Pedotransfer Functions for Estimations of Soil Moisture Retention and Hydro-limits: The Case of *Abreha Atsbeha* in Northern Ethiopia

M. Sebhatleab[1], T. Berihu[2], G. Girmay Woldetensai[3]

The water retained in the soil is determined by factors such as soil texture, soil structure, soil organic matter, clay content and its type. However, determination of water retention is an expensive process with time, manpower and capital required. Pedotransfer functions (PTF) can help to predict the physical or chemical properties of a soil as a response variable. Soil moisture retention (SMR) and hydro-limits are complex and expensive data when generated using the routine laboratory procedures, however it may be possible to estimate them with a PTF. This study was intended to develop a PTF model for soil hydro-limits for different land uses and soil depths for the *Abreha Atsbeha* area, northern Ethiopia (Figure 1). Soil samples were gathered from four land use and land cover classes: bare land, farm land, grass land and exclosures, and bulk density, organic carbon and particle size distribution were analyzed. The soil of the area had an average bulk density value of 1.48 g cm^{-3} (Table 1) and average soil organic matter of 1.41%, though bare land had much less organic matter (0.61%).

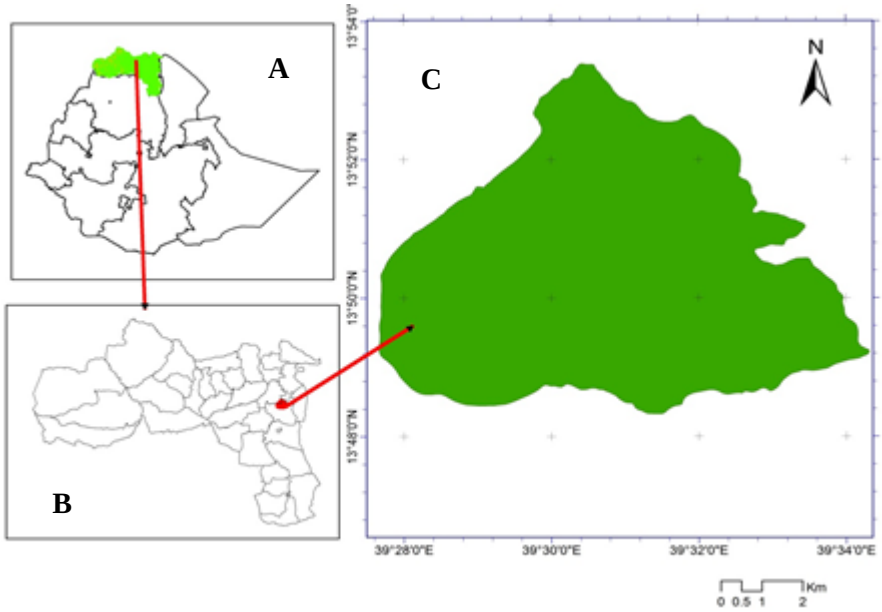

Figure 1. Study area map: (A) Location of Tigray region within Ethiopia (B) Location of the study district within Tigray (C) *Abreha-Weatsibeha tabia* research site.

The pedotransfer functions were found to be linearly related to soil bulk density, clay and organic carbon contents. PTFs developed (Table 2) for the top soil layer (0-30 cm) of the grassland (R^2=0.968), exclosures (R^2=0.858), and bare land (R^2=0.584) were found to be highly significant for predicting the water potential at -33 kPa when compared to that for the entire area (R^2=0.305, data not shown). The grasslands are on the valley floor landscapes and livestock grazing is controlled. The exclosures are better managed through natural regeneration of the vegetation. In both cases, there were higher additions of biomass to the soils. The bare land on the other hand exhibited a very dense soil surface. The PTFs developed for the farm lands were less reliable (R^2=0.423), probably to the perturbations during tillage.

[1]Mulugeta Sebhatleab1, [2]Tesfay Berihu1, and [3]Gebreyohannes Girmay Woldetensai, Department of Land Resources, Management & Environmental Protection, Mekelle University, Mekelle, Tigray, Ethiopia. Corresponding author: G. Girmay Woldetensai, email: gebreyohannes.girmay@gmail.com.

Table 1. Average results for all soil parameters by land use and land cover (LULC) and overall statistical summary.

		LULC				All LULC			
Parameters	Unit	Exclosure	Bare	Grass	Farm	Mean	Max	Min	SD
BD	g/cm^3	1.50	1.66	1.07	1.52	1.48	2.01	1.01	0.32
SOM	%	1.34	0.61	2.73	1.50	1.41	3.68	0.21	0.83
Clay	%	20.1	15.6	20.2	14.6	17.4	36.0	7.00	5.93
Sand	%	37.8	43.4	33.4	38.9	38.9	51.0	23.0	5.65
Silt	%	42.0	41.0	46.3	46.5	43.8	64.0	24.0	7.15
FC	%	28.7	15.1	20.0	24.5	22.7	42.2	8.32	7.70
PWP	%	11.8	8.06	7.29	9.09	9.38	16.9	2.28	3.30

*BD – bulk density; SOM – soil organic matter; FC – field capacity water content; PWP – permanent wilting point water content; SD-Standard deviation.

Table 2. Pedotransfer functions (PTFs) for estimating soil moisture potential at -33 and -1500 kPa at two soil depths and land use types.

Land use	**Depth**	**PTF***	**R^2**
Exclosure	0-30	FC = 24.1557BD + 5.6951SOM - 0.1243Cl - 11.4851	0.858
		PWP = 12.5054BD + 2.4945SOM + 0.0798Cl - 12.1868	0.458
	30-70	FC = 31.8559BD + 18.7765SOM - 0.8901Cl - 23.469	0.585
		PWP = 4.0516BD + 0.424SOM + 0.102Cl + 3.767	0.515
Grass land	0-30	FCFC = 3.787SOM - 24.811BD - 0.088Cl + 36.5869	0.968
		PWP = 121.4631 + 6.096 - 0.1548Cl - 135.408	0.851
	30-70	FC = 2.756BD + 0.251SOM - 0.275Cl + 22.319	0.823
		PWP = 41.235BD + 6.888SOM + 0.312Cl - 60.947	0.936
Farm land	0-30	FC = 10.623BD + 4.909SOM - 0.677Cl + 13.235	0.423
		PWP = 10.531BD + 4.101SOM + 0.0243Cl - 14.144	0.493
	30-70	FC = 25.33BD + 12.499SOM - 0.179Cl - 30.129	0.603
		PWP = 6.881BD + 1.007SOM + 0.148Cl - 4.721	0.421
Bare land	0-30	FC = 9.611BD - 0.538SOM - 0.033Cl + 0.459	0.584
		PWP = 8.367BD + 1.503SOM + 0.403Cl - 13.093	0.901
	30-70	FC = 15.549BD + 10.359SOM + 0.138Cl - 18.808	0.745
		PWP = 6.338BD - 2.938SOM + 0.465Cl - 8.132	0.559

*PTF – Pedotransfer Function, FC – Field Capacity (-33 kPa), PWP – Permanent Wilting Point (-1500 kPa), BD – Bulk Density, SOM – Soil Organic Matter, Cl – Clay Content.

In general, the selected soil parameters were linearly correlated with the soil moisture potentials. Thus, soil water retention at the -33 and -1500 kPa can be estimated from simple attributes such as particle size distribution, bulk density and soil organic matter through PTFs. This study, in *Abreha Atsbeha* in northern Ethiopia, shows total available moisture higher for exclosures and grasslands due to better management practices. Stratifying the soils based on land use types resulted in more reliable estimates of the PTFs indicating that monitoring of impacts of introduced technologies on soil water and nutrients can be simplified. Developing a soil database from routine analyses in laboratories for use to develop and apply prediction models can minimize cost and laboratory errors, leading to efficient planning of rural land management strategies in developing countries.