer require-ment	-	-	significant need	-	low need	low need	no need	low need	need		significant need	
	Working fields perception	-	difficult to moderatly difficult		-	easy	easy			relatively difficult to relatively easy			
Risk Variables	Lack of rain	dry soil	dry soil, risk for cultures		-	dry soil, risk for cultures	burning of soils and plants			dry soil, plant growth difficult		no risk, water management mastered	
	Too much rain	formation of "lavaka", erosion		erosion	-	dibbling closing	silting, sand accumulation			silting, sand accumulation, flood		silting, sand accumulation	

Figure 5: Local soil types, south-east (Ilafy Commune)


Summit soil tray *(tanetibe)*


Steep hills' soil *(sompirana)*


Low slope hills' soil (tanety marimarina)


White soil (taniravo)


Foot hills'soil (voditany)


Black baiboho *(baiboho-pasika mainty)*


White baiboho *(baiboho fotsy)*


Silty baiboho *(baiboho bedana)*

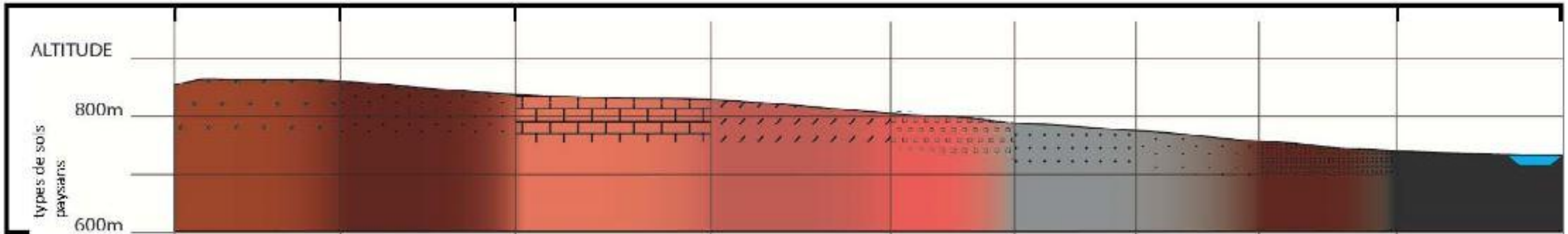

Black rainfed paddy fields *(hotsahotsaka mainty)*


Yellow-red rainfed paddy fields *(hotsahotsaka mavo-mena)*


Flooded yellow-red paddy soil (*tanifotaka mavo-mena)*


Flooded black paddy soil (*tanifotaka mainty)*

Clichés 1 : Soil type recognised by farmer in the south-east area (Ilafy)



local soil denomination		*yellow-red upland soil*	*dark red upland soil*	*sandy baiboho*	*not sandy baiboho*	*silty rainfed paddy field*	*rainfed paddy field richOM*	*muddy black soil*	*muddy dark red soil*	*marshy soil*
code soil		*tanety mavo mena*	*tanety manja mainty*	*baiboho fasehana*	*baiboho tsyfasehana*	hotsahotsaka misy bedana	hotsahotsaka tany tompotra	tanifotaka manja mainty	tanifotaka manja mena	ankaiafo
Citation		100%	75%	13%	69%	6%	44%	69%	6%	13%
Description variables	Color	yellow-red	dard red	light yellow-red	dark red	yellow-red	black	black	dark red	black
	Structure, consistency	compact to moderly compact, massive to less massive	lumpy, soft	granular, crumbly, thinly compact	lumpy, soft	moderly compact to soft, less massive to lumpy				soft, light, muddy
	Texture	thicker sand	clay, silt, sand	high rate sand	clay, silt, sand	clay, sand covered with silt	clay, sand	clay, sand	clay, sand covered with	black peaty-muds&clay
	Location	hill (tray)		low-slope		low-bottom				banks of lake
Fonction variables	Cultural vocation	dries crops (peanut, cassava...) or types of trees	rainfed crops : rice, maize	cassava, peanut, fruit trees, without off-season culture	all types of cultures	rice in growing season, no off-season cult	rice in growing season, rice or vegetables in off-season culture if possible			rice in dry periods
	Fertilizer requirement	no need in the majority	need	low need		need		significant need		no need
	Working fields	difficult to moderatly difficult	easy	easy		moderatly difficult to easy				easy
Risk variables	Lack of rain	dry soil, risk for cultures		burning of soils and plants		plant growth difficult		-		no risk
	Too much rain	significant departure of superficial elements		silting, sand accumulation		flood, silting, sand accumulation		silting, sand accumulation		culture smothered by flood

Figure 6 : Local soil types, north-east (Imerimandroso, Commune)

Yellow red upland soil

(tanety mavo-mena)

Dark red upland soil

(tanety manja-mainty)

Sandy baiboho

(baihoho fahehana)

Non-sandy baiboho

(baihoho fahehana)

Rainfed paddy field rich on organic matter (hotsahotaka tany fompotra)

Silty rainfed paddy field

(hotsahotaka misy bedana)

Muddy dark-red soil

(tanifotaka manja mena)

Muddy black soil

(tanifotaka manja mainty)

Marshy soil

(ankaiafo)

Clichés 2 : Soil type recognised by farmer in the north-east area (Imerimandroso)

4.3.2 Farmers' assessment of soil fertility

Farmers defined fertile soil as « tany masaka » which literally means « cooked soil» or « tany feno zavatra lo», meaning « soil rich in organic matter » and infertile soil as « tany manta », meaning « raw soil » or «tany kotra», « poor soil ». To assess soil fertility status, farmers used 11 main local indicators. They can be categorized in 3 classes : soil physical indicators, biological indicators and soil productivity indicators.

Soil physical fertility indicators

Tableau 4: soil physical fertility indicators

	Indicators	Rich soil	Poor soil	Respondents*
Soil physical status indicators	Color	Black Yellow red dark or dark color	Pink Light yellow red or light color	89%
	Structure	Granular, friable, lumpy	Massive, resistant	95%
	Texture	Balanced ratio between sand, silt, clay	Significant disproportion of sand, silt, clay	87%
	consistency	Soft, thinly compact	Sticky, hard, compact	95%

To evaluate soil fertility level, farmers in Alaotra Lake use first soil physical indicators, 89% of respondents refer to soil color, 95% to structure, 87% to texture and 95% to consistency. According to farmers, rich soils were black, yellow-red dark or dark color. Rich soils were perceived through their granular, friable or lumpy structure. They were, as well, soft, thinly compact and characterised by a balanced ratio between sand, silt and clay. Besides, poor soils were lighter or pink, massive and resistant. They were sticky, hard, compact and characterised by a significant disproportion between sand, silt and clay.

Biological indicators

Table 5 : Biological indicators

	Indicators	Rich soil	Poor Soil	Respondents
Biological indicators	Presence of particular species	Covered mostly with rounded and broadleaf plants	Covered mostly with elongated and narrow leaves plants	66%
	Plant state during sprouting	Rapid seedling growth and few Empty pocket	Low seedling growth and many empty pocket	84%
	Plant height	Big size	Small size	77%
	Leaf color	Blue green	Yellowish	90%
	Leaf state	Large and good quality	Mangy and wilted	75%
	Growth rate	Good crop growth	Slow growth	85%

Land users refer, secondly, to 6 main biological indicators to perceive the fertility level of their plots. 66% of the farmers refer to the presence of particular species. The result show that a rich soil is mostly covered with broad leaf and rounded plants and a poor one with elongated and narrow leaves plants. Table 5 summarizes the specific weed species used to assess soil fertility.

Table 6 : Main plant species used by farmers as local indicators of soil fertility status

Species indicators for rich soil (n%)**	**Species indicators for poor soil (n%)****
Hisatsa (Tribulus terrestri) (61%)	*Bozaka (Aristida multicaulis) (36%)*
Fandrotrarana (Cynodon dactylon) (56%)	*Besofina (Urena lobata) (29%)*
Tsipolitra (Biden spilosa) (41%)	*Danga (Heteropogon contortus) (24%)*
Radriaka (Lantana camara) (37%)	*Dingadingana (Psiadia altissima) (15%)*
Tsindahory (Corchorus olitorus) (39%)	*Bakakely (Acanthospermum hispidum) (15%)*
Anampatsa (Amaranthus spinosus) (17%)	*Angamay (Mitracarpus hirtus) (14%)*
Anapetraka (Centella asiatica) (16%)	*Ahidambo (Aristida spp) (13%)*

**n% Percentage of farmers citing the plant species


Hisatsa (Tribulus terrestri) (61%)


Fandrotrarana (Cynodon dactylon) (56%)


Tsipolitra (Biden spilosa) (41%)


Radriaka (Lantana camara) (37%)


Tsindahory (Corchorus olitorus) (39%)


Anapatsa *(Amaranthus spinosus)* (17%)

Clichés 3 : Rich soil species indicators example


Bozaka (Aristida multicaulis) (36%)


Besofina (Urena lobata) (29%)


Danga *(Heteropogon contortus* 24%)


Dingadingana (Psiadia altissima) (15%)


Bakakely (acanthospermum hispidum) (15%)


Angamay (Mitracarpus hirtus) (14%)

Clichés 4 : Poor soil species indicators example

For the others biological indicators, 84% of farmers referred to plant state during sprouting. A rich soil is recognized by its rapid emergence of seedlings and by a restricted number of empty pocket in which seed had not germinated. 77% referred to plant height stating that a rich soil is characterised by its ability to produce crop of big size. 90%, 75% and 85% respectively referred to leaf color, to leaf state and to plant growth rate, stating that a rich soil is recognised by plants with a permanent blue-green, large and good quality leaves and by a good crop growth. Besides, slow emergence of seedlings, many empty pockets, small size of plants with yellowish leaves, and a low growth of plants would attest a poor soil.

Productivity indicators

Table 7 : Productivity indicators

	Indicators	Rich soil	Poor Soil	Respondents
Productivity indicators	Yield	High	Low	96%

Finally, farmers refer to productivity indicators to complete their soil status fertility assessment. 96% of farmers said that in fertile soils, they can easily get, in continous way, high yield production. Yields expected in rich soils and those presaged in poor soils for 4 main crops were summarized on table 8.

Table 8 : Yields expected in rich soils and prognosticate in poor soils ($t.ha^{-1}$)

Position on landscape	Level fertility	Speculation	Average	Ecart-type (n-1)
Flooded paddy field	Rich	Rice	3,806	0,742
Flooded paddy field	Poor	Rice	1,302	0,587
Rainfed paddy field	Rich	Rice	3,458	0,459
Rainfed paddy field	Poof	Rice	0,745	0,308
Hills'soil	Rich	Rice	2,242	0,251
Hills'soil	Poor	Rice	0,789	0,248
Hills'soil	Rich	Maize	2,835	0,244
Hills'soil	Poor	Maize	1,776	0,227
Hills'soil	Rich	Peanut	2,153	0,312
Hills'soil	Poor	Peanut	0,585	0,119
Hills'soil	Rich	Cassava	25,464	3,129
Hills'soil	Poor	cassava	6,371	2,92

Significant differences in yields were observed between poor and rich soil. As example, on a rich muddy soil, as for example, farmers expected 3 to 5 $t.ha^{-1}$ with an average of 3,8 $t.ha^{-1}$ of paddy, while they could only get an average yield of 1,3$t.ha^{-1}$ on a poor muddy soil with the same treatment. On rich hills'soil, the rice production should reach an average of 2,2 $t.ha^{-1}$ for an average of 0,8 $t.ha^{-1}$ on a poor one. The same trend occurred for cassava as well as for the other speculations. A fertile soil is evaluated by farmers according to its ability to produce more compare to a poor soil.

4.4 Discussion

The communes of Ilafy and Imerimandroso were the best examples to represent farmers' typologies of soil for the 5 studied communes. They were representative because the two possible cases of morphological successions units in the study area were observed. For indeed, Ilafy located at 14 km in the south – east of Ambatondrazaka[6], is structured by a wide extent of plain with surrounding hills on slope steep raised up to 1 100 to 1 200 m of altitude. As for Imerimandroso, the commune is located at 50 km in the north of Ambatondrazaka. It is characterised by a small surface of plain, but with large hill zone distinguished by a gentle slope and a moderate elevation between 750 – 780 m of altitude. The 12 and the 9 soil types recognised at Ilafy and Imerimandroso respectively correspond to the unity of each area landscape, following the toposequence. The method of soil classification used by farmers in Alaotra Lake by toposequence is confirmed by literature (Habarurema et al, 1997, Corbeels et al., 2000, Blanchard et al, 2010, Gosai et al, 2011). Farmers surveyed in Alaotra lake use color, texture, structure and consistency to describe each recognized soil. Similar findings are reported by others studies (Barrera-Bassols et al., 2003 ; Saito et al., 2006 ; Blanchard et al., 2010 ; Gosai et al., 2011).

To complement soil descriptions, farmers in Alaotra Lake use as well functions and risks variables which are also quoted in the study of Blanchard et al, 2010 as variables used by farmers in Mali.

There is good correlation between soil types recognised locally and previous soils study made in Alaotra Lake by Raunet (1984) ; Garin (1998) and Rabenandro et al., (2009) (Table 9 : Corresponding between farmers and scientific soil classification). However, the local soil

[6] Central town of the region

knowledge is more detailed compared to CPCS (French soil classification, 1967). The scale of this map soil is too coarse to take into account real soil type variation as it specifies only 3 soils type for all of Alaotra region (Table 9).

Table 9 : Corresponding between farmers and scientific soil classification

Morpho-logical units	**Local soil classification, *Ilafy***	**Soil classification according to scientific literature** (Raunet, 1984 ; Garin, 1998 ; Rabenandro et al, 2009)	**French classification of soil, (CPCS, 1967)**	**Local soil classification, *Imerimandroso***	**Soil classification according to scientific literature** (Raunet, 1984 ; Garin, 1998 ; Rabenandro et al, 2009)	**French classification of soil, (CPCS, 1967)**
Tanety (hills)	Summit tray's soil	**Topsoil ferralitic soils,** silty to sandy loam, pH 4 to 6	Highly rejuvenated Soils, « pené-volués »	Yellow-red upland soil	**Ferralitic soils of hills,** medium to very differentiated, neutral pH or slightly basic, generally clayey	Rejuvenated soils with a degraded structure or highly rejuvenated, "pénévolués"
	Steep hills'soil	**Ferralitic soil of slopes,** limono-sandy with presence of quartz sand, pH 4 to 5		Dark-red upland soil		
	Low hills'soil	**Ferralitic soils of hills,** medium to very differentiated, neutral pH or slightly basic, generally clayey		-	**-**	-
	White soil	-		-	**-**	-
	Foot hills'soil	**Ferralitic soils of hills's foot :** enriched in organic matter (OM), mineral soils, predominantly clay-sandy, acid pH 4.5 to 5		-	-	-
Baiboho (down-slope)	Black baiboho	**Alluvial soils of valley bottoms :** rich in OM, rounded type structure, granular, porous, friable and stable, pH neutral, sandy-silty	Rejuvenated soils with a degraded structure or highly rejuvenated, "pénévolués"	Non-sandy baiboho	**Silty alluvial soils,** mixed of sand, silt and clay, fragmentary structure with angular aggregates, neutral pH	Rejuvenated soils with a degraded structure or highly rejuvenated, "pénévolués"
	Silty baiboho	**Silty alluvial soils,** mixed of sand, silt and clay, fragmentary structure with angular aggregates, neutral pH		Sandy baiboho	**Sandy alluvial soils,** continuous structure, often located near rivers, sandy, pH neutral	
	White baiboho	**Sandy alluvial soils,** continuous structure, often located near rivers, sandy, pH neutral		-	**-**	-
Plain (low-bottom)	Rainfed black paddy field	**Hydromorphic soils fairly organic (fo)**, 6 à 15 % OM, occurrence of sandy strata, water management not mastered (wnm)	Hydromor-phic soils	Rainfed paddy field rich in organic matter	**Hydromorphic soils fairly organic (fo)**, 6 à 15 % OM, clayey with occurrence of sandy strata, wnm	Hydromorphic soils
	Rainfed Yellow-red paddy field	**Mineral hydromorphic soils**, very clayey, pH between 5 and 6, wnm		Silty rainfed paddy field	**Mineral hydromorphic soils**, very clayey, pH between 5 and 6, wnm	
	Flooded yellow red paddy field	**Mineral hydromorphic soils**, very clayey, pH between 5 and 6, water management mastered (wmm)		Muddy dark red soil	**Mineral hydromorphic soils**, very clayey, pH between 5 and 6, wmm	
	Flooded black paddy field	**Hydromorphic soils fo**, 6 à 15 % OM, clayey with occurrence of sandy strata , wmm		Muddy black soil	**Hydromorphic soils fo**, 6 à 15 % OM, clayey with occurrence of sandy strata , wmm	
Marshy zone (banks of the lake)	-	-	-	Marshy soil	**Organic soils with residual peat :** upper peat horizon, more than 15% OM	

Farmers in Alaotra Lake refer to 11 main local indicators to assess soil fertility status.

They are mainly noticeable by the sense organs and are based on the knowledge gained from several years of field experience.

Similar indicators have been identified in other parts of the world. Barrera-Bassols and Zinck (2003), based on survey results from 25 countries in Africa, America and Asia, reported that color and texture were the most commonly recognized descriptors of soil in most cultures (Saito et al, 2006). Darker soils were seen as rich soil by several authors (Barrios and Trejo, 2003; Desbiez et al., 2004; Blanchard, 2010). The same authors state that rich soil were perceived as those that do not compact, easy to work as soil aggregates can be broken easily by tillage.

Apart from soil color and texture, farmers in other countries, referred too to biological indicators as weed species to assess the fertility of their soils (Desbiez et al, 2004).

Handayani et al. (2006) and Corbeels et al. (2000) demonstrate the use of these biological indicators as an efficient tool to judge soil fertility status.

Compared to the study of Husson et al. (2010) and expertises from some scientists (botanist/agronomist) results from FCA **(figure 7)** confirm that perception of weed species indicators used by farmers in Alaotra Lake correlates positively with scientists' expertise except for Lantana camara and Acanthospermum hispidum. Scientifically, these two species are not qualified as indicators of soil fertility as they can be seen in all types of soil. The reason why farmers consider Lantana camara as an indicator of rich soil is probably because it provides rich biomass to the soil by its big amounts of leaf litter, falling easily and making the soil black with organic matter. In the opposite, poor soils were deemed exhausted with the spreading of Acanthospermum hispidum. Locally, it is considered as drying out and hardening the soil.

C1 and C2 axes were able to explain 97% of total variation.

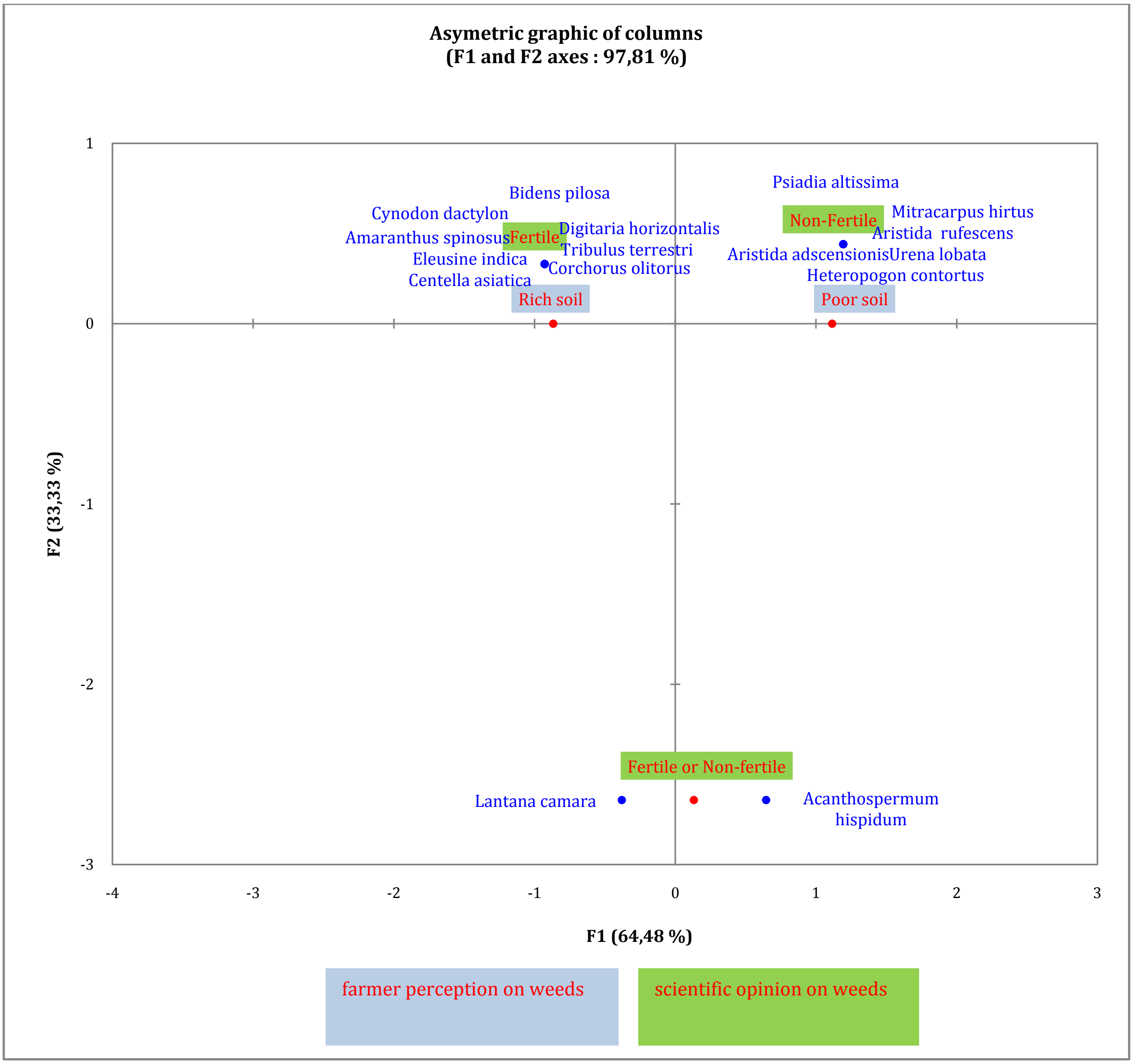


Figure 7 : Correspondance between farmers' perception and scientific opinion on plants species indicators (FCA)

Besides, biological indicators related to germination, plant height, leaf color, leaf state and growth rate used by farmers in Alaotra Lake are as well in lines to other studies. Good germination, plant of big size, green crop leaves and good growth of the crop are associated to fertile soils according to Corbeels et al., 2000, Barrios and Trejo, 2003, Desbiez et al., 2004.

The relevance of productivity indicators related to crop performance and yield in assessing soil fertility status has been reported by Murage et al. (2000) ; Njeru et al. (2010) and Mairura et al. (2007).

4.5 Conclusion

The study revealed that farmers in Alaotra lake are knowledgeable of their soils. They are able to draw up local soil classification. For the 5 communes of investigation, results show that farmers recognize 2 different soil classifications. 12 and 9 local soil types were identified in the southeast and northeast, respectively. Soils in the south include summit soil tray, steep hills' soil, low slope hills' soil, white soil, foot hills' soil, black baiboho, white baiboho, silty baiboho, rainfed black paddy field, rainfed yellow-red paddy field, flooded yellow-red paddy field and flooded black paddy field. As for the north, the recognized soils types are yellow-red upland soil, dark red upland soil, sandy baiboho, non sandy baiboho, silsty rainfed paddy field, rainfed paddy field rich on organic matter, muddy black soil, muddy dark red soil and mashy soil. Soils are named especially by their position on toposequence. However, farmers refer as well to other variables as color, structure, consistency, texture, cultural vocation, fertiliser requirement, workability and soil reaction to water to distiguish their soils. Soil types recognized by the farmers are in agreement with previous studies and are more detailed compared to French soil classification (CPCS, 1967).

Farmers used a set of well-defined indicators to evaluate soil fertility status to each recognised soil. They referred to 4 soil physical properties indicators, 6 ecological indicators and 1 soil productivity indicators. The results indicate that there is a good agreement between some local indicators and scientific indicators of soil fertility. Similar findings on how farmers around the world assess soil fertility status are seen also in Alaotra Lake. Informations written in this paper can be valued as a common language between farmers, extension workers and researchers. They can be used to facilitate communication between those 3 entities to implement any new agriculture projects in a better way. What is lacking is a further research developing an effective and easy methodology combining technical soil parameters and farmers soil indicators to meet efficiently land users need and scientists' expectation to any agricultural project.

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