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Effect of agroecological practices on soil carbon sequestration using synchronic and diachronic approaches in Madagascar

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Supplementary Data 1: Description of the land uses and agricultural practices assessed in this study

Site	**Land use and agricultural practice (LUAP)**	**n**	**Description**	**Estimated age in 2014**	**Estimated age in 2018**
AF	Agroforestry	12	Agroforestry involves combining annual crops and trees on the same piece of land. In the Itasy Region, trees were introduced to annual crops that had been grown for many years. Annual crops are mainly defined by the rotation of different crops, such as rainfed rice, cassava, sweet potato, maize, beans and vegetables. The trees planted in Itasy region were mainly fruit species (coffee - *Coffea arabica*, lemon - *Citrus X limon.*, orange – *Citrus X sinensis*, mandarin - *Citrus reticulate*, lychee - *Litchi chinensis*, Mango - *Mangifera indica* and avocado – *Persea sp.*) with a plantation density estimated at 200-500 trees per hectare. Agroforestry sites were fertilised by around 9 to 12 tons per hectare per year of organic matter, such as compost and improved manure.	4–6 years	8–10 years
TP	Tree plantation	12	The trees planted were forest species for energy production or for timber (native species such as Voandelaka - *Melia* sp., eucalyptus - *Eucalyptus* sp., pine - *Pinus* sp. and acacia - *Acacia* sp.). Organic fertiliser (mainly manure) is applied in the first year of plantation (5 tons per hectare). The planting density was estimated at between 500 and 1,200 trees per hectare.	9–11 years	13–15 years
IF	Improved farming practices	12	This system is characterized by the rotation of different crops such as rainfed rice, cassava, sweet potato, maize, beans and vegetables. Crop plots are fertilized with an estimated 9 tons per hectare of organic matter, such as compost and improved manure. This does not occur every year and depends on the availability of organic fertiliser.	4 years	9 years
TF	Traditional farming practices	36	This system is the most common practice that farmers adopt in the Itasy Region. It is characterized by the rotation of rainfed rice, maize, beans and cassava. Organic matter is not supplied regularly, and there is a very low intake rate (< 5 tons per hectare).	-	>10 years
FL	Fallow land	24	Fallow land is dominated by vegetation belonging to the Poaceae family (*Aristida* sp.). Fallow land, known locally as bozaka, is uncultivated land that was abandoned by farmers due to soil infertility and low water retention.	-	>5 years

Supplementary Data 2: Prediction models used to quantify soil carbon content in the Itasy Region using mid-infrared spectrometry (MIRS)

Soil Type	Preprocessing	Calibration				Validation			
		n	R2	RMSEC	RPD	n	R2	RMSEP	RPD
Ferralsols	SNV	500	0.91	3.74	3.19	232	0.86	4.34	2.72
Andosols	-	160	0.97	1.59	6.5	50	0.95	2.54	4.08

n=number of observations, SNV=standard normal variate, RMSEE=root mean square error of calibration, RMSEP=root mean square error of the prediction, RPD=residual prediction deviation.

Supplementry Data 3: Soil bulk densities and carbon contents for the sampled sites with different land uses and agricultural practices (LUAPs) in Madagascar's Itasy Region

LUAP*	n	2014			2018		
		0–10 cm	10–20 cm	20–30 cm	0–10 cm	10–20 cm	20–30 cm
Bulk density							
All samples (g cm^{-3})							
AF	12	1.03 (±0.13)^{Aa}	1.08 (±0.13)^{Aa}	1.08 (±0.16)^{Aa}	1.14 (±0.15)^{Aa}	1.19 (±0.15)^{Aa}	1.18 (±0.17)^{Aa}
TP	12	1.04 (±0.12)^{Ab}	1.11 (±0.15)^{Aa}	1.13 (±0.22)^{Aa}	1.2 (±0.11)^{Aa}	1.19 (±0.17)^{Aa}	1.19 (±0.24)^{Aa}
IFs	12	1.07 (±0.08)^{Ab}	1.13 (±0.13)^{Aa}	1.17 (±0.12)^{Aa}	1.19 (±0.17)^{Aa}	1.2 (±0.15)^{Aa}	1.18 (±0.21)^{Aa}
TFs	36	-	-	-	1.18 (±0.14)^{A}	1.2 (±0.17)^{A}	1.22 (±0.21)^{A}
FL	24	-	-	-	1.21 (±0.16)^{A}	1.2(±0.19)^{A}	1.21(±0.21)^{A}
Ferralsols (g cm^{-3})							
AF	8	1.06 (±0.14)^{Aa}	1.09 (±0.15)^{Ab}	1.1 (±0.18)^{Aa}	1.18 (±0.15)^{Aa}	1.26 (±0.1)^{Aa}	1.25 (±0.15)^{Aa}
TP	8	1.04 (±0.14)^{Ab}	1.18 (±0.11)^{Ab}	1.18 (±0.18)^{Aa}	1.24 (±0.06)^{Aa}	1.29 (±0.1)^{Aa}	1.31 (±0.18)^{Aa}
IFs	8	1.04 (±0.07)^{Ab}	1.19 (±0.05)^{Aa}	1.23 (±0.07)^{Aa}	1.23 (±0.19)^{Aa}	1.24 (±0.17)^{Aa}	1.25 (±0.22)^{Aa}
TFs	24	-	-	-	1.23 (±0.12)^{A}	1.27 (±0.15)^{A}	1.33 (±0.15)^{A}
FL	16	-	-	-	1.27 (±0.13)^{A}	1.30 (±0.12)^{A}	1.32 (±0.11)^{A}
Andosols (g cm^{-3})							
AF	4	0.98 (±0.11)^{Aa}	1.06 (±0.07)^{Aa}	1.03 (±0.08)^{Aa}	1.07 (±0.12)^{Aa}	1.04 (±0.12)^{Aa}	1.04 (±0.1)^{Aa}
TP	4	1.03 (±0.05)^{Aa}	0.99 (±0.16)^{Aa}	1.01 (±0.29)^{Aa}	1.12 (±0.16)^{Aa}	1.01 (±0.1)^{Aa}	0.93 (±0.08)^{Aa}
IFs	4	1.11 (±0.11)^{Aa}	1.04 (±0.19)^{Aa}	1.06 (±0.12)^{ABa}	1.11 (±0.05)^{Aa}	1.14 (±0.07)^{Aa}	1.03 (±0.13)^{Aa}
TFs	12	-	-	-	1.07 (±0.10)^{A}	1.06 (±0.11)^{A}	1.00 (±0.10)^{A}
FL	8	-	-	-	1.07(±0.12)^{A}	0.99 (±0.14)^{A}	0.97(±0.16)^{A}
Carbon content							
All samples (g C kg^{-1})							
AF	12	33.7 (±16)^{Aa}	31.1 (±13.6)^{Aa}	31.9 (±13.2)^{Aa}	38 (±15.7)^{Aa}	36 (±14.9)^{Aa}	29.6 (±14.5)^{Aa}
TP	12	24.2 (±4.6)^{Aa}	20.3 (±9.8)^{Ba}	17.5 (±8)^{Ba}	22.5 (±8.2)^{Ba}	19.8 (±9.8)^{Ba}	17.6 (±9.1)^{Ba}
IFs	12	26.7 (±6.2)^{Aa}	22.7 (±6.7)^{ABa}	20.8 (±4.4)^{Ba}	22.4 (±7.8)^{Ba}	21.7 (±6.7)^{Ba}	20.6 (±6.7)^{Ba}
TFs	36	-	-	-	23.8 (±10.8)^{B}	21.7 (±11.9)^{B}	20.2 (±11.9)^{AB}
FL	24	-	-	-	22 (±13.3)^{B}	20.2 (±12.6)^{B}	17.2 (±11.8)^{B}
Ferralsols (g C kg^{-1})							
AF	8	27.8 (±16.2)^{Ba}	24.5 (±11.4)^{Ba}	24.4 (±8)^{Ba}	32.2 (±14)^{Aa}	29.5 (±12.4)^{Aa}	23.3 (±11.9)^{Aa}
TP	8	24 (±4.6)^{Ba}	18.7 (±10.6)^{Ba}	16.8 (±6.4)^{Ba}	23.6 (±4.8)^{Ba}	18.9 (±6.5)^{Ba}	15.7 (±6.4)^{ABa}
IFs	8	26.5 (±7.4)^{Ba}	20.6 (±4.4)^{Ba}	19.9 (±4.1)^{Ba}	19.9 (±6.7)^{Ba}	20.7 (±5.4)^{Ba}	19.2 (±5.5)^{ABa}
TFs	24	-	-	-	21.2 (±7.7)^{B}	18.4 (±8.1)^{B}	16.9 (±7.9)^{AB}
FL	16	-	-	-	17.3 (±8.0)^{B}	15.8 (±7.9)^{B}	13.1 (±5.9)^{B}
Andosols (g C kg^{-1})							
AF	4	45.3 (±7.4)^{Aa}	44.5 (±3.5)^{Aa}	46.9 (±6.2)^{Aa}	49.4 (±13.4)^{Aa}	49 (±11)^{Aa}	42.2 (±11)^{Aa}
TP	4	24.6 (±5.2)^{Ba}	23.5 (±8.5)^{Ba}	19 (±11.7)^{Ba}	20.4 (±13.6)^{Ba}	21.7 (±15.7)^{Ba}	21.3 (±13.5)^{Aa}
IFs	4	27 (±4.4)^{Ba}	26.5 (±9)^{Ba}	22.3 (±5.2)^{Ba}	27.6 (±8.2)^{ABa}	23.7 (±9.3)^{Ba}	23.4 (±8.9)^{Aa}
TFs	12	-	-	-	29(±14.0)^{AB}	27.9(±15.5)^{B}	26.6(±15.6)^{A}
FL	8	-	-	-	32.7 (±17.1)^{AB}	30(±16.1)^{B}	26.5(±16.4)^{A}

Values in parenthesis refer to the standard deviation. Uppercase letters show results of ANOVA test comparing LUAPs at same depth and using synchronic approach (same letters accompanying the values indicate they are not significantly different at $p<0.05$). Lowercase letters show results of LUAP comparison at same depth using diachronic approach.

* LUAPs: AF=agroforestry, TP=tree plantation, IFs=improved farming practices, TFs=traditional farming practices, FL=fallow land.