Chapter 8. Soil Water Retention Characteristic Estimation

8.1 Estimation of Soil Water Retention Characteristic

The measurement of soil water characteristics is time consuming and expensive. Soil water retention characteristic may be predicted using empirical equations from more easily measurable soil properties such as soil texture and bulk density (Arya and Paris, 1981; Campbell, 1985; Scheinost et al, 1997). Such empirical equations are known as pedotransfer functions (PTFs). The soil water retention equation is fitted to soil water retention measurements adjusting its parameters to match as close as possible measured water retention values. The parameter values control the position and shape of the water retention curves. The following sections discuss the method of developing water retention PTFs for soils of the SIR.

8.2 Correlation Analysis

Correlation analyses of measured soil water retention characteristic at 0, 10, 60 and 1500 kPa suction and soil properties of Horizons A and B1 were carried out to determine which soil properties were closely related to soil water characteristic. The closely correlated parameters to soil water retention characteristic were then used in the development of the pedotransfer functions.

Figures 8.1 and 8.2 show the relationships between soil water content and soil properties of Horizons A and B1. Water content showed an increasing trend with clay content and the correlation between water content and clay content is stronger at high matric suctions. Conversely, water content showed a decreasing trend with bulk density and the correlation between water content and bulk density is stronger at low matric suctions

Table 8.1 Correlation Coefficients between Soil Water Characteristic and Soil Properties (Horizon A)

Matric Suction	Correlation Coefficient										
	Clay%	Silt%	Sand %	BD	dg	OM	Ca	Mg	Na	K	TC	ESP
0 kPa	0.25	-0.12	-0.13	-0.62	0.02	0.38	0.37	0.27	-0.06	0.25	0.33	-0.21
10 kPa	0.35	-0.02	-0.27	-0.54	-0.09	0.49	0.47	0.40	0.09	0.23	0.45	-0.10
60 kPa	0.43	-0.02	-0.34	-0.48	-0.18	0.48	0.50	0.44	0.13	0.28	0.49	-0.08
1500 kPa	0.63	0.11	-0.58	-0.37	-0.55	0.40	0.58	0.53	0.24	0.31	0.59	0.01

Note : BD = Bulk density, dg= Geometric mean particle size diameter, OM = Organic matter, TC = Total cations (sum of four exchangeable cations).

Table 8.2 Correlation Coefficients between Soil Water Characteristic and Soil Properties (Horizon B1)

Matric Suction	Correlation Coefficient										
	Clay%	Silt%	Sand %	BD	dg	OM	Ca	Mg	Na	K	TC	ESP
0 kPa	0.64	-0.10	-0.57	-0.59	-0.29	0.33	0.53	0.67	0.55	0.44	0.69	0.25
10 kPa	0.76	-0.07	-0.71	-0.59	-0.58	0.35	0.50	0.70	0.59	0.40	0.69	0.31
60 kPa	0.80	-0.08	-0.75	-0.60	-0.61	0.31	0.53	0.70	0.58	0.43	0.71	0.30
1500 kPa	0.83	-0.01	-0.81	-0.62	-0.62	0.30	0.57	0.66	0.52	0.40	0.70	0.24

Note : BD = Bulk density, dg= Geometric mean particle size diameter, OM = Organic matter, TC = Total cations (sum of four exchangeable cations).

In general, soil parameters of Horizon B1 showed relatively stronger correlation with soil water retention characteristics than the parameters of Horizon A (Tables 8.1 and 8.2). Some of the chemical properties showed stronger correlation with soil water retention characteristic. However, measurement of chemical properties such as exchangeable cations is expensive, therefore not considered for the development of pedotransfer functions. Only easily measurable soil physical properties such as clay%, silt%, sand% and bulk density were considered for the development pedotransfer functions for soils of the SIR.

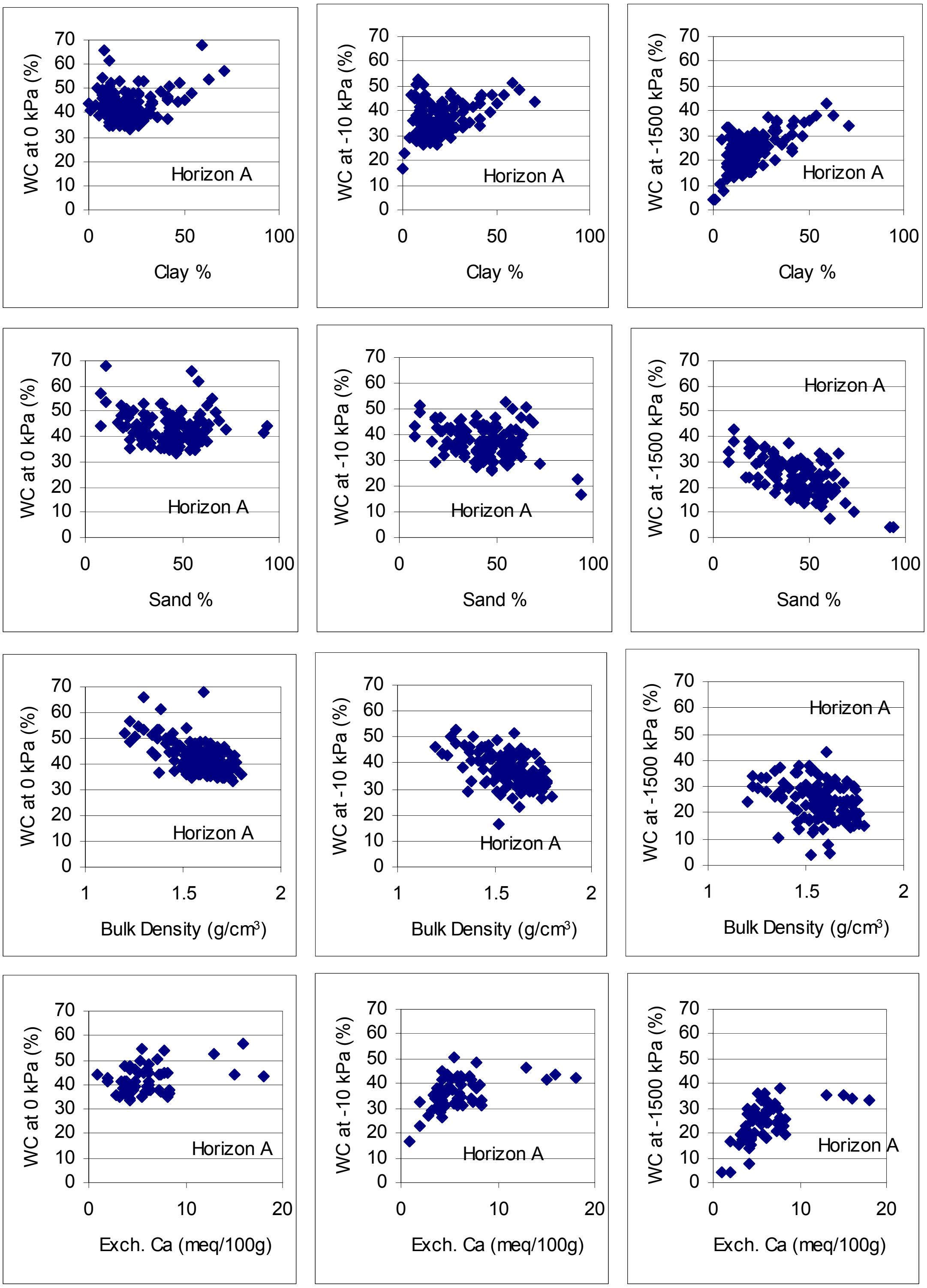

Figure 8.1 Relation of Water Content of Horizon A at Various Suctions with Soil Properties

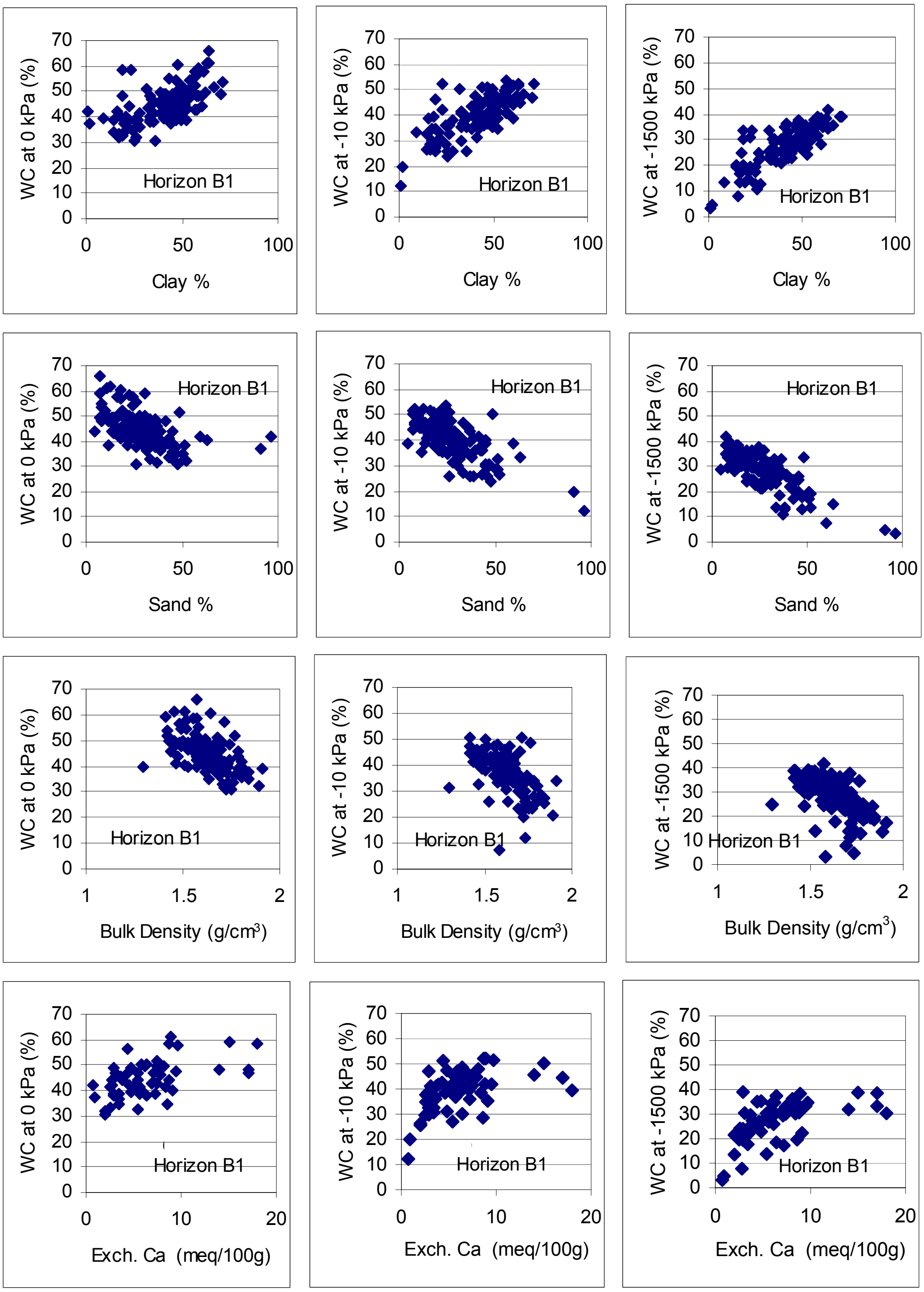

Figure 8.2 Relation of Water Content of Horizon B1 at Various Suctions with Soil Properties

Correlation analysis of measured soil water capacities such as AWC0 and AWC, and soil properties of Horizons A and B1 were carried out to determine which soil properties were closely related to soil water capacities. The results of analysis are summarised in Tables 8.3 and 8.4. Soil water capacities of Horizon A are closely related to clay and sand percentages. For Horizon B1, correlation coefficients between soil water capacities and clay and sand percentages were smaller compared to those of Horizon A.

Table 8.3 Correlation Coefficients between Soil Water Capacities and Soil Properties (Horizon A)

Parameter	Correlation Coefficient										
	Clay%	Silt%	Sand%	BD	OM	Ca	Mg	Na	K	TC	ESP
AWC0	-0.49	-0.26	0.56	-0.19	-0.14	-0.36	-0.38	-0.35	-0.15	-0.41	-0.21
AWC	-0.47	-0.20	0.51	-0.17	0.04	-0.27	-0.28	-0.27	-0.16	-0.31	-0.17

Note : BD = Bulk density, OM = Organic matter, TC = Total exchangeable cations (sum of four cations)

Table 8.4 Correlation Coefficients between Soil Water Capacities and Soil Properties (Horizon B1)

Parameter	Correlation Coefficient										
	Clay%	Silt%	Sand%	BD	OM	Ca	Mg	Na	K	TC	ESP
AWC0	-0.35	-0.13	0.43	0.09	-0.01	-0.17	-0.11	-0.06	-0.02	-0.15	-0.03
AWC	-0.15	-0.12	0.22	0.04	0.09	-0.17	0.05	0.12	-0.01	-0.05	0.15

Note : BD = Bulk density, OM = Organic matter, TC = Total exchangeable cations (sum of four cations)

Figures 8.3 and 8.4 show relationship between soil water capacities (AWC0 and AWC) and soil properties of Horizons A and B1. Soil water capacities showed an increasing trend with clay content. In general, correlations between soil water capacities and other soil properties were weak. Therefore, the accurate estimation of soil water capacities directly from soil properties would be difficult. Soil water capacities can be determined from the pedotransfer functions developed for soil water retention characteristics.

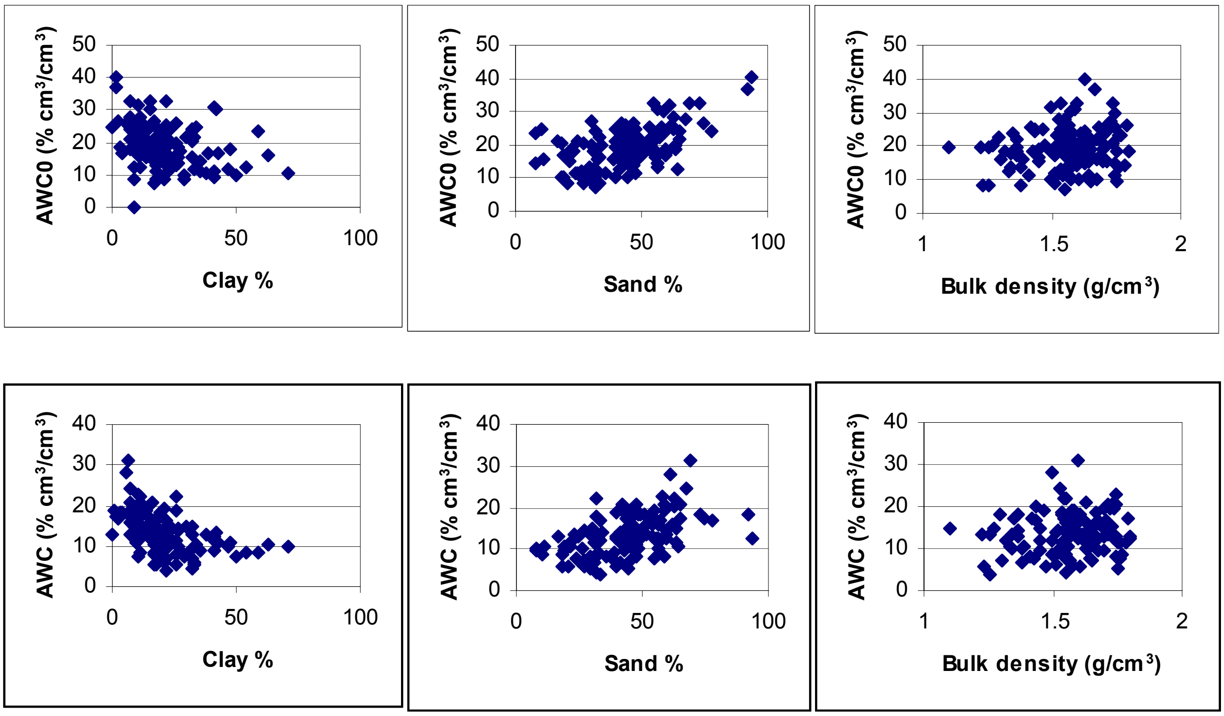

Figure 8.3 Relation of AWC0 and AWC of Horizon A with Soil Properties

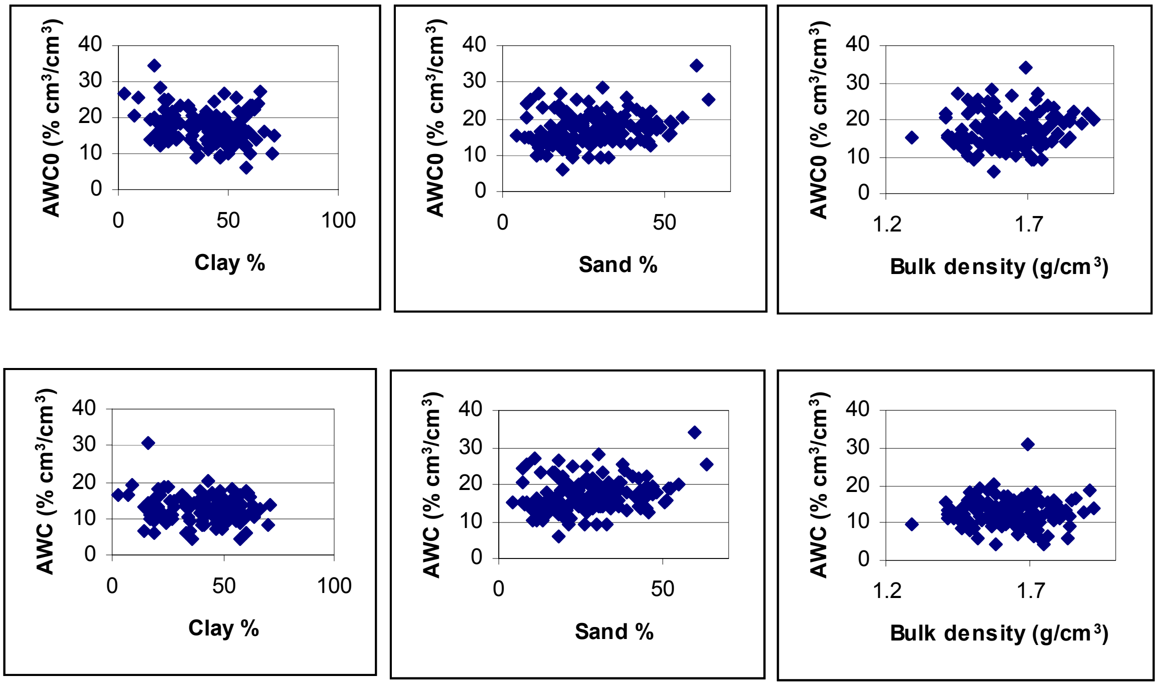

Figure 8.4 Relation of AWC0 and AWC of Horizon B1 with Soil Properties

8.3 Type of PTF Estimation

Pedotransfer functions for predicting the water retention curve can be divided into 3 types:

(1) Point Estimation

This type of PTF predicts water content (θ) at a predefined soil water suction (h). The most frequently estimated θ are at 10 kPa (corresponding to field capacity) and at 1500 kPa (corresponding to permanent wilting point), which are needed to determine soil water capacity.

(2) Parametric Estimation

Parametric PTFs are based on the assumption that the soil water retention function can be described by a closed form equation with a certain number of parameters such as Brooks and Corey (1964), Campbell (1974) and van Genuchten (1980). The parametric approach is usually preferred as it yields a continuous function of θ(h) relationship. Water retention at any potential can be estimated, and it also ensures that the water content predicted at lower potential will be smaller than the one at higher potential. The estimated parameters can be used to predict the unsaturated hydraulic conductivity based on hydraulic models (Mualem, 1976). Soil water transport models usually only require the parameters of the hydraulic functions, thus the predicted parameters can be used directly in the models.

(3) Physico-empirical Model

In this approach, the soil water retention characteristics are derived from physical attributes. Arya and Paris (1981) translated the particle-size distribution into a soil water retention curve by converting solid mass fractions to water, and pore size distribution into soil water potential by means of a capillary equation. The method is difficult to apply as it requires information on the packing of soil particles. This method was not further considered in this study.

8.4 Developing PTFs for the SIR

Developing new PTFs requires a large soil database containing many soil measurements. Soil hydraulic and physical properties were measured for 34 soil types across 79 sites in the SIR. Using these data, which contribute to a soil database, statistical relationships relating soil water retention characteristics to soil properties were derived. The distinct properties of Australian soil (Williams, 1983) means that PTFs developed elsewhere cannot be directly applied without testing. Testing of available PTFs was carried out so that the most suitable PTFs could be identified.

8.4.1 Soil Hydraulic Properties Database for SIR soils

A database of measured soil hydraulic and soil properties in SIR was established. It contains measured data of soil water retention characteristic and soil properties such as particle size distribution, bulk density, organic matter content and exchangeable cations of Horizons A and B1. The soil physical properties common to all data sets were tabulated and were used to develop pedotransfer functions for estimation of soil water retention characteristics. The soil properties used were:

(i) Particle size fractions of clay (<2 μm), silt (5-50 μm) and sand (50-2000 μm),

(ii) Bulk density (BD) in g cm^{-3}.

(iii) Measured soil water contents at water suctions of 0, 1, 5, 8, 10, 60, 80, 200 and 1500 kPa.

(iv) Geometric mean particle size diameter d_g (mm) and geometric standard deviation σ_g (mm).

These were calculated from main grain size fractions (m_1, m_2, m_3 are clay, silt and sand mass fractions respectively) as

$$d_g = \exp \sum_{i=1}^{3} m_i \ln d_i \quad (1)$$

$$\sigma_g = \exp\left[\sum_{i=1}^{3} m_i \left(\ln d_i\right)^2 - \left(\sum_{i=1}^{3} m_i \left(\ln d_i\right) \right)^2 \right]^{0.5} \quad (2)$$

where m_i is the mass fraction and d_i is the mean particle size diameter of the i^{th} mass fraction class.

8.4.2 Soil Water Retention PTFs

(1) Point PTF

The method below is the most common method used in the point estimation PTF. The relationship between θ and soil properties at a specified matric suction can be expressed as (Minasny et al., 1999).

$$\theta = a_1 c + a_2 s + a_3 BD + a_4 \quad (3)$$

$$\theta = a_1 c + a_2 (1 - BD/2.65) + a_3 \quad (4)$$

where θ is water content at specified suction h (kPa), c is clay content (%), s is sand content (%), BD bulk density (g/cm^3), and a_1, a_2, a_3, a_4 and n are regression coefficients.

Parameters for Point PTFs were estimated using multiple regression.

(2) Parametric PTF

The van Genuchten model (1980) was used in the parametric estimation of PTF. The relationship between $\theta(h)$ and soil properties is expressed as

$$\theta(h) = \theta_r + \frac{(\theta_s - \theta_r)}{\left[1 + (\alpha h)^N\right]^{(1-1/N)}} \tag{5}$$

where $\theta(h)$ is the measured volumetric water content (cm^3 cm^{-3}) at the suction h (kPa). The parameters θ_r and θ_s are residual and saturated water contents, respectively, (cm^3 cm^{-3}); α is a scaling parameter (>0, in cm^{-1}) related to the inverse of the air entry suction, and N (>1) is a curve shape parameter, a measure of the pore-size distribution (van Genuchten, 1980).

The parameters of the equation were estimated using nonlinear regression (NLR) analysis as well as by artificial neural network (ANN). These two methods are described below.

(a) Nonlinear Regression (NLR)

The parameters of the van Genuchten Equation (6) such as θ_s, θ_r, α, and N can be expressed in terms of soil physical properties.

$$\theta_s = s_1 (1 - BD/2.65) + s_2 \tag{6}$$

$$\theta_r = r_1 c + r_2 s + r_3 \tag{7}$$

$$\alpha = a_1 + a_2 d_g \tag{8}$$

$$N = n_1 + n_2 \sigma_g \tag{9}$$

where BD is bulk density in g/cm^3, c is clay percentage, s is sand percentage, d_g (mm) is geometric mean diameter and σ_g is geometric standard deviation and s_1, s_2, r_1, r_2, r_3, a_1, a_2, n_1 and n_2 are empirical parameters.

θ_s , θ_r , α, and N of the van Genuchten Equation (5) are replaced with Equations (6), (7), (8), and (9), which results in following equation.

$$\theta(h) = r_1 c + r_2 s + r_3 + \frac{(s_1 (1 - BD/2.65) + s_2 - r_1 c - r_2 s - r_3)}{\left[1 + ((a_1 + a_2 d_g) h)^{(n_1 + n_2 \sigma_g)}\right]^{(1 - 1/(n_1 + n_2 \sigma_g))}} \tag{10}$$

Nonlinear regression analysis was used to fit the parameters of the PTF Equation (10) from measured data.

(b) Artificial Neural Network (ANN)

A more recent approach for fitting PTFs is to use artificial neural networks (ANN) (Tamari *et al.*, 1996; Pachepsky *et al.*, 1996; Schaap and Bouten, 1996). ANN is simply a sophisticated regression, which has a network of many simple elements or processors or 'neurons'. The elements are connected by communication channels or 'connectors' which usually carry numeric data, encoded by a variety of means, and often organized into subgroups or layers. A neural network can perform a particular function when certain values are assigned to the connections or 'weights' between elements. To describe a system, there is no assumed structure of the model, instead the networks are adjusted, or 'trained', so that a particular input leads to a specific target output, which is called supervised learning (Demuth and Beale, 1998). The objective of the training is to minimize the residual sum of squares between the measured and predicted output. An advantage of neural networks, as compared to traditional PTFs, is that neural networks require no a priori model concept. The optimal, possibly nonlinear, relations that link input data (particle-size data, bulk density, etc.) to output data (hydraulic parameters) are obtained and implemented in an iterative calibration procedure. As a result, neural network models typically extract the maximum amount of information from the data. Schaap et al. (1998) used neural network analyses to estimate van Genuchten (1980) water retention parameters.

In this study, Neuroman Version 1.2 software, developed by Australian Centre of Precision Agriculture, was used to fit parameters of the van Genuchten Equation (6) using ANN.

8.4.3 Evaluation Criteria

The performance of PTFs was analysed comparing the quality of the estimations when applied on a particular soil data set. The following indicators were determined to evaluate the performance of PTFs.

(1) Sum of Squares Residuals (SSR)

All methods for estimating the PTF parameters were based on minimising the sum of squares residuals (SSR) of measured θ and predicted $\hat{\theta}$.

$$SSR = \sum_{i=1}^{N} \left(\hat{\theta}_i - \theta_i\right)^2 \qquad (11)$$

(2) Root Mean Squares of Residuals (RMSR)

Root mean squares of residuals (RMSR) calculates the mean accuracy of prediction, which represents the expected magnitude of error.

$$RMSR = \left\{\frac{1}{N} \sum_{i=1}^{N} \left(\hat{\theta}_i - \theta_i\right)^2 \right\}^{\frac{1}{2}} \qquad (12)$$

where N is number of data points.

(3) Mean Deviation (MD)

Tietje and Tapkenhinrichs (1993) proposed the use of Mean Deviations (MD) as a measure of how well the PTFs fit to the retention curve. It is the sum of the area difference between the observed and predicted water retention curves. A single number can represent how well the PTFs fit to the whole water retention curve. MD indicates whether the PTFs over or underestimate the observed data.

$$MD = \frac{1}{b-a} \int_a^b \left[\hat{\theta} - \theta\right] d(\log_{10} h) \qquad (13)$$

To allow for the log normal distribution of h, the MDs were calculated using $\log_{10}(h)$. The integration boundaries a and b were set to a = $\log_{10}$(0.1 kPa) and b = $\log_{10}$(1500 kPa)

(4) Root Mean Square Deviation (RMSD)

Tietje and Tapkenhinrichs (1993) also introduced RMSD as a measure of the absolute deviation from the observed data. RMSD between measured and predicted water contents was calculated as:

$$RMSD = \left(\frac{1}{b-a} \int_a^b \left[\hat{\theta} - \theta\right]^2 d(\log_{10} h) \right)^{1/2} \qquad (14)$$

The RMSD equals zero if there is no difference between the predicted and the measured values. a and b were set to the same values as for MD calculation.

8.5 Results and Discussion

8.5.1 Point PTFs

Tables 8.5 and 8.6 show the parameters of Point PTFs for water content at 0, 10, 60, 1500 kPa water suctions of Horizons A and B1. RMSR of all the equations varies between 0.037 and 0.054 cm^3 cm^{-3}, which can be considered satisfactory. The amount of variance explained by the equations for Horizon A is relatively poor (R^2 between 0.38 and 0.52). On the other hand, the amount of variance explained by the equations of Horizon B1 for 10, 60 and 1500 kPa is relatively better (R^2 between 0.59 and 0.76). For Horizon B1, higher values of R^2 were obtained for the equations for higher matric suction.

Table 8.5 Parameters of Point Estimation PTFs of Horizon A

Matric Suction (kPa)	Equation	No of Data	RMSR	R^2
0	0.00173 c + 0.00071 s – 0. 288 BD + 0.821	131	0.048	0.43
	0.00104 c + 0.765 * (1-BD/2.65) + 0.102	131	0.048	0.42
10	0.00167 c + 0.0001 s – 0.255 BD+ 0.738	131	0.052	0.38
	0.00165 c + 0.676 * (1-BD/2.65) + 0.067	131	0.051	0.38
60	0.00223 c + 0.00001 s – 0.239 BD + 0.667	131	0.054	0.40
	0.00222 c + 0.636 * (1-BD/2.65) + 0.032	131	0.054	0.40
1500	0.00244 c - 0.00109 s – 0.183 BD + 0.529	131	0.050	0.52
	0.00349 c + 0.484 * (1-BD/2.65) – 0.025	131	0.052	0.50

Table 8.6 Parameters of Point Estimation Equations of Horizon B1

Matric Suction (kPa)	Equation	No of Data	RMSR	R^2
0	0.00164 c - 0.00061 s – 0.198 BD + 0.723 0.00203 c + 0.556 (1- BD/2.65) + 0.153	136 136	.052 .052	0.49 0.48
10	0.00208 c - 0.00142 s – 0.135 BD + 0.577 0.00298 c + 0.429 (1- BD/2.65) + 0.115	136 136	.047 .049	0.63 0.59
60	0.00248 c - 0.0016 s – 0.116 BD + 0.50 0.0035 c + 0.389 (1- BD/2.65) + 0.073	136 136	.046 .049	0.69 0.64
1500	0.00197 c - 0.00213 s – 0.107 BD + 0.432 0.00333 c + 0.393 (1- BD/2.65) - 0.0108	136 136	.037 .044	0.76 0.67

8.5.2 Parametric PTFs of Horizon A

Table 8.7 shows the parameters for water retention PTFs of Horizon A determined by the NLR method. Sandmount sand was considered separately for the estimation of PTFs as the shape of measured water retention curve is significantly different from other duplex soils of the SIR. The precision of the PTF equation was determined by calculating R^2, MD, and RMSD for soil water contents predicted at the suctions for which measured data were available. RMSD of the NLR parametric PTF is 0.032 cm^3cm^{-3} for duplex soils, which is satisfactory. The amount of variance explained by the NLR PTF is $R^2 = 0.78$, which is satisfactory.

ANN method was also used to fit soil water retention characteristic curve because this method is considered efficient in fitting nonlinear relations. Table 8.8 shows the performance of the ANN PTF for Horizon A. RMSD of the ANN PTF is 0.036 cm^3cm^{-3} for the data set from which the model was trained. The amount of variance explained by the ANN PTF is satisfactory ($R^2 = 0.88$). However, the ANN's prediction with new data is poor (RMSD=0.04 and R^2=0.69) than using NLR (RMSD=0.03 and R^2=0.78). This indicates that the training of ANN PTF may require larger dataset than the existing dataset to have better prediction with any new dataset.

Figure 8.5 shows the comparison of measured and estimated water contents of Horizon A by the NLR and ANN PTFs. The scatter of data around 1:1 line is small for both methods.

Figures 8.6a and 8.6b a show the comparison of the measured and estimated water retention curve of Horizon A from the NLR and ANN PTFs. Both PTFs provided a good fit with measured water retention data.

Table 8.7 Parameters of PTFs of Horizon A Determined by NLR PTF

Soil	Equation	Parameters		No. of Data	RMSR	R^2	MD	RMSD
All duplex soils in SIR	$\theta(h)=\theta_r+\frac{(\theta_s-\theta_s)}{(1+(\alpha h)^N)^{(1-1/N)}}$ $\theta_s = s_1\,(1\text{-}BD/2.65) + s_2$ $\theta_r = r_1\,c + r_2\,s + r_3$ $\alpha = a_1 + a_2\,d_g$ $N = n_1 + n_2\,\sigma_g$	s_1=1.199 s_2= - 0.0394 r_1=0.0029 r_2= -0.0045 r_3=0.03 a_1=0.1 a_2=0.80 n_1=1.10 n_2=-0.003	Prediction with data set used for estimating parameters of regression equation	465	.043	0.78	0.00	0.032
			Prediction with new data set	108	0.033	0.78	-0.3	0.034
Sandmount sand	$\theta_S = s_1\,c + s_2\,BD + s_3$ $\theta_r = r_1\,c + r_2\,s$ $\alpha = a_1 + a_2\,d_g$ $N = n_1 + n_2\,\sigma_g$	s_1= 0.00724 s_2= -0.454 s_3=1.162 r_1=0.002 r_2= 0.00047 a_1=-0.724 a_2=1.66 n_1=2.917 n_2=-0.461	Prediction with data set used for estimating parameters of regression equation	16	0.019	0.98	0.00	0.020

Table 8.8 Performance Indicators of PTF of Horizon A Determined by ANN Method

Soil		No. of Data	RMSR	R^2	MD	RMSD
All duplex soils of the SIR	Prediction with data set used for training	465	0.035	0.88	0.004	0.036
	Prediction for new data set	108	0.056	0.69	-0.50	0.040

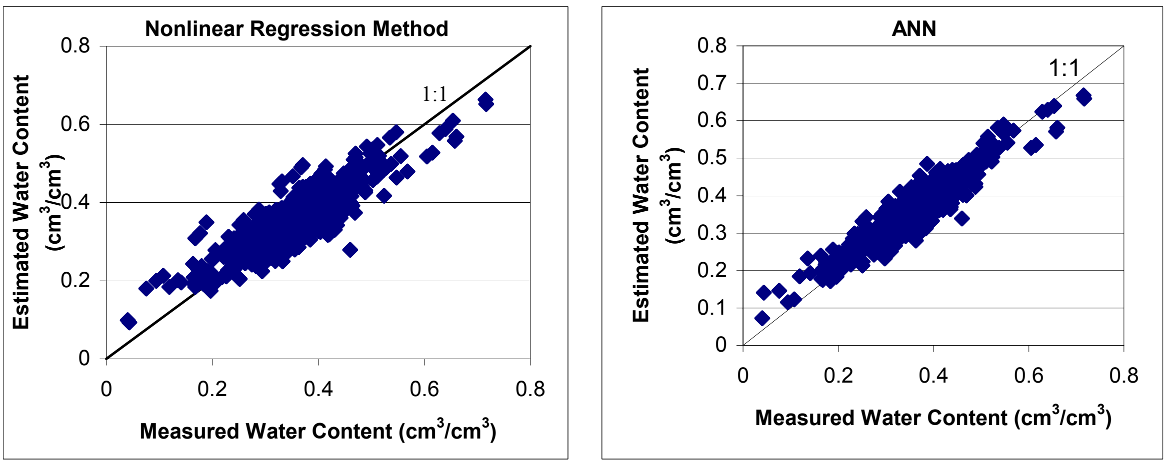

Figure 8.5 Measured and Estimated Water Contents of Horizon A

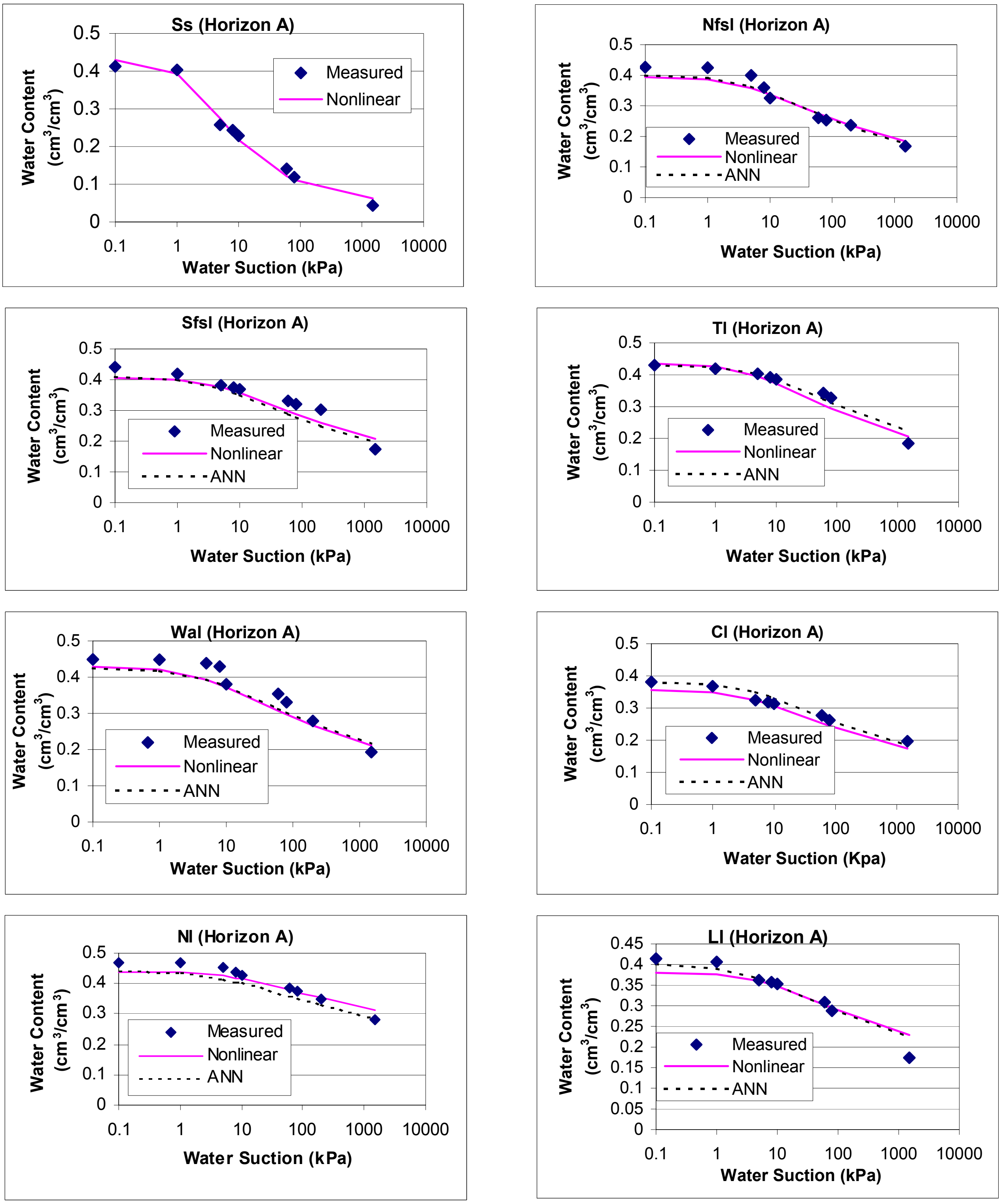

Figure 8.6a Measured and Estimated Soil Water Retention Curve of Horizon A of Selected Soils

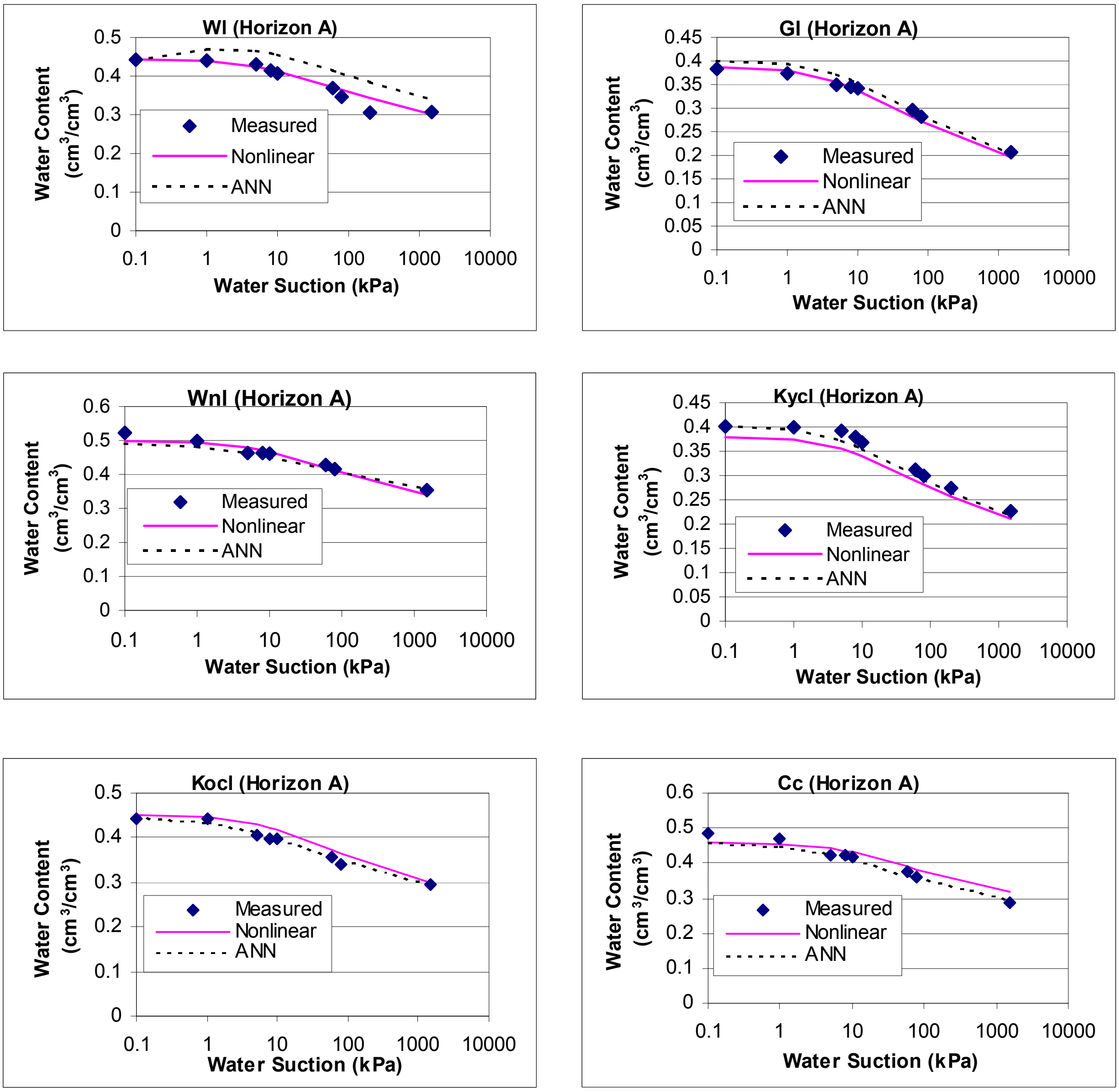

Figure 8.6b Measured and Estimated Soil Water Retention Curve of Horizon A of Selected Soils

8.5.3 Parametric PTFs of Horizon B1

Table 8.9 shows the parameters of water retention PTFs for Horizon B1 determined using NLR. The RMSD of PTFs is 0.028 cm^3cm^{-3} for duplex soils, which is satisfactory. The amount of variance explained by the functions is satisfactory (R^2 = 0.82).

Table 8.10 shows the performance indicators of PTFs of Horizons B1 determined from the ANN method. Sandmount sand was not considered for the estimation of PTF as the number of measured data was not sufficient for the ANN method. The RMSD of the PTF is 0.035 cm^3cm^{-3} for the data set from which the model was trained. The amount of variance explained by the ANN PTF is satisfactory (R^2 = 0.84). However, the ANN's prediction with new data is poor (RMSD=0.033 and R^2=0.66) than using NLR (RMSD=0.019 and R^2=0.88).

Figure 8.7 shows the comparison of measured and estimated water contents of Horizon B1 by the NLR and ANN PTFs. The scatter of data around the 1:1 line is small for both methods.

Figures 8.8a and 8.8b show the comparison of measured and estimated water retention curve of Horizon B1 by the NLR and ANN PTFs. The estimated PTFs fit reasonably well over the entire range of measured water contents. Both methods provided a similar fit with measured water retention data.

Table 8.9 Parameters of the NLR PTFs of Horizon B1

Point Estimation	Equation	Parameter		No of Data	RMSR	R^2	MD	RMSD
All duplex soil in SIR	$\theta(h)=\theta_r+\frac{(\theta_s-\theta_s)}{(1+(\alpha h)^N)^{(1-1/N)}}$ $\theta_s = s_1\, c + s_2\, BD + s_3$ $\theta_r = r_1\, c + r_2\, s + r_3$ $\alpha = a_1 + a_2\, d_g$ $N = n_1 + n_2\, \sigma_g$	s_1= 0.00058 s_2= - 0.322 s_3= 0.9575 r_1= 0.00109 r_2= - 0.003 r_3= 0.230 a_1= 0.096 a_2= 1.74 n_1= 1.329 n_2= - 0.0087	Prediction with data set used for estimating parameters of regression equation	436	0.038	0.82	0.00	0.028
			Prediction with new data set	54	0.028	0.88	-0.13	0.019
Sandmount sand	$\theta(h)=\theta_r+\frac{(\theta_s-\theta_s)}{(1+(\alpha h)^N)^{(1-1/N)}}$ $\theta_s = s_1\, c + s_2\, BD + s_3$ $\theta_r = r_1\, c + r_2\, s + r_3$ $\alpha = a_1 + a_2\, d_g$ $N = n_1 + n_2\, \sigma_g$	s_1=0.011 s_2=-0.331 s_3=0.938 r_1=-0.130 r_2=-0.0045 r_3=0.651 a_1=1.691 a_2=-1.355 n_1=4.458 n_2=-0.842	Prediction with data set used for estimating parameters of regression equation	16	0.014	0.99	0.00 3	0.017

Table 8.8 Performance Indicators of PTF of Horizon B1 Determined from ANN Method

Soil		No. of Data	RMSR	R^2	MD	RMSD
All duplex soils excluding Ss	Prediction with data set used for training	436	0.034	0.84	0.005	0.035
	Prediction for new data set	54	0.047	0.66	-0.13	0.033

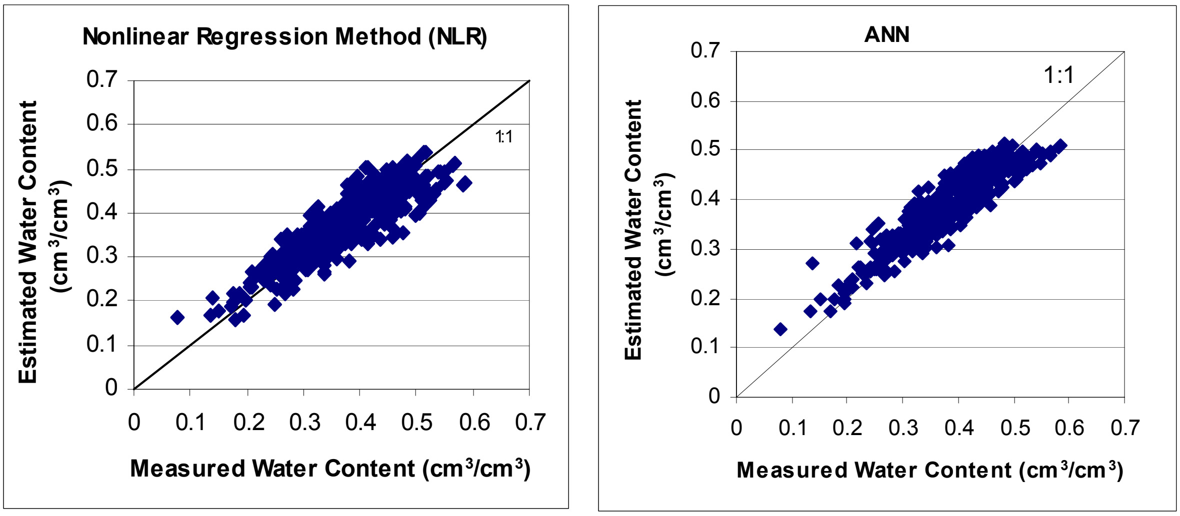

Figure 8.7 Measured and Estimated Soil Water Contents of Horizon B1

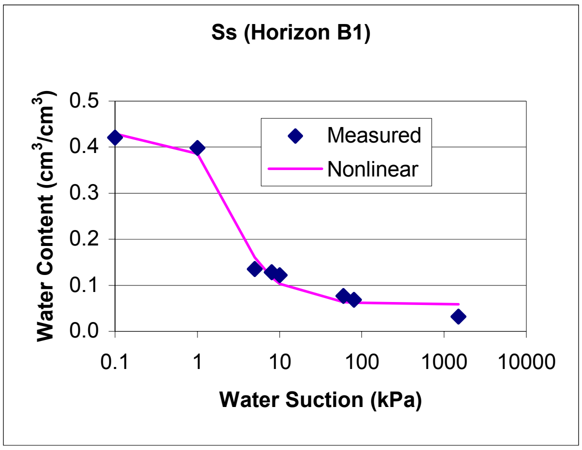

Figure 8.8 Soil Water Retention Curve of Horizon B1 of Sandmount Sand

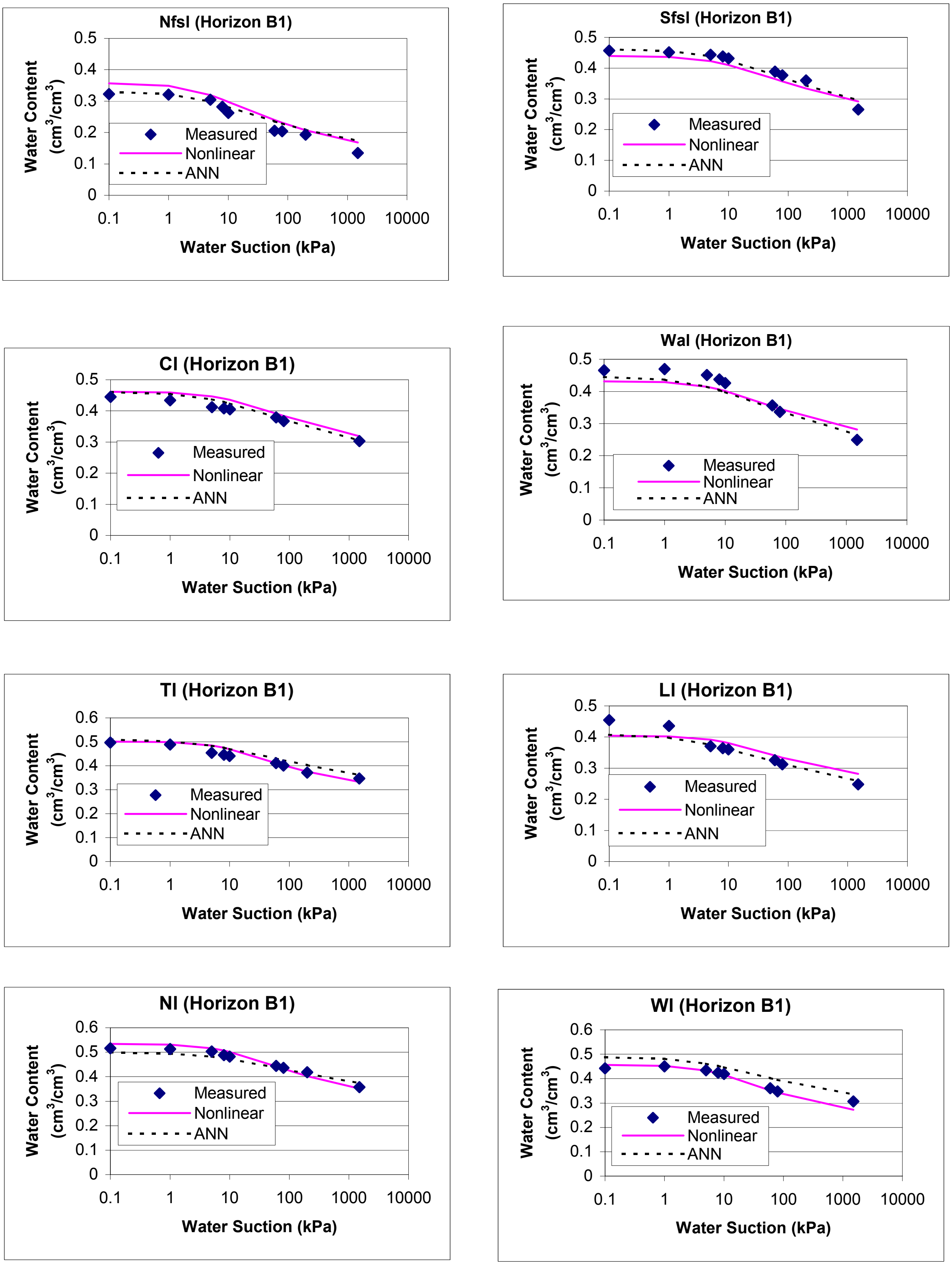

Figure 8.8a Measured and Estimated Soil Water Retention Curve of Horizon B1 of Selected Soils

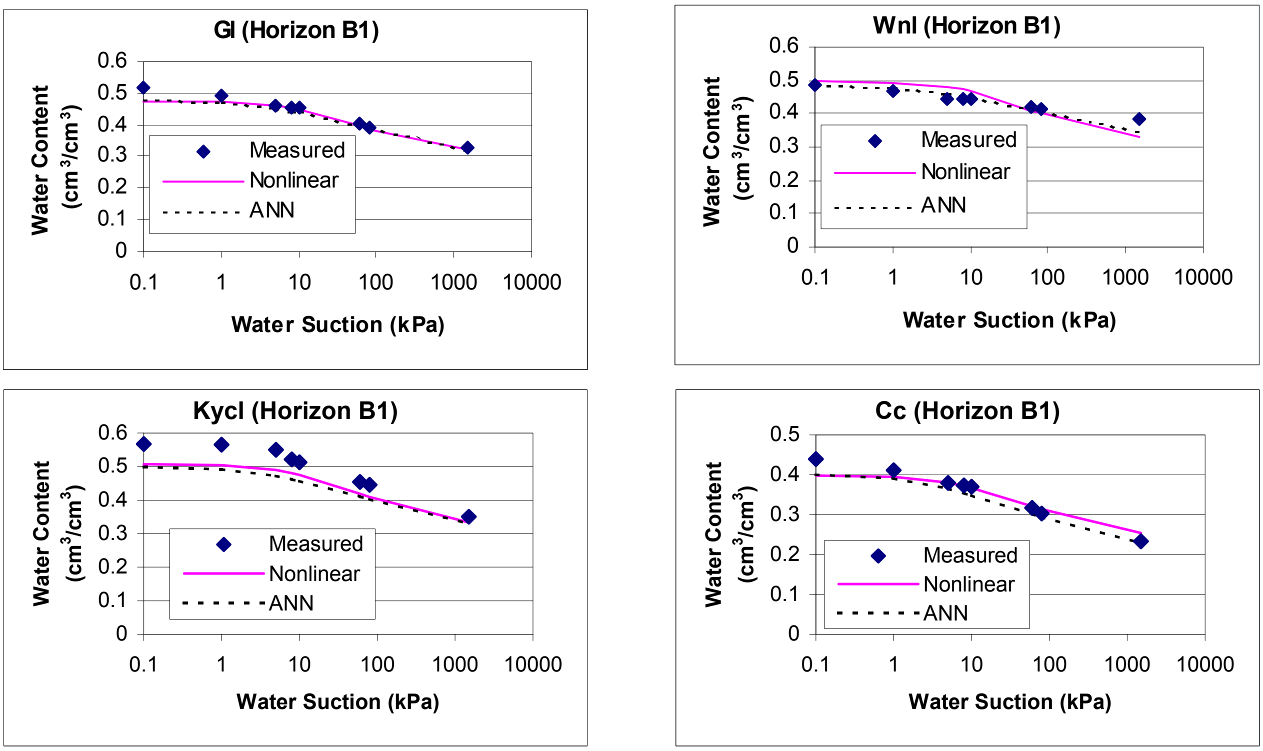

Figure 8.8b Measured and Estimated Soil Water Retention Curve of Horizon B1 of Selected Soils

8.6 Soil Water Capacities

Soil water capacities, AWC0 and AWC, of Horizons A and B1 were estimated using the Point, NLR and ANN PTFs. Results of the estimation were compared with measured soil water capacities. Table 8.11 shows the performance of the three PTFs for the estimation of soil water capacities. The parametric NLR PTFs have generally lower values of RMSR compared to the other PTFs. The amount of variation explained for Horizon B1 by all the PTFs is poor as there is a small difference in absolute values of soil water capacities of soil types. The performance of the parametric NLR PTFs is generally better than other PTFs.

Table 8.11 Performance of PTFs for the Estimation of Soil Water Capacities

Horizon	Soil Water Capacities	No of Points	Point Estimation		Parametric NLR		Parametric ANN	
			RMSR	R^2	RMSR	R^2	RMSR	R^2
Horizon A	AWC0	131	0.049	0.37	0.043	0.36	0.060	0.24
	AWC	131	0.040	0.31	0.043	0.30	0.049	0.29
Horizon B1	AWC0	136	0.059	0.19	0.043	0.20	0.057	0.10
	AWC	136	0.043	0.05	0.035	0.14	0.047	0.06

8.7 Conclusions

Pedotransfer functions (PTFs) for estimating soil water retention of Horizons A and B1 were developed for soils of the SIR. The developed PTFs predicted water content at different suctions with reasonable accuracy from easily measurable soil properties such as particle size distribution and bulk density. The performance of NLR PTFs is generally better than ANN and Point PTFs.