

# Should commercial forestry in South Africa pay for water? Valuing water and its contribution to the industry

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## Abstract

Water is a limiting input/factor in the production of timber in the commercial forestry industry of South Africa. Being a water-stressed country, South Africa has opted for demand management strategies which suggest pricing of water as a commodity. Since commercial forestry is one of the big users of the country's water resources, it is time to decide whether the industry should now pay for water or not. The questions that need to be answered are:

- If yes, how much should the industry pay?
- Is the current proposed charge for water a fair representation of the value of water in timber production?

The value of water used by the commercial forestry is essential information and is very much needed for making water-demand management decisions. The results of the study indicate that water values are much higher than the water management charge levied on the commercial forestry, confirming large subsidies being transferred to the industry. This ushers in a debate on whether South Africa should have more commercial forests or significantly convert them to grasslands.

**Keywords:** water value, residual value, marginal value, subsidy, commercial forestry, South Africa

## Background and objectives

Commercial forestry is an economic force in the South African economy. It has a capital base of R30 bn. (US\$ 5 bn. @ R6 = 1 US\$) and an annual turnover of R12 bn. (US\$ 2 bn.). It meets 95% of the country's needs in wood-based products and has a positive trade balance of R2 bn./a (US\$ 333m./a). The industry employs some 75 000 people directly, 500 000 people indirectly in the related industry, and some 2.1 m. people are dependent on commercial forestry for their survival (Forest Owners' Association, 2000). For every one direct job created in the commercial forestry sector, six jobs are created indirectly through the multiplier effect. Each job generated (directly and indirectly) supports roughly four dependents. (Based on data from Forest Owners' Association (2000)).

Commercial forestry is also one of the major users of scarce water resources. Hydrological research during the past six decades in South Africa indicates that water is the most important limiting input in the growth of alien trees such as eucalyptus, pine, and wattle. These trees use a lot of water through evapotranspiration (ET). This leads to a reduction in the runoff or streamflow from the afforested site (known as streamflow reduction or SFR). The ET use consists of transpiration by vegetation and evaporation from soil, lakes, and water intercepted by canopy surfaces; it is also known as green water. The streamflow reduction or SFR use refers to the runoff reductions due to afforestation; this is known as blue water (Jewitt, 2002). The SFR use in the commercial forestry industry is estimated to be in the order of 1.4 bn-m<sup>3</sup>/a from an area of 1.44 m-ha of plantation (equivalent to 972.2 m<sup>3</sup>/ha-a or 100 l/m<sup>2</sup>). This accounts for about 8% of the total utilisable water (Anonymous, 1998).

The SFR is thus a major concern in South Africa, as it reduces water availability to downstream users. The ET use is roughly 10 times that of the SFR use (Tewari, 2003).

South Africa being a water-stressed country has opted for a new approach in water demand management in early 1990s. The approach aims at meeting water demand by making its use more efficient and put water to more productive uses (Gleick, 2000). As a result, South Africa has developed a National Water Resource Strategy (NWRS) which entails using water judiciously and pricing water for all possible uses is its major objective (Department of Water Affairs and Forestry, 2004). Following these developments, valuation of water in commercial forestry is essential information required for water pricing policy. The major objective of this study is to put value on water use (ET and SFR) in commercial forestry using non-market valuation techniques. And, based on these estimates, decide on the extent to which the industry is being subsidised.

The material of this study is organised under various sections: first, the conceptual model used for valuing water uses in the commercial forestry is described; secondly, a description of selected species and experimental sites is given; this is followed by the method of estimation and data and the results are discussed next. Water subsidy and policy implications are explored in the semi-final section followed by conclusions.

## Measuring the value of water: The conceptual model

The value of any commodity can be defined in terms of use and its exchange value. No doubt water is an essential element for human survival and its utility in that sense is non-priceable. However, economists in general refer to the exchange value - a value that is determined by the interaction of demand-and-supply forces. The value of water can be estimated like the value of any economic good. The value of an economic good can be approximated by a measure of the user's willingness-to-pay

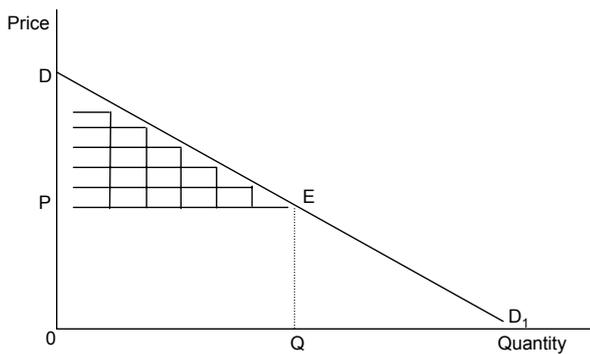
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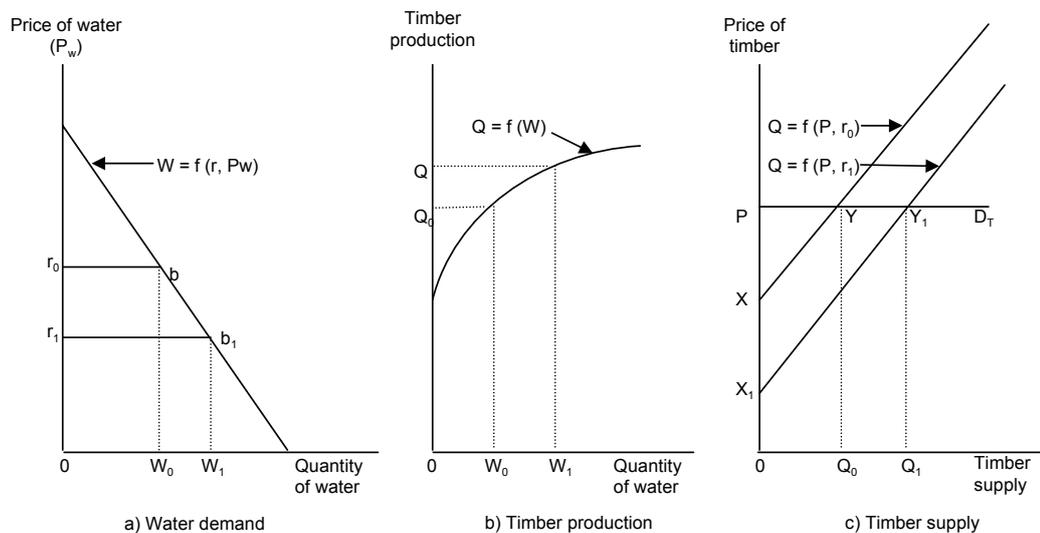
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(WTP) for the good rather than go without it. The WTP measure for a good can be approximated from a demand curve for the good in question; see Fig. 1, where  $DD_1$  is the demand curve for water. For a given price  $P$ , the total utility gained is represented by area  $OQED$ ; the expenditure or cost incurred to obtain total utility is measured by area  $OQEP$ . The net utility gained by the consumer is shown by the shaded area  $DPE$ . In other words, the WTP value may be approximated by measuring consumer surplus. There are two measures of welfare changes: compensating variation (CV) and equivalent variation (EV). However, under certain conditions they can be approximated by consumers' and producers' surplus (Just et al., 1982; Willig, 1976)

However, in applying the above model to commercial forestry, two major problems arise. Firstly, water is not consumed directly by final consumers, unlike the case of drinking water. Secondly, no explicit market for water exists. Hence, the direct measurement of utility is not possible. Rather, water provides utility indirectly as an input into the production of the commercial forestry crop. Hence the WTP for water depends upon the nature of the timber production function in which water is one of the inputs. In this case, the WTP for water is derived from the timber production function in which water is an input. Although a tree produces not only timber but also non-timber and environmental outputs, in the case of commercial forestry, timber is the major output. Basically commercial forestry does not produce any non-timber outputs but produces negative environmental outputs. All other outputs other than timber will be ignored, in computing the value of water in this study.



**Figure 1**  
A theoretical model to estimate the WTP for water as a final commodity



**Figure 2**  
A theoretical model of valuation of water in commercial forestry

The WTP for water will therefore depend upon the increased value of the output over and above the cost of producing extra output. This concept is referred to as producer surplus. A simple model, as shown in Fig. 2, will illustrate that the WTP measures can still be derived from the water-demand curve estimated from the timber production function. A derived water-demand function, timber production function, and timber output-supply curve are shown in panels (a), (b) and (c), respectively. Demand for timber output is assumed to be perfectly elastic (a perfectly elastic demand refers to a situation where change in output has no impact upon the price of timber; this is shown by  $D_T$ ). Initially  $W_0$  units of water at a water price of  $r_0$  are demanded in the production of the  $Q_0$  level of output, as shown in panel (b). A timber supply function,  $Q_0 = f(P, r_0)$ , intersects the perfectly elastic demand schedule,  $D_T$ , at  $Y$ , where  $P$  is the price of timber. If the price of water is lowered to  $r_1$ , water use increases to  $W_1$  level, and the timber supply curve shifts out, the new supply curve is given by  $Q = f(P, r_1)$ . The net addition to the producer surplus is represented by the area  $(XX_1Y_1Y)$ . This is the maximum amount that commercial forestry would be willing to pay to obtain water for timber production, and any amount paid over and above this would leave them worse off. However, the theory of duality of surpluses in factor and product markets ensures that area  $(XX_1Y_1Y)$  in panel (c) is equal to the area  $(r_0 r_1 b_1 b)$  in panel (a) (Just et al., 1982). In other words, the value of water use in commercial forestry can be estimated directly from the derived demand curve for water. The demand curve can be derived from the timber-production function as shown in panel (b). In the past, researchers have resorted to various methods to put a value on water which is derived directly or indirectly from the above. These can vary from simple budgeting to mathematical programming or econometric estimations.

A number of approaches have been used to estimate the value of water in different circumstances (Gibbon, 1986). Water values have been estimated in different sectors such as residential, agricultural, industrial, and recreational and aesthetics, navigation, hydropower, and so on. A brief review was done by Tewari (2003) in which the author indicated that there was no estimate of value of water use in forestry. In this sense, this should be considered a pioneering study in the valuation of water use in forestry. A major requirement for this study was therefore to obtain the timber production/yield functions from the forestry scientists.

## Selection of species and experimental sites

Commercial forestry in South Africa encompasses various tree species. All tree species can be classified into two categories: hardwoods and softwoods. Hardwoods include eucalyptus and wattle species while softwoods include pine and poplars. Among these species, pine and eucalyptus predominate. For example, some 91.9% of the total forestry acreage is under pine and eucalyptus species (based on data obtain from Forest Owners' Association, 2000). Of eucalyptus species, the *Eucalyptus grandis* is the most important one constituting some 73.3% of total acreage. Other species include: *E. nitens*, *E. macarthurii*, and *E. fastigata*. Similarly, *Pinus patula* is most favourable among the pine species. More than 47% of acreage under pine consists of *P. patula*. Various pine species include: *Pinus elliotii*, *P. teada*, *P. radiata*, *P. pinaster*, and *P. patula*. Total area under *P. patula* is 375 883 ha which is about 47% of total area under pine (Dye, 2000).

It should be noted that both tree species – eucalyptus and pine – could be grown for sawn-wood and pulpwood regimes. However, pulpwood production dominates in South Africa, and the pulpwood regime was preferred for two reasons. Firstly, most of the pine and eucalyptus trees that grow in KwaZulu-Natal and surrounding areas are grown for pulpwood. Sawn-wood is more prevalent in Mpumalanga and Limpopo Provinces. Secondly, data on the sawn-wood regime were difficult to obtain.

Having made the choice of dominant species for the value estimation, the next task was to choose representative sites. The task was performed by the Institute for Commercial Forestry Research (ICFR), Pietermaritzburg; the group included experts from ICFR, and CSIR. Some four eucalyptus and three pine sites were recommended. Most of these sites fall in KwaZulu-Natal or nearby localities, which represent the South African forestry on the eastern coast. Based on 1997/98 data, some 79.3% of commercial forestry acreage lies in two provinces – Mpumalanga and KwaZulu-Natal. The selected eucalyptus sites include Kia-Ora, Baynesfield, Tanhurst, and KwaMbonambi. The pine sites are: Richmond, Greytown, and Usutu (Fig. 3). Timber production functions were obtained for these sites and were based on many years of experimental results (for details, see Tewari, 2003). These timber production functions were essentially used to generate the water demand functions or values in general.

## Method of estimation and data

The literature review also revealed that a number of methods have been used towards water valuation. These include contingent valuation, hedonic estimation, econometrics, budgeting, mathematical programming, and production function

techniques, among others. For the current study, we chose the following two techniques:

- Residual value or budgeting method
- Production function or marginal value product method.

The selected methods were used to estimate the value of water in both ET and SFR use (Fig. 4).

The residual value (RV) method is based on the premise that the residual value, obtained as total revenue minus total cost, including compensation for other factors of production such as land, capital and management, is attributed to water. Water as input is paid after having paid all the expenses, including both fixed and variable costs.

The production function or marginal value product (MVP) method is based on the elementary microeconomic theory, i.e., the marginal value product curve of any input/factor represents the demand curve for that input/factor. The cumulative area under the MVP curve can then be approximated equal to WTP for water or total value of water. This can be done by simple integration of the MVP function. In this context, the timber production (water-yield response) functions were obtained for all pine and eucalyptus sites by fitting a quadratic function to the data. The Rand value per unit of water was computed from the estimated quadratic function.

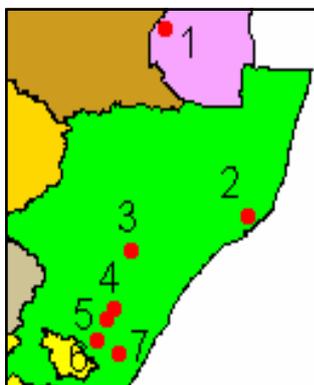
The estimated water values by RV or MVP methods just give the static or one-time annual value of water. Assuming that the same water value is generated in perpetuity, then the capitalised value ( $V$ ) can be given by  $a/r$ , where, “ $a$ ” is the constant future water value or income in perpetuity and “ $r$ ” is the long-run interest rate (Barlowe, 1978). The capitalised values were computed for both ET and SFR water use estimated by RV and MVP methods.

In terms of data requirements, the typical information required for the estimation of water values are:

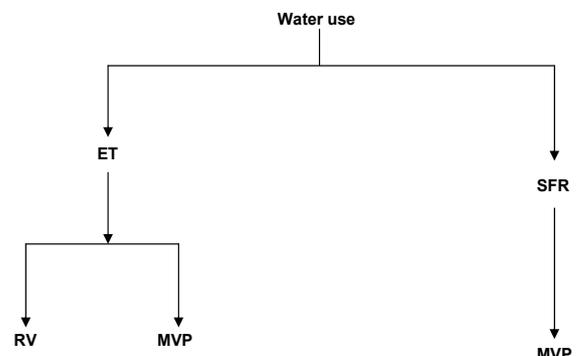
- Relationship between water and timber yield of selected species (pine and eucalyptus) on selected sites or timber production functions
- The cost and price data for both species. The timber production function data were provided by the Institute of Commercial Forestry and CSIR, as mentioned above. The cost and price data for the study were obtained from the Forestry Economics Services (1996). The entire analysis was done in terms of 1996 prices (1996=100). On the cost side, both fixed and variable costs were included. Fixed costs included cost of establishment, tending, land, interest on capital, management and administration cost, and others Whether land cost should or should not be included has been a

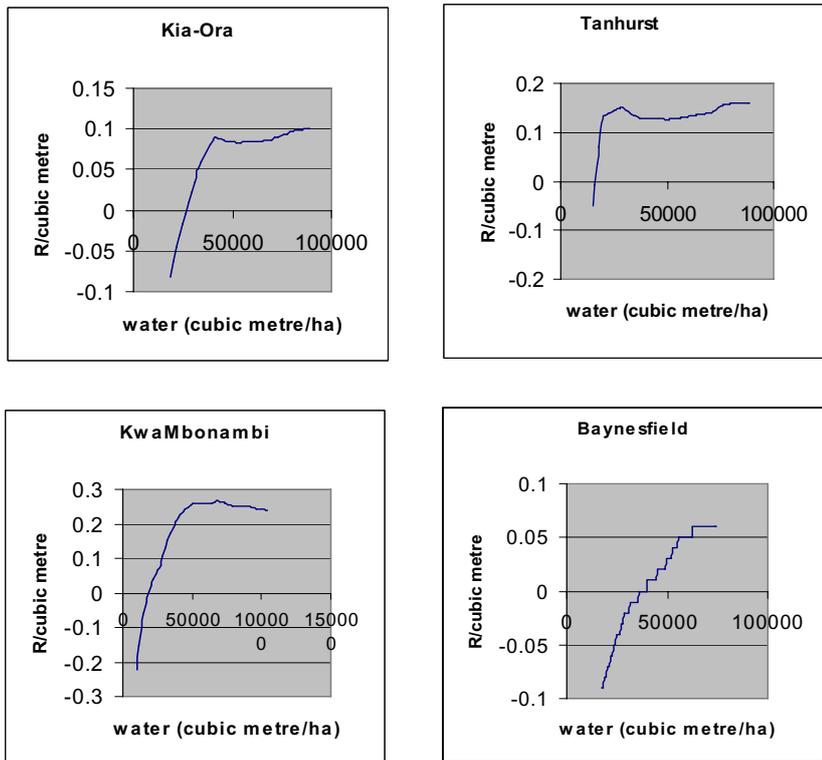
**Figure 3**  
The location of the trial sites described

- 1- Usutu;
- 2 – KwaMbonambi;
- 3 – Greytown;
- 4 – Baynesfield;
- 5 – Richmond;
- 6 – Kia-Ora;
- 7 – Tanhurst).

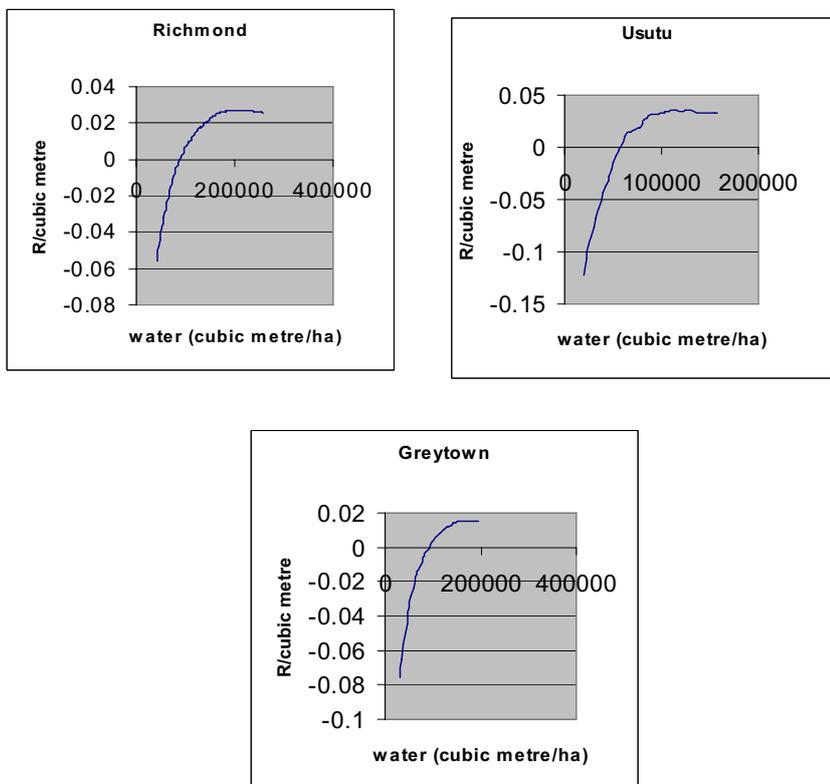


**Figure 4**  
Selected methods of estimation of water value in commercial forestry, South Africa





**Figure 5**  
Evapotranspiration (ET) water values ( $R/m^3$ ) for four eucalyptus sites in KwaZulu-Natal in South Africa, estimated by the RV method



**Figure 6**  
Evapotranspiration (ET) water values ( $R/m^3$ ) for pine on selected sites in KwaZulu-Natal in South Africa (estimated by RV method)

controversial point. Economic theory in general suggests that land cost should not be included. However, the other view has been taken here, which recognises land as an investment input, which should be paid for. Here water is defined as residual input. This is a more pragmatic approach estimating the value of water in commercial forestry. Variable costs included cost of harvesting, loading, and, transportation.

## Results and discussion

The water values for ET and SFR uses are reported here.

### ET use value for eucalyptus and pine

The ET water values for four eucalyptus sites and three pine sites by RV method are shown respectively in Figs. 5 and 6. A typical pattern in the water values is that they are negative in the beginning at low yield or water-use level and become positive and rise as the yield or water-use level rises. A similar trend is seen in the capitalised values as well. However, for reporting purposes I have resorted to the range- and mid-values only. The range-values include the first discrete positive value and the highest positive value; and, mid-value is the average of these two.

Both range- and mid-value estimates for eucalyptus and pine are summarised in Table 1. A perusal of Table 1 reveals the highest water values for the KwaMbonambi site, ranging from R0.02 to R0.24/ $m^3$ ; the lowest water values are found for the Baynesfield site, ranging from R0.01 to R0.06/ $m^3$ . The highest value in the KwaMbonambi site could be explained in the light of good weather/climate condition for timber growth. The site is in the Zululand area where higher temperature coupled with higher rainfall contributes to fast growth in eucalyptus trees. By contrast, Baynesfield is the driest site and experiences low rainfall, resulting in low water values falling between 1 and 6  $c/m^3$ . The mid-values vary from R0.04 for the Baynesfield to R0.13/ $m^3$  for the KwaMbonambi site. However, the range of ET water value in the four sites is from R0.01 to R0.24/ $m^3$  (Table 1).

As opposed to eucalyptus, the ET water values on pine sites are relatively low. The water values in all three pine sites vary between R0.001 and R0.058/ $m^3$ . The low value for pine can be explained in terms of differential growth patterns of eucalyptus and pine. For example, eucalyptus trees grow fast and reach economic maturity around 10 to 12 years of age. Pine

trees grow slowly and reach economic maturity much later around 25 to 30 years. Eucalyptus is hence a more efficient user of water than pine. The capitalised values are computed using a 10% discount rate in perpetuity. The capitalised values vary between R0.40 and R1.30 for eucalyptus and between R0.08 and R0.31 for pine (Table 1).

The ET values for both tree species, computed by the MVP method, are given in Table 2. A comparison of water values estimated by both methods reveals that ET values estimated by the MVP method are higher than those estimated by the RV method. In the case of eucalyptus sites, the ET values by the MVP method are roughly 2 to 5 times higher, whereas in the case of pine this is roughly 5 to 15 times higher. This variation can be attributed to the assumptions that are made for each method. The RV method measures the residual net value attributed to water after paying for all other inputs in the production process. On the other hand, the MVP method measures the value before all other costs are paid off. I suggest that they represent upper boundaries of water values, whereas the values estimated by the RV method show the lower boundaries. The true value would lie in-between these two boundary values.

#### SFR Use values for eucalyptus and pine

The SFR values for eucalyptus and pine are estimated by the MVP method and are given in Table 3. As before, the SFR values are the highest for the KwaMbonambi site, ranging between R2.76 and R5.09/m<sup>3</sup> (Table 3). For the Tanhurst site, the value ranges between R3.99 and R4.89/m<sup>3</sup>. The mid-value estimates for eucalyptus sites range from R1.90 to R4.44/m<sup>3</sup>. The SFR values for pine are relatively lower; for example, the mid-value estimates for Richmond, Greytown and Usutu are respectively R1.27, R2.20, and R1.89/m<sup>3</sup> (Table 3). Interestingly enough, SFR values are much higher than ET values in general.

#### A brief comparison of all water values

A comparison of water values across different methods of estimation and across different water use types is presented in Table 4. The estimated ET water values for eucalyptus by the MVP method vary from 4 c to 34 c/m<sup>3</sup>, the average being 31 c/m<sup>3</sup>. On the other hand the water value estimates by the RV method vary from 4 c to 13 c/m<sup>3</sup>, the average being 8 c/m<sup>3</sup>. Roughly speaking, the ET water values by the MVP method are two to four times of the values estimated by the RV method. We can take marginal values as upper bounds and residual values as lower bounds. Here SFR values for eucalyptus vary between R1.90 and R4.44/m<sup>3</sup>, the average being R3.42/m<sup>3</sup>. This value is roughly 10 times the ET values estimated by the MVP method,

**TABLE 1**  
Evapotranspiration (ET) water values for eucalyptus and pine, estimated by RV method in KwaZulu-Natal, South Africa

Sites	Range of water values R/m <sup>3</sup> ·yr	Mid-value R/m <sup>3</sup> ·yr	Range of capitalised values (at 10%) R/m <sup>3</sup>	Mid-capitalised values R/m <sup>3</sup>
<b>Eucalyptus</b>				
Kia-Ora	0.01-0.10	0.06	0.10-1.00	0.60
Tanhurst	0.035-0.159	0.10	0.35-1.59	1.00
KwaMbonambi	0.02-0.20	0.13	0.20-2.40	1.30
Baynesfield	0.01-0.06	0.04	0.10-0.60	0.40
<b>Pine</b>				
Richmond	0.001-0.025	0.013	0.01-0.025	0.13
Greytown	0.001-0.015	0.008	0.01-0.15	0.08
Usutu	0.003-0.058	0.031	0.03-0.58	0.31

**TABLE 2**  
Evapotranspiration (ET) water values by the marginal value product (MVP) method for eucalyptus and pine sites in KwaZulu-Natal, South Africa

Name of sites	Range of water values R/m <sup>3</sup>	Mid-value R/m <sup>3</sup>	Range of capitalisation value R/m <sup>3</sup>	Mid-value R/m <sup>3</sup>
<b>Eucalyptus</b>				
Kia-Ora	0.28-0.39	0.34	2.83-3.91	3.37
Tanhurst	0.23-0.27	0.25	2.39-2.72	2.56
KwaMbonambi	0.48-0.72	0.60	4.89-7.20	6.05
Baynesfield	0.009-0.07	0.04	0.09-0.72	0.41
Average	0.25-0.36	0.31	2.55-3.64	3.10
<b>Pine</b>				
Richmond	0.12-0.17	0.15	1.22-1.79	1.51
Greytown	0.09-0.13	0.11	0.95-1.39	1.17
Usutu	0.16-0.26	0.21	1.66-2.57	2.12
Average	0.12-0.19	0.16	1.28-1.92	1.60

**TABLE 3**  
The streamflow reduction (SFR) values for eucalyptus and pine sites in KwaZulu-Natal, South Africa

Name of site	Range of values R/m <sup>3</sup>	Mid values R/m <sup>3</sup>	Range of capitalisation values R/m <sup>3</sup>	Mid-value R/m <sup>3</sup>
<b>Eucalyptus</b>				
Kia-Ora	3.99-4.89	4.44	39.91-48.93	44.41
Tanhurst	1.73-2.06	1.90	17.31-20.65	18.96
KwaMbonambi	2.76-5.09	3.92	27.68-50.98	39.33
Baynesfield	--	--	--	--
Average	2.82-4.01	3.42	28.3-40.20	34.20
<b>Pine</b>				
Richmond	1.03-1.51	1.27	10.34-15.18	12.76
Greytown	1.78-2.61	2.20	17.89-26.11	22.00
Usutu	1.39-2.39	1.89	13.97-23.97	18.95
Average	1.4-2.17	1.79	14.07-21.74	17.9

Name of sites	ET values (R/m <sup>3</sup> )		SFR values by MVP method	Capitalisation values		
	RV method	Marginal value product (MVP) method		ET values		SFR values by MVP method
				RV method (R/m <sup>3</sup> )	Marginal value product method (R/m <sup>3</sup> )	
<b>Eucalyptus</b>						
Kia-Ora	0.06	0.34	4.44	0.66	3.37	44.41
Tanhurst	0.10	0.25	1.90	1.00	2.56	18.98
KwaMbonambi	0.13	0.60	3.92	1.30	6.05	39.33
Baynesfield	0.04	0.04	--	0.40	0.41	--
Average	0.08	0.31	3.42	0.83	3.10	34.24
<b>Pine</b>						
Richmond	0.013	0.15	1.27	0.13	1.51	12.76
Greytown	0.008	0.11	2.20	0.08	1.17	22.00
Usutu	0.031	0.21	1.89	0.31	2.12	18.98
Average	0.017	0.15	1.79	0.17	1.6	17.90

Species	Area in <sup>a</sup> RSA, ha	SFR <sup>b</sup> m <sup>3</sup> /ha	Aggregate SFR in RSA 10 <sup>6</sup> m <sup>3</sup>	Annual economic value @		
				Low price 10 <sup>6</sup> R	High price 10 <sup>6</sup> R	Average price 10 <sup>6</sup> R
Eucalyptus	601 675	736	442.8	841.3 (1.90) <sup>c</sup>	1 966.0 (4.44)	1 514.4 (3.42)
Pine	794 451	573	455.2	578.1 (1.27)	1 001.4 (2.20)	814.9 (1.79)
Total	1 396 126	-	898.0	1 419.4	2 967.4	2 329.3

<sup>a</sup> These are figures for the year 2000, obtained from the Forest Owners' Association (2000)  
<sup>b</sup> Data supported by Prof. Peter Roberts, Forestry Consultant, Pietermaritzburg  
<sup>c</sup> Figures in parentheses show water values used to compute the aggregate economic value

and 40 times the ET values estimated by the RV method. The capitalised values for eucalyptus represent the long-run values at 10% interest rate. The average capitalised values of ET water use come to R0.83 and R3.10/m<sup>3</sup> respectively by the RV and MVP methods. The SFR value is R34.24/m<sup>3</sup> (Table 4).

The ET water values for pine by the RV method vary from 1.3c to 3.1 c/m<sup>3</sup>, the average being 1.7 c/m<sup>3</sup>. The ET water values by the MVP method range between 11c to 21 c/m<sup>3</sup>, the average being 15 c/m<sup>3</sup>. The ET water values by the MVP method are roughly 9 times the values estimated by the RV method. The SFR values range from R1.27 to R2.20 /m<sup>3</sup>, the average being R1.79 /m<sup>3</sup>. This value is roughly 12 times the ET value by MVP method and 100 times the ET value by the RV method. The capitalisation values by RV and MVP methods are respectively R0.17 and R1.60/m<sup>3</sup>. The average SFR water capitalised value is R17.90/m<sup>3</sup>.

### Water subsidy and policy implications

Based on the estimated water values, we can now tentatively put some aggregate value on the water use by commercial forestry. This particular estimate is made for eucalyptus and pine; other water-using trees such as wattle and poplar are excluded. Both pine and eucalyptus species together constitute some 91.9% of total area under commercial forestry, based on data from FOA

(2000). The estimates of aggregate economic value placed on SFR water use at low, high and average values of water, as estimated in the study, are given in Table 5. The aggregate value ranges from R1419.4 m. to R2 967.4 m., the average being R2 329.3 m. (Table5).

The aggregate ET use is estimated by multiplying SFR use by 10. The rule of thumb is that ET use is roughly 10 times the SFR use (Tewari, 2003). The aggregate ET use and its economic values are given in Table 6. The aggregate value ranges from R431.6 m. at low water price to R2054.2 m. at high water price, average being R1249.8 m. (Table 6). The aggregate economic value of both (ET and SFR) water uses are given in Table 7. The estimates range from the lowest R1851.0 m. to R5021.6 m. at the highest, the average being R3579.1 m. This is obvious from the above analyses that value of water is enormous. Taking an average of R3579.1 m. or approximately R3.6 bn., this value is significant as it accounts roughly 30 % of the annual turnover of R12 bn. In other words, almost one-third of the revenue of the forestry is attributed to water alone.

The policy implications of this finding depend upon how this information is taken in government circles. In this context, there are two schools of thought: One says that water should be priced as per its value and the other says we should use it as principle of water allocation, not as a policy to price water. As per the first school, the price of water should be the full economic value. The

Species	Aggregate ET use in RSA (10 <sup>6</sup> ) m <sup>3</sup> /a	Annual economic value placed		
		Low price 10 <sup>6</sup> R	High price 10 <sup>6</sup> R	Average price 10 <sup>6</sup> R
Eucalyptus	4 428	354.2 (0.08)	1 371.4 (0.31)	885.6 (0.20)
Pine	4 552	77.4 (0.017)	682.8 (0.15)	364.2 (0.08)
Total	8 980	431.64	2054.2	1249.8

Species	Annual economic value placed @		
	Low price 10 <sup>6</sup> R	High price 10 <sup>6</sup> R	Average price
<b>SFR use</b>			
Eucalyptus	841.3	1966.0	1514.4
Pine	578.1	1001.4	814.9
Subtotal 1	1419.4	2967.4	2329.3
<b>ET Use</b>			
Eucalyptus	354.2	1371.4	885.6
Pine	77.4	682.8	364.2
Subtotal 2	431.6	2054.2	1249.8
Grand Total(1+2)	1851.0	5021.6	3579.1

second school advocates that the decision to allocate resources on economic grounds comes first, and this decision should be conceptually separated from the decision of how this allocation should be financed (Savenije and Van der Zaag, 2002). This is because the financing of water allocation entails several considerations in water pricing such as the state of institutions, equity considerations, cross-subsidisation of poor, and so on. South Africa has chosen the second approach at this point in time. According to the 1999 Pricing Strategy of Department of Water Affairs and Forestry, all water uses will be charged in principle. There are 11 categories of water uses identified in the country. However, initially only two types, surface and ground-water plus streamflow reduction from commercial forestry are subject to billing. Water resource management (WRM) charges are calculated from the actual costs of WRM activities within the catchment per unit of water that is used. The water management charge in the commercial forestry sector varies from one catchment to other, the average being 32c/m<sup>3</sup>; this is much below the level of water value estimated. In a nutshell, the commercial forestry sector still gets a large subsidy in terms of water use. One way to rationalise this subsidy would be to create an environment fund to which commercial forestry should contribute as some per cent of income. This fund could be used to mitigate the negative environmental externalities that the industry creates.

## Conclusions

Water is the limiting input in timber production in the commercial forestry industry in South Africa. However, South Africa, being a water-stressed country, has opted for demand management strategies which resort to water pricing policies. Commercial forestry is now being asked to pay for water; however, this payment is far lower than what water contributes to the industry; in other words, the value of water is much higher than what it would cost the industry. This translates into a substantial water

subsidy to the industry. This study estimated the water values for both types of water uses: ET and SFR. The ET values vary from an average of 2 to 8c/m<sup>3</sup>, while SFR use ranges between R1.79 and R3.42/m<sup>3</sup>. Currently, commercial forestry would be paying about 32c/m<sup>3</sup> only. This suggests that substantial subsidies are going into the industry. Rationalisation of this subsidy may require that industry makes a contribution towards reclaiming the environment that is vitiated by the industry. It also stimulates the debate on whether South Africa should continue to expand the commercial forestry or move back to the promotion of naturally growing grassland vegetation.

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