Valuation procedures for selected non-water benefits of the Working for Water Programme in South Africa

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ABSTRACT

The Working for Water Programme (WfW) is a public works programme designed to clear South Africa of invasive alien trees, the benefit thereof being increased water supply. However, numerous non-water benefits have been identified, which can substantially alter the outcome of a complete Cost-Benefit analysis. This paper proposes a method for determining the net agricultural livestock benefit for the Albany WfW site in the Eastern Cape. It also suggests methods for valuing two other benefits, namely the reduction in fire protection costs and risk of damage to infrastructure as a result of wildfires, and conservation of biodiversity. Deeper investigation into these two benefits is required, as methods suggested for valuing them are addressed only from a literature survey perspective. Regarding the fire benefit, it is proposed that an expert opinion database on fire management costs be developed. The Contingent Valuation Method (CVM) is proposed as the best method for determining the value of biodiversity, even though it is subject to certain problems and shortcomings.

1 INTRODUCTION

The Working for Water programme (WfW) is a public works programme designed to clear South Africa of invasive alien plant and tree species. The main rationale underlying the programme is that invasive alien plant and tree species have a much higher standing biomass than the indigenous vegetation they replace and consequently use much more water. The increased water yield due to these clearing initiatives is deemed to be the primary benefit of the Working for Water Programme. The economic case for this programme in the Western, Southern and Eastern Cape has been presented by applying social cost benefit analysis by van Wilgen, Little, Chapman, Görgens, Willems and Marais (1998) and Hosking, du Preez, Campbell, Woolridge and du Plessis (2001). Cost-benefit analysis (CBA) is designed to compare social costs of alternative projects or investments with their benefits. These costs and benefits are quantified and then compared in order to enable decision makers to make informed decisions on the viability of projects.

The most obvious deficiency of these CBA's is that they only incorporate the water runoff yield benefit of the WfW. Some aspects of these social cost benefit analyses thus require more attention than has so far been given them: the quantification, valuation and incorporation of non-water benefits. This study aims to fill this gap to some extent. Numerous non-water benefits can be derived from the programme. These include: a reduction in fire protection costs and less risk of damage to infrastructure as a result of wildfires; conservation of biodiversity and the promotion of ecosystem resilience; gains in potentially productive land, grazing potential and livestock production (net agricultural benefit); secondary industry development; social development and poverty alleviation; job creation, economic empowerment and training; containment of erosion and the prevention of siltation of dams [2]. When the economic values of the non-water benefits are added to the water benefit derived from the WfW, a more comprehensive benefit stream of the programme can be calculated in monetary terms [3]. The cost of the programme includes those for initial clearing and follow-up and maintenance of previously cleared areas. These cost areas are also calculated as a stream. These benefit-cost profiles are used to generate decision-making criteria. Typically one or more of three decision criteria are used: net present value (NPV), internal rate of return (IRR) and the benefit-cost ratio (BCR). When the NPV is positive, the IRR exceeds the discount rate used or when the BCR is larger than unity, the project is seen as viable (Hosking and du Preez, 1999). The NPV is calculated using the formula:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

NPV = Net Present Value
B = Benefit in year t
Ct = cost in year t
$(1 + i)^t$ = factor by which difference in Bt and Ct is discounted.
i = discount rate

The IRR is by definition the discount rate (i), in the equation:

$$\sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} = 0$$

The BCR is defined in the following way:

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}}$$

This paper describes and proposes a procedure by which the increase in livestock holding capacity of agricultural land can be calculated. The procedure for valuing this non-water benefit is applied to the Albany site of the WfW, situated in the Eastern Cape. Methods for estimating the reduced fire damage and increased indigenous vegetation coverage of the land (biodiversity) benefits are proposed, but it must be stressed that further discussion and investigation are needed for valuing these benefits, as no in-depth research – other than a literature survey - is provided.

A literature survey on the three non-water benefits will be provided in the following section (section 2), whereafter the process of calculating the net agricultural livestock benefit will be discussed and the reporting on the research, i.e. results will be given (section 3). Methods for estimating the value of the remaining two benefits, namely the reduction in fire hazard and the increase in ecosystem resilience, will be put forward in section 4, followed by the conclusion (section 5).

2 LITERATRUE SURVEY

Studies conducted to calculate values for livestock benefits

In 1996 a study was done on the impact of knapweed (invasive species) on the economy of Montana, USA (Hirsch and Leitch, 1996). The monetary effect of knapweed on grazing land and wilderness areas was estimated. For grazing land, acres of infested private and public land were estimated, with corresponding carrying capacities in these areas. For wilderness areas, wildland coefficients (a percentage of land use that provides wildland benefits) were estimated from survey data. This study was based on an input-output model analysis, where inputs to agriculture, for example lost forage and employment opportunities were estimated – thus direct costs to Montana's economy (Hirsch and Leitch, 1996). [4]

A cost benefit analysis of a soil conservation project done in Eppalock, Australia, in 1979 provided interesting points of tangency to the current study. In the Eppalock analysis, the agricultural benefits due to improved pastures were calculated (Abelson, 1979). As in our study, the benefits were restricted to that accruing to increased livestock. In the Abelson study (1979:87, 88), the livestock benefit was determined by the following formula:

$$B = \sum_{L=1}^{3} [(Q1-Q2)(P-C) - A(N1-N2)]$$

Where
B = net annual agricultural benefit in years that project is running
Q1 = annual output with project
Q2 = annual output in base case (without project)
P = price per unit of output each year
C = variable costs of producing one unit of output
A = cost of acquiring additional stock
N1 = annual number of stock purchased with project
N2 = annual number of stock purchased in base case
L = livestock categories (wethers, mixed sheep flock and cattle)

The output form livestock (Q1 – Q2) was calculated as a product of the area carrying livestock, the amount of livestock per hectare and the output per head of livestock. Potential stocking rates (carrying capacities) depended on soil types and rainfall conditions (Abelson, 1979:88).

Operating profits for livestock (P – C) were determined. For sheep, this was done by using historic wool prices (1974 A$) and forecasted figures. Shearing, deaths, veterinary costs and dipping made up part of the operating costs, and the composition of the flock was taken into account (for example 44% kapaters, 31% ewes). For cattle, a breeding cow enterprise was chosen as representative of cattle activities in the catchment area, with costs determined in similar ways. In our study, the Enterprise Budget (2001) is used, and it contains all information on costs and prices, as well as the composition of flocks and herds.

In the Eppalock study, capital costs of purchasing additional livestock were also included under costs.

Biodiversity and the promotion of ecosystem resilience

Biodiversity is the total biological diversity found is a specific area. [5]

Market prices for environmental goods and services usually do not exist, because of their public good nature. However, for decision making purposes, with respect to these assets it is often useful to generate some idea of its economic values. Biodiversity is an example of an environmental good which has a definite "public good" nature, and distortions occur in the market place as to its value (Cabo, 1999 and Turner: 1993).

The contingent valuation method (CVM) is normally applied to measure biodiversity values. This method entails eliciting responses from tourists as to ask for their willingness to pay (WTP) to have indigenous vegetation (i.e. fynbos) preserved, or their willingness to accept (WTA) compensation if the biodiversity is reduced (Turner, 1993). This is achieved by surveying (through personal interviews) by means of a questionnaire to state their WTP for an environmental asset. The average WTP of respondents must be multiplied by the total number of people who derive some benefit from the site to obtain an estimate of the total value of the asset (Turner, 1993:122). An advantage of the CVM is that it captures use- as well as non-use (existence) and option values. In order to calculate people's total willingness to pay for a natural resource, the use, option and non-use values must be summed. Use values reflect the direct use of the resource in question, for instance to catch fish, harvest cut flowers or plants for medicinal purposes. Option value refers to the value people put on the future existence of the resource, thus their willingness to pay to preserve the natural resource

in order to use it in future. Non-use values, in contrast, refer to people's willingness to pay for conserving a natural resource that they might never use (Tietenberg, 2000: 37).
However, there are some pitfalls, which must be taken into account when using the CVM.
These include:

- Understating WTP – due to the hypothetical nature of questionnaires, people might understate their WTP for nature conservation. This can also be related to the free-rider problem.
- WTA vs WTP – people generally feel the cost of a loss (WTA) more severely than a benefit of gain, thus WTA may be an overstatement of the real benefit of the asset.
- Part-whole bias, also referred to as "embedding" – people tend to put similar values on a part of an asset and the whole asset, because of the way they allocate their budget. Thus people put a certain amount away for recreation, and will value the asset according to this amount. Care must thus be taken to value the whole asset, instead of its parts.
- Vehicle bias – the way in which a payment must be made can influence respondents. People generally prefer to pay a tax on the use of an environment, because it is perceived as being efficient, as opposed to, for instance, a trust.
- Starting point bias – sometimes respondents are given a starting price to bid from. This price, naturally, might be wrong to start with, thus leading to bias.

(Tietenberg, 2000:39)

A reduction in fire protection costs and less risk of damage to infrastructure as a result of wildfires

A vast amount of literature is available on fire and its effect on plants (Bond and van Wilgen, 1996 and van Wilgen et al., 1992), as well as the ecological impact of fire in different veld types (van Wilgen et al., 1992, van Wilgen et al., 1997 and Cowling, 1992). However, little data is available on procedures for valuing the risk these fires pose to infrastructure and the damage done by wildfires. Therefore, the data available will have to be interpreted in economic terms and values.

Fires have a crucial role to play in the resilience of ecosystems, but the presence of alien species may significantly alter the natural fire regime (van Wilgen et al., 1992: 165) and the ecosystem balance. A definite link exists between the erodability of soil after very hot fires and the quality of the soil (Marais, pers. comm., 2001). There is a loss in topsoil due to water repellancy after severe fires in fynbos and other areas.
Fire plays a role in the spread of invasive species (Marais, pers. comm,. 2001). Because most invasive species have a bigger biomass than for instance fynbos, it burns much quicker, and the fires are much hotter than in the normal fire cycle. Fire also acts as cataliser for the release of large quantities of invasive seed (Jeffrey, Holmes and Rebelo, 1987).

3 THE NET AGRICULTURAL LIVESTOCK BENEFIT

The net agricultural livestock benefit[6] of the WfW programme is certainly the most obvious of the non-water benefits (Marais, pers. comm., 2000). However, little data are available on the subject, and the fact that numerous factors need to be taken into account to determine this benefit, complicates matters further.

Study site information

The Albany area is situated in the Valley Bushveld area in the upper catchment of the Kowie and Kariega rivers (33°18's; 26°31'E). The alien plant cover in this area is estimated at 5.1-10%. The indigenous ground cover is grassland and Valley Bush. The types of alien vegetation present are *Acacia spp.*, *Hakea spp*., and *Eucalyptus spp*. This area comprises of privately owned land (cattle farming is the main agricultural activity) and land owned and managed by the Grahamstown Municipality. The topography of Albany can be described as folded mountainous with exposed rocky outcrops. Rolling hills are found closer to the coast. Soils are derived from quartzitic sandstone and shale, but are generally sandy, shallow and poor in organic matter. The mean annual precipitation is 950mm (du Preez, pers. comm., 2001).

Methods

This paper attempts to develop a model to determine the net agricultural livestock benefit due to activities of the WfW. The model used five factors to estimate the net agricultural livestock benefit:

(i) Carrying capacity
(ii) Level of alien infestation
(iii) Hectares cleared
(iv) Margin above cost
(v) Livestock categories

(i) Carrying capacity

Determining the gain in potentially productive land for livestock production for the project site mentioned above entailed establishing the carrying capacity in the area. Obtaining this information proved to be difficult, as capacities can vary substantially within the same area, due to factors such as changing slopes, soil types and soil depths (Maphuma, pers. comm., 2000). Moreover, some animals might be grazers by preference, but will still eat bush - suggesting an overlap in grazing areas and carrying capacity (Zeeman, pers. comm., 2001).
Carrying capacity is divided into hectares per Large Stock Unit (ha/ LSU) and hectares per Small Stock Unit (ha/SSU). The average carrying capacity in the Albany area is 5.5ha per LSU and 0.92 ha per SSU.[7]
To calculate the LSU/ha ratio, one is divided by the carrying capacity (ha/LSU). Thus, for Albany: 1/5.5= 0.18. This means that 0.18 LSU's can be sustained on one hectare, or, differently stated, 2073 LSU's can be sustained on the total area cleared for Albany (0.18 multiplied by 11400ha).

The ideal would be to calculate the carrying capacity for the areas under consideration with and without infestation, and to compare the two figures in order to calculate the net agricultural livestock benefit of clearing. Unfortunately, no data are available on the carrying capacity of areas with and without infestation, thus calculations are done assuming that carrying capacities stay constant regardless of infestation levels, but the area available for livestock farming increases with WfW activities.[8]

(ii) Level of alien infestation

The level of alien infestation for the Albany site was obtained from the WfW office in the area. Infestation levels in Albany vary between 5.1% and 10%. For the purpose of this study, the average infestation level of 7.5% was used. This level of infestation is relatively low. However, if infestation levels were higher, it would be advisable to add cultivated grazing costs to total costs, as cleared areas with previously high infestation levels do need some kind of cultivation for it to return to natural levels (Scheltema, pers. comm., 2001). It takes between one and five years for a cleared area to return to its natural level, and in some cases teff is planted to help on regeneration, especially on land prone to erosion after clearing efforts have taken place (Zeeman & Scheltema, pers. comm., 2001).[9]

(iii) Hectares cleared

This constitutes the total amount of hectares intended for clearing by the WfW, which amount to 11400 ha in the Albany region. We assume for the purpose of this study that all areas have been completely cleared. Mechanical clearing with chainsaws and brushcutters is employed during initial clearing. The cleared areas are burned within 2 months after clearing has taken place. Follow-up operations, to prevent re-infestation are carried out for 2 years following initial clearing. Five years of maintenance of management units occurs after follow-up operations. Clearing of state owned land is the first priority in this area. Initial clearing is initiated in upper parts of the catchments of the Kowie and Kariega rivers (du Preez, pers. comm., 2001).

(iv) Margin above cost

The difference between the profit per the amount of hectares under investigation before clearing (smaller area) and the profit per amount of hectares under investigation after clearing (larger area) constitutes the net agricultural livestock benefit.

As stated before, the Department of Agriculture's Enterprise Budget (2001) is used to determine the net profit per LSU. This is done by using the formula:

Margin above cost (net profit) per LSU/SSU = Total Gross income minus directly allocable costs.[10]

We have decided not to add any form of capital cost to the Enterprise Budget's (2001) directly allocated costs.[11]

The margin above cost per LSU is used to calculate the net agricultural cattle benefit. Total gross income consists out of total capital income with provision made for the purchase of a bull. Capital income includes the composition of the herd (for example, 23 old cows, 20 heifers, 45 steers, and one old bull, minus 1 bull purchased for both cattle herds).

Directly allocable costs include: cattle marketing; transportation; medicine costs; lick and feed costs, together with a gestation examination for beef cattle herd 7 and 30 months (Enterprise Budget, 2001:3, 4).

The margin above cost is once again used to calculate the net livestock benefit for goats and sheep, but this time it is determined per SSU.

Margin above cost = Total capital income – total directly allocable costs.

Total capital income for a Boergoat flock consists of 16 old ewes, 42 ewe lambs, 63 kapaters, 1 ram, with provision made for the purchase of 1 ram. Directly allocated costs consist of livestock marketing; transportation; medicine- and lick and feed costs (Enterprise Budget, 2001:5).

For the Angora breeding ewe flock, income is divided into capital and product income. Capital income consists of 21 old ewes, 4 ewe lambs, 29 kapaters, 1 ram, with provision made for the purchase of 1 ram.

Product income consists of the hair of mature goats, kids and young goats.

Directly allocated costs are made up of shearing costs; marketing; packing material and transport of hair, marketing livestock (auction) and medicine, lick and feed costs (Enterprise Budget, 2001:1).

(v) Livestock categories

The main livestock activities (livestock categories) taking place in the Albany area are cattle, sheep, and goat farming – particularly Angora goats (du Preez, pers. comm., 2001)[12.] The 1995 Veterinarian livestock census (Döhne Agricultural Institute, 1996:10) is used to determine the composition of cattle, goat and sheep farming as a percentage of total livestock activity. The livestock census provides data by magisterial district. For Albany, the Albany (Grahamstown) district was used. The Eastern Cape Province map of regions, subregions, agricultural- and veterinary offices (Hall, Döhne Agricultural Institute) is used to determine the representative magisterial district of the WfW sites. The Acocks (1988:59) map of veld types of South Africa also provides information on natural grazing areas.

The Enterprise Budget (2001:3, 4) contains budgets for beef cattle in the Queenstown area only, but it was used nonetheless, due to the fact that similar figures for Albany and the other areas do not exist. It is assumed that most cattle farming in the area is targeted for the beef market, with no dairy farming (no data on dairy farming is available in the Enterprise Budget). However, two budgets for a beef cattle herd are available – that for weaned calves and excess heifers sold at 7 and 30 months respectively, and that of cattle sold at 7 or 12 months, or mated at 15 months. The net cattle benefit was calculated for both these budgets, with the average of it representing the overall net agricultural livestock benefit for cattle.

To establish the goat benefit, two budgets are used - a Boergoat ewe flock from the Grahamstown area, weaned at 5 months and sold at 6 and 10 months, and an Angora breeding ewe flock, also from Grahamstown, sold at 6 and 18 months (Enterprise Budget, 2001).

The sheep farmed with are mainly for wool and meat purposes, with dual-purpose sheep also used (Scheltema, pers. comm., 2001). Döhne Merino sheep was used as an example of wool sheep, and Dorpers as an example of meat sheep (Department of Agriculture, 1982:3). Accordingly, in the Enterprise Budget (2001:7), a Dorper ewe flock from the Grahamstown region (lambs 3 times in 2 years, sell at 5 months) and a Döhne Merino ewe flock, also from the Grahamstown area (wean at 5 months and sell at 6 months) are included (Enterprise Budget 2001:9).

Results

The average net cattle, goat and sheep benefits are calculated as in the steps set out in table 1 below. Cattle farming make up approximately 9.7% of all livestock activity in Albany, with goat and sheep farming coming in at 28.3% and 62% respectively. These percentages of total livestock activity need to be incorporated in the estimation of the net agricultural livestock benefit. This is done by calculating the average net cattle, goat and sheep benefit as a percentage of the livestock activity. For the cattle benefit, it follows that the average net benefit (R 78967.66) be multiplied by 9.7%, which amounts to R 7659.86. To determine the net goat and sheep benefit, the same steps are followed as that for cattle, replacing the percentage of livestock activity by 28.3% for goats and 62% for sheep. Thus the net agricultural livestock benefit for goats and sheep will be R 50 503 and R 101 026 respectively.

In the case of WfW clearing resulting in increased grazing land for beef cattle, goat and sheep farming, the total net benefit would amount to R 159 189.

Table 1 below depicts the steps followed in order to derive the net agricultural livestock benefit for the Albany site.