
Assessing the Financial Drivers in Eucalypt Nursery Production Systems: A Conjoint Analysis Approach

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ABSTRACT

This paper focuses on an application of conjoint analysis within forestry economics. More specifically, it was used to determine eucalypt plant value perceptions among South African nurserymen, to assess the financial drivers of the eucalypt production system, and to attempt to quantify the trade-offs between attributes of a eucalypt nursery and the selling price of the plants. Utility functions for the selected attributes, and a model estimating the value of eucalypt plants, were developed. Results show that selling price is the most important determinant of perceived value of a package. Nursery production costs appear to be the strongest financial driver within eucalypt production systems, as it is the highest price influencer of all the significant attributes. This paper describes conjoint research, which can be used to determine benchmark selling prices for new and altered environmental goods and services. In general, such a study can assist resource owners and managers with high-level marketing, a pricing system, and competitive-strategy planning.

1 INTRODUCTION

The objective of this study has been to investigate the eucalypt production system in South Africa and to assess the financial drivers thereof, thus gaining an understanding of the behaviour of the relevant decision-makers, here being the nursery managers and owners. This was done, firstly by attempting to determine what the significant aspects of a nursery system are, and which the nurserymen believe to be the most important, and, secondly, by assessing what the trade-off's are that nurserymen make between the quality of the plants, the cost of production and the selling price.

Buyers make purchase decisions based on value¹ (quality for price). Nurserymen take advantage of this value-based approach to marketing, by manipulating eucalypt plant features and price to provide the best value for their customers, the foresters. Through developing a model to estimate the value of eucalypt plants, one can gain an understanding of how nurserymen inherently price their plants and what they believe their plants to be worth.

A study such as this could be applied to many other areas within environmental resource economics, although this particular study has focussed on applying conjoint analysis within forestry economics.

¹ *Value* or *utility* is used to indicate 'the amount of desirability' obtainable or obtained from an event or condition, or a

2 METHODS

Conjoint Analysis

Luce and Tukey, a mathematician and statistician wrote the first paper that sparked off marketers' interest in conjoint analysis in 1964. They named their approach conjoint measurement. The first detailed paper on the applicability of conjoint methodology to consumer behaviour was published by Green and Rao in 1971 (Green and Krieger, 1993). Since that time, the academic and applied literature on this technique has grown tremendously. The use of conjoint analysis has moved beyond utility measurement and buyer-choice simulations to market segmentation, product design and competitive strategy within marketing research, and has more recently also been applied in fields such as transportation and environmental valuation. It has been shown to have the highest percentage of judgement success (85.3%) among the nine value assessment methods used by industrial firms (Anderson et al., 1993, as referred to by Reddy and Bush, 1998).

Conjoint analysis is a multi-attribute utility-measurement approach primarily applied by marketing researchers. It is based on the assumption that individuals derive value from the attributes¹ of a product, and not from the product itself. Conjoint analysis is really a form of decomposition. A respondent's choice of product or service is analysed to determine how much influence each attribute had on that choice. An added advantage of conjoint analysis, over most other market analysis techniques, is that it provides the preferences of each respondent within a group. This can then be aggregated to provide a profile of the entire group. These preferences then allow one to quantify value perceptions and make trade-offs between the different attribute levels.

In brief, the technique that we employed works as follows: respondents are faced with a number of packages² also known as scenarios, profiles or brands. These packages are each made up of one level from each pre-selected attribute. The respondents are then asked to rate each scenario from the lowest likelihood of success to the highest likelihood of success, thus collecting preference scores for several alternative product configurations.

Population

The population of interest was eucalypt nurserymen in South Africa. This included owners, managers and researchers within private and company-owned nurseries that dealt with eucalypt breeding, who felt that they had enough understanding of the nursery business. Due to the population size being so small, the full population was targeted for the sample group.

Attributes

A comprehensive range of attributes and possible attribute levels that play a role in eucalypt nursery production were identified and assessed. The most important and relevant attributes were then chosen in discussion with CSIR's Tree Breeding Business Area, which specializes in eucalypt research. In order to handle the design process and not to confuse the respondents, a limited number of attributes and levels have to be chosen. The selected attributes and levels are shown in Table 1.

The chosen attributes and levels allow one to assess the financial drivers in eucalypt production systems by providing insight into the value that nurserymen attach to certain attributes of nursery management. This can be achieved by looking at four of the five selected attributes related to nursery production, and then comparing these to a selling price that can be realistically fetched in the market (the fifth attribute).

The price levels were chosen to range from the average price of 1,000 *Eucalyptus grandis* seedlings (R200) to the price of 1,000 eucalypt clones (R700), which are currently the most expensive. The four price levels thus relate to the current market price for average eucalypt seedlings.

¹ The term *attribute* is reserved for the determinant decision criteria that consumers or suppliers use to evaluate products or services.

² A *package* represents a hypothetical product or service (made up of different attributes) that is or could be available in

Design

A full profile design was used to collect data from eucalypt nurserymen. This is the most common form of design in conjoint measurement studies (Wittink et al., 1994). Orthogonal fractional factorial design is then utilized to reduce the judgment burden on respondents. Twenty packages were included in the study. An example of these packages can be seen in Table 3 below. Packages representing average eucalypt seedlings, clones and hybrids were included within the twenty randomly selected packages.

Choice-based methods, of which conjoint analysis is one, can take different forms of rankings and ratings for packages. Respondents can be asked to rank a number of packages from most favoured to least favoured, to assign a numerical rating to each package (the full-profile design), to complete a trade-off table, or to be given a pair-wise comparison where you rate your preference between two packages. Our study made use of rating packages, using a 7-point scale (see Table 2), which is the most commonly used scale in conjoint studies (Riquelme and Rickards, 1992, as referred to by Reddy & Bush, 1998).

Data Collection

Contact was made with all nurseries involved in eucalypt breeding in South Africa during February and March 2001. Questionnaires were then faxed or emailed to all relevant nurseries, with a covering letter and explanation sheet. Follow-up calls were made until questionnaires were returned or until it was clear that certain questionnaires were not going to be returned. Twenty questionnaires were sent out and fifteen properly completed questionnaires were returned. The response rate for the study was thus 75%.

Table 1 Attributes and attribute levels used to assess the financial drivers in eucalypt nursery production

ATTRIBUTE	LEVEL
Productivity Time in trays until ready to sell to plantation managers	1. 3 months 2. 4 months 3. 5 months
Success rate Rooting or germination percentage	1. 26-49% 2. 50-74% 3. 75-100%
Nursery production costs Cost of producing cutting or seedling (inclusive of infrastructure costs and wages)	1. Same as seedling 2. 2 times seedlings 3. 4 times seedlings
Quality of species/source	1. L: Quality equivalent to an unimproved seedling 2. M: Intermediate quality 3. H: Quality equivalent to a good quality clone
Possible selling price Realistic selling price for 1, 000 plants (Current refers to current market price for average seedlings at R200)	1. Current = R200 2. Current + R50 3. Current + R200 4. Current + R500

Table 2 Instructions given to respondents for rating procedure

Each scenario/package can be rated from 1 to 7 as follows:

Poor likelihood of success






Intermediate likelihood of success


Excellent likelihood of success

1
2
3
4
5
6
7

Please indicate the rating that best represents the likelihood of scenario success, i.e. level of the attributes/factors for a realistic selling price. For instance, a nurseryman’s likelihood of scenario success will be low if the selling price is too low, or too high, for the level of attributes in a package. Please assume that the scenarios/packages only differ on the listed attributes, and that the nursery bought all the seeds/clones at their respective market prices.

Table 3 Example of a package offered to respondents

Crop Package	Productivity (mths)			Success Rate (%)			Nursery Production Costs			Quality of Source/Species			Possible Sales Price (for 1000 plants)				Likelihood of Scenario Success (1-7)
	3	4	5	26-49	50-74	75-100	Same as seedlings	2x seedlings	4x seedlings	L	M	H	Current = R200	Current + R 50	Current + R 200	Current + R 500	
1																	

 = Selected level of the attribute for this package

3 DATA ANALYSIS

Information Integration Theory

The utility is linearly related to a consumer’s rating.

$$U_{ij} = a + bR_{ij} + \dots_{ij}$$

Where

U_{ij} = Utility of j^{th} package for the i^{th} respondent

R_{ij} = Rating for i^{th} package for the i^{th} respondent

ϵ_{ij} = random error term for j^{th} package, where $\epsilon_{ij} \sim (0, \sigma^2)$
 a, b = constant coefficients

It is assumed that the utility of each package is a function of the sum of the utilities of the attributes. We therefore assume an additive model.

Thus, utility of the j^{th} package for the i^{th} respondent can be represented as follows:

$$U_{ij} = a + A_{ij1} + A_{ij2} + A_{ij3} + A_{ij4} + A_{ij5} + \epsilon_{ij}$$

Where

A_{ij1}, \dots, A_{ij5} are the partial utilities (utilities of the 5 attributes) of the j^{th} package for the i^{th} respondent (Louviere, 1988).

Regression

The conceptual model (for the i^{th} respondent) used as a basis for regression analysis is as follows:

$$U_{ij} = \epsilon_0 + \epsilon_1 X_{ij11} + \epsilon_2 X_{ij12} + \epsilon_3 X_{ij21} + \epsilon_4 X_{ij22} + \epsilon_5 X_{ij31} + \epsilon_6 X_{ij32} + \epsilon_7 X_{ij41} + \epsilon_8 X_{ij42} + \epsilon_9 X_{ij51} + \epsilon_{10} X_{ij52} + \epsilon_{11} X_{ij53} + \epsilon_{ij}$$

Where

U_{ij} = perceived utility rating by the i^{th} respondent to the j^{th} package

ϵ_0 = intercept term

$\epsilon_1, \epsilon_2, \dots, \epsilon_{11}$ = regression coefficients

$\epsilon_1 X_{ij11}; \epsilon_2 X_{ij12}$ = 1st and 2nd levels of the attribute ‘productivity’ in the j^{th} package

$\epsilon_3 X_{ij21}; \epsilon_4 X_{ij22}$ = 1st and 2nd levels of the attribute ‘success rate’ in the j^{th} package

$\epsilon_5 X_{ij31}; \epsilon_6 X_{ij32}$ = 1st and 2nd levels of the attribute ‘nursery production costs’ in the j^{th} package

$\epsilon_7 X_{ij41}; \epsilon_8 X_{ij42}$ = 1st and 2nd levels of the attribute ‘quality of species’ in the j^{th} package

$\epsilon_9 X_{ij51}; \epsilon_{10} X_{ij52}; \epsilon_{11} X_{ij53}$ = 1st, 2nd and 3rd levels of the attribute sales price in the j^{th} package

ϵ_{ij} = random error term

$j = 1, 2, \dots, 20$ the number of packages

The X variables are substituted with the appropriate dummy variables, for that level, using effect-coding values for attributes. For instance, X_{ij11} is substituted with D_1 .

For dummy variables, D_1, D_2 and D_3 this works as follows (Louviere, Hensher & Swait, 2000):

$$D_1 \text{ (dummy variable for level 1)} = \begin{cases} 1 & \text{if 1}^{\text{st}} \text{ level of an attribute is contained in package} \\ 0 & \text{any other level/otherwise} \\ -1 & \text{if m}^{\text{th}} \text{ level of an attribute is contained in package} \end{cases}$$

$$D_2 \text{ (dummy variable for level 2)} = \begin{cases} 1 & \text{if 2}^{\text{nd}} \text{ level of an attribute is contained in package} \\ 0 & \text{any other level/otherwise} \\ -1 & \text{if m}^{\text{th}} \text{ level of an attribute is contained in package} \end{cases}$$

In the case where there are four levels to an attribute (e.g. sales price), a third dummy variable is needed. The m^{th} level of each attribute is not included in the regression.

$$D_3 \text{ (dummy variable for level 3)} = \begin{cases} 1 & \text{if } m-1^{\text{th}} \text{ level of an attribute contained in package} \\ 0 & \text{any other level/otherwise} \\ -1 & \text{if } m^{\text{th}} \text{ level of an attribute contained in package} \end{cases}$$

Let $n = 1, 2, \dots, m$

Where m is the number of levels of an attribute

Effect codes are uncorrelated with the grand mean or intercept ($_0$) while dummy codes are correlated (Louviere, Hensher & Swait, 2000). The i^{th} response to the n^{th} level of a certain attribute can thus be represented as follows:

$$_1D_{i1} + _2D_{i2} + \dots + _mD_{im-1}$$

The X variables in the conceptual model were substituted with the dummy variables using the above equation. This was done for each attribute. After representing all the attribute levels by dummy variables, we applied the ordinary least squares (OLS) procedure to derive the partial utilities that are given in Table 4.

The coefficient of the m^{th} level = $-\sum_n _m$

Although no respondent provided the same rating to each package and the adjusted coefficient of determination of the estimated model for each respondent was much greater than 0.1, rating data from only fourteen of the fifteen respondents were included in the analysis, since one of the respondents had clearly not understood the questionnaire. Considering the small population size and therefore sample size available for the study, it was regarded acceptable to discard four of the twenty packages from the analysis due to respondents' confusion with these packages.

4 RESULTS

Utility

Utility scores can be used to gain an indication as to how influential each attribute level is in the formation of preferences for a product. This means that it represents respondents' degrees of preference for each attribute level. Figure 1 shows the utility functions for each attribute that were developed through pooled analysis.

Revealed Preference

The utility estimates show that eucalypt nurserymen prefer the following level of each of the five attributes: a three-month productivity, a high success rate, same cost as producing a seedling, high source quality, and a selling price of current + R500. All of these confirm what would be expected.

This confirms that nurserymen prefer high quality and high success rate to low quality and low success rate, while desiring the highest feasible selling prices and lowest production costs. In general, the utility values show that quality, success rate and price have a positive impact, while productivity (time in trays) and production costs have a negative impact on perceived value of the package.

Model Interpretation

The utility functions also allow us to compute the degree of preference that a nurseryman has for any of the attribute combinations, or his/her belief in its likelihood of success.

For example: a low source quality and a high selling price combination has a combined utility score³ of 2.93, whereas a high source quality and high selling price combination has a combined utility score⁴ of 4.52. This means that the average nurseryman in a eucalypt nursery system believes that there is a greater likelihood of success with the second combination than with the first. This can be interpreted as follows: a nurseryman feels that he can sell his plants for a higher price if the source or species quality is higher. In terms of profitability, he will be more profitable if he sells high quality plants at a high price rather than attempting to sell plants of lower quality at the same price.

Table 4 Provides the partial utility scores (β), standard errors (S), t-values, and p-values associated with the attribute levels when using responses from private and company-owned nurseries

Multiple Regression Analysis					
Attribute	Level	Partial utility (β)	Standard error (S)	T statistic	P-value
Productivity	Three mths	0.81	0.47	1.73	0.08
	Four mths	0.05	0.31	0.16	0.87
	Five mths	-0.86			
Success rate	L S rate	-1.18	0.37	-3.20	0.00
	M S rate	0.21	0.45	0.46	0.64
	H S rate	0.97			
Nursery costs	Same costs	0.58	0.35	1.69	0.09
	Twice cost	0.49	0.26	1.89	0.06
	Four times cost	-1.07			
Source quality	L quality	-0.72	0.33	-2.22	0.03
	M quality	-0.15	0.22	-0.68	0.50
	H quality	0.87			
Selling price	Current P	-0.28	0.39	-0.72	0.47
	Price B	-0.03	0.26	-0.13	0.90
	Price C	0.15	0.20	0.71	0.48
	Price D	0.16			
	Intercept	3.49	0.30	11.71	0.00
Analysis of Variance		F-ratio	P-value		
Model		8.52	0.00		
Adjusted R-squared		27.07%			
Durbin-Watson Statistic		2.01			

These types of combinations can show us the trade-offs that respondents make in deciding among multi-attribute products. It can show, for instance, how strongly a nurseryman feels that he must improve his success rate or source quality before he can increase his selling price by a certain amount or level.

³ Combined utility score is the sum of the intercept (3.49), the utility of low source quality (-0.72) and the utility of a high selling price (0.16).

⁴ Here the combined utility score is the sum of the intercept (3.49), the utility of high source quality (0.87) and the

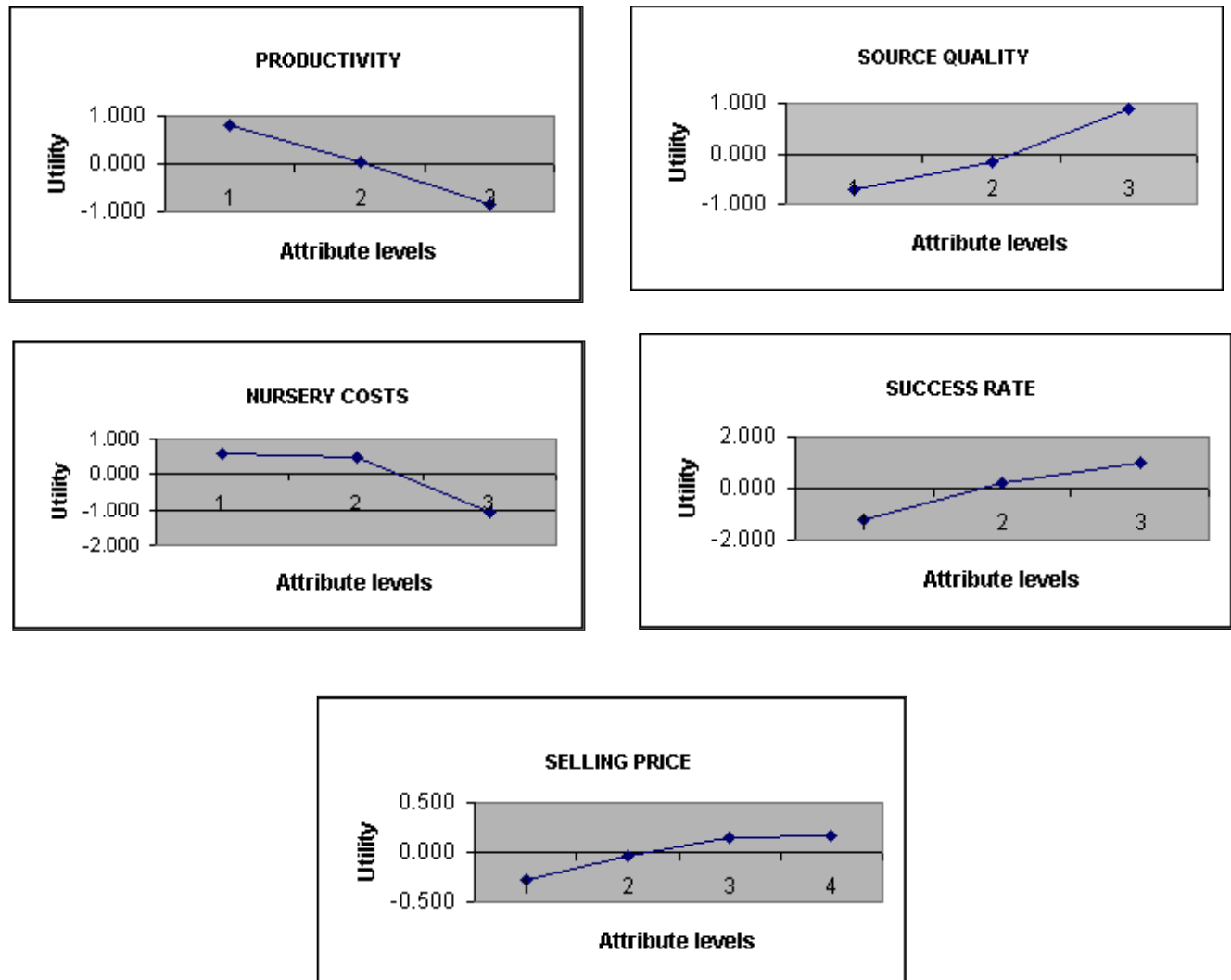
Interpretation of Statistical Indicators

The output of fitting a multiple linear regression model (see Table 4) to describe the relationship between likelihood of success and dummy variables for the different attribute levels can be explained as follows: Since the p-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at a 99% confidence interval. The Durbin-Watson statistic is 2.01 and thus there is no serious autocorrelation between the residuals. From the t-values associated with each attribute level, it is clear that not all levels are statistically significant. Only low source quality, low success rate, same costs, twice costs and three months productivity seem to be significant in explaining the variance in the likelihood of success. Those attribute levels that are insignificant appear not to have much influence on the average ratings that are given for the different packages. This, however, does not mean that the insignificant attribute levels should be discarded from the model, as they were initially selected for their known importance in eucalypt nursery production systems, and were found to be significant in the estimated models for each individual respondent. The low adjusted coefficient of determination (27.07%) might be due to the respondents not being in agreement with one another on the importance of certain attribute levels for achieving success with the package (i.e. what makes a realistic and profitable package.)

Importance of Attributes

The relative importance of each attribute can be determined using the partial utility values from Table 4. This can be calculated by dividing the utility score range of one attribute by the sum of utility score ranges of all attributes, where utility score range is the difference between the utility score of the most preferred level and the least preferred level of an attribute. Relative importance indicates how important each attribute in a nursery is, in relation to all other attributes, in influencing a nurseryman's impression of a package or particular scenario with which he/she is faced. This relative importance can then be expressed in percentage by multiplying by 100. Nurseryman will try to trade better levels of less important attributes with better important attributes.

Figure 1 Partial utilities by attribute and level (all other attributes held constant) from the pooled analysis using the responses from private and company-owned nurseries. Attribute levels conform to those in Table 1



For the pooled analysis using all 14 respondents, success rate was found to be the most important attribute in determining the perceived value of a package, with a relative importance of 28.61%. (A high rating for likelihood of success implies a high perceived value of the package.) This was then followed by productivity, nursery costs and source quality, and then price, which was significantly less important, with a relative importance of 6.01%.

At this stage, the questionnaires were split into private and company-owned nurseries and analysed as independent clusters, to assess whether this differentiation in nurseries may play a role in the value perceptions of the nurserymen. The adjusted coefficient of determination improved to 54.17% for the analysis using responses from private nurseries, while for the responses from company-owned nurseries, it fell to 16.52%. This means that in the private nursery model the different attribute levels can explain 54.17% of the variation in the perceived value of a package. Whereas the company-owned nursery model is not a good fit and the perceived value of the packages are not well explained through the model. Therefore, from here onwards the results will be taken from the private nursery model, and will be assumed to represent the average nurseryman’s perceptions.

Figure 2 Relative importance of attributes in influencing perceptions of the value of eucalypt plants in a nursery system, using responses from only the private nurseries

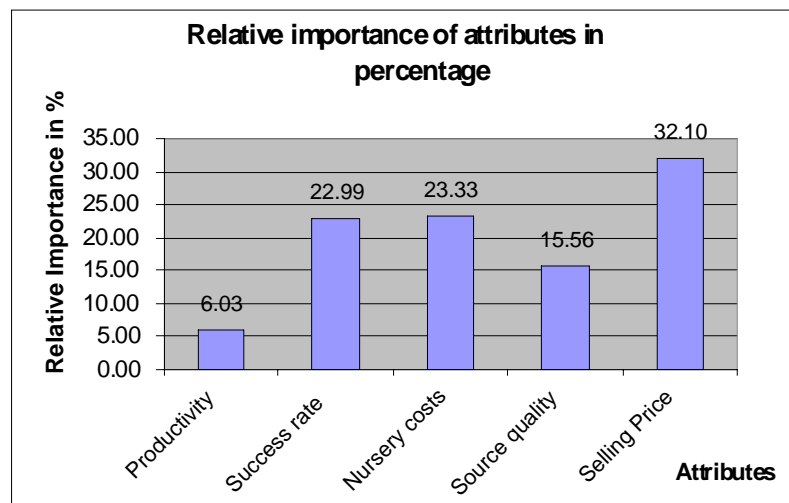


Figure 2 shows the relative importance of various attributes in determining the perceived value of a package, using pooled analysis from the seven responses from the private nurseries. From this figure, it is clear that the selling price is the most important determinant of value, with a relative importance of 32.10%. Nursery costs and success rate have similar relative importances, with 23.33% and 22.99% respectively, and then source quality with 15.56%, and finally productivity with 6.03%.

From the pooled analysis using the responses from private and company-owned nurseries, recall that the selling price had the lowest relative importance, with only 6.01%. This shows that the average nurseryman, when determining the perceived value of a package, placed at least three and a half times the importance on all other attributes than on price. While for the analysis using responses from only private nurseries, the relative importance of price was 32.10%. From these results, we can infer that the nurserymen from company-owned nurseries answered the questionnaire from a production point of view, rather than focusing on the trade-offs between production and quality attributes, and the potential selling price (as did the nurserymen from private nurseries). These relative importance scores show that nurserymen do not value each attribute within a eucalypt nursery system equally, but attach different weights to each of them.

Price Sensitivity

Dividing the relative importance score of one attribute by the relative importance score of price, and then multiplying this figure by the price range⁵ can estimate price sensitivity. This allows us to find the price that equates the value of one product offering with the price associated with another product offering. This is known as equivalent-value pricing.

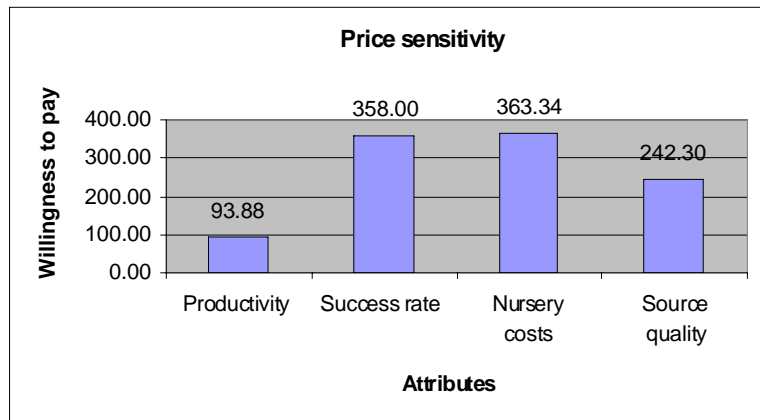
Figure 3 provides the inferred willingness to pay of buyers for a package with the most favoured level rather than the least favoured level for each attribute. The respondents feel that buyers will choose either of the eucalypt plant packages once the price difference between the higher quality package and the lower quality package reaches the amounts shown in Figure 3.

Nursery production costs appear to be the strongest financial driver within South Africa's eucalypt production system, as it is the highest price influencer of all the significant attributes. Understanding price

⁵ The price range is the difference in price between the highest price level and the lowest price level. (Current market price + R500) – (Current market price) = R500.

sensitivity can be explained as follows: if nursery costs were to increase from the production costs of average seedlings to four times the cost of average seedlings, then nurserymen on average feel that they would need to sell their 1,000 plants for R363.34 more than before. In this way, their financial profitability would remain constant, as increased costs would merely have been covered by an increased selling price.

Figure 3 This shows the inferred willingness to pay of buyers (in rands) of 1000 eucalypt plants for obtaining the best attribute level rather than the worst attribute level for each attribute



For example, the results show that when source quality improves from the lowest source quality to the highest source quality, the package is believed to be able to sell for R242.30 more, on average. The price sensitivities seem feasible and they all fall under the maximum selling price that exists currently in the market, being R700 for clones. It is also known that a tray of 1,000 plants from average eucalypt seedlings sells for about R200, whereas a tray of 1,000 plants from eucalypt improved seedlings sells for approximately R50 more. This is due to the improvement in seedling quality from low quality to medium quality. Knowing this it would still be possible for a tray of 1,000 plants to sell for R242.30 more when only source quality improves from the lowest source quality to the highest source quality.

4 DISCUSSION

The results of this study provide the average eucalypt nurseryman's perceptions of his/her market and the relative importance of the most significant attributes within the nursery production system. Having an understanding of one's market and the financial drivers therein is of critical importance if one is to keep or gain a competitive advantage in the marketplace. Nurserymen should be informed and able to decide whether they wish to supply eucalypt plants of high value at higher prices or lower quality plants at lower prices. This decision would then alter their buying patterns. Thus, would they buy high quality seeds and clones at high prices or would they opt for purchasing inferior quality seeds at lower prices?

Included in this study were the five most important attributes influencing eucalypt nursery production. Of these, nursery costs were the most important attribute for determining the value of a package. Including a price attribute in the evaluation process would apparently cause nurserymen to make trade-offs between the price that they would like to receive for the plants, on the one hand, and species quality, productivity and costs, on the other.

Implications of Value-pricing Approach

This value-pricing approach or price sensitivity analysis has interesting implications. Firstly, it can give the nurserymen an idea as to where their greatest financial return may be, by showing the price sensitivity of attributes when improving from the worst level to the best level. For example, if the costs involved in

improving productivity (time in trays) from three to five months would be less than the additional price that can now be expected for 1, 000 plants, then it would make financial sense for the nurserymen to improve their productivity. Secondly, this can show the average nurseryman's perception as to which attribute has the greatest potential to drive the selling price of the plants. This was clearly shown to be nursery costs. Once again, if a nursery can purchase high rather than low quality eucalypt seeds or clones at a cost less than the additional price that can now be expected for 1, 000 plants, this will be a financially viable option for them. Thirdly, it can be used as a benchmark for determining what the selling price should be depending on the package and the choice of attribute levels. If a nurseryman increases his/her selling price by much more than the price sensitivity figure of a certain attribute, after improving from the worst level to the best level in that attribute, then he/she will probably be pricing himself/herself out of the market. (This would assume that the original price fell within the market norm and that all other attributes remained constant.)

Limitations

The first limitation of this study is that there are only a small number of nurseries in South Africa that deal with eucalypt species, and thus the sample size was limited to the small population size. This, however, still depicts the actual South African eucalypt nursery system. Secondly, a conjoint analysis needs a restricted number of attributes and levels to make it possible for the respondents to make multi-attribute decisions relatively quickly. This should not be a significant problem, since customers will also generally make purchase decisions based on a limited number of attributes; and the most important attributes were included. Thirdly, the packages included in the questionnaire were randomly selected and were not chosen from the orthogonal fractional factorial design process. The authors contend that the chosen packages covered the necessary attribute combinations, and that their random selection should not significantly affect the results. Fourthly, an additive model (a main-effect design), which may not completely capture value perceptions, was used. However, previous research indicates that the quality of the obtained data will be higher if a simple method is used. Moreover, the advantages of a simple design should compensate for any information missed by not employing higher-interaction effects (Reibstein et al., 1998, as referred to by Reddy V.S. & Bush R.J., 1998). Finally, care needs to be taken regarding the choice of respondents for a study. As discovered during analysis, the nurserymen from company-owned nurseries (salaried employees) were not very sensitive to price changes, while nurserymen from private nurseries (owners and managers) were.

5 CONCLUSION

This conjoint-analysis study, as applied within forestry economics, provides data that can be used to estimate the perceived value of any combination of the selected attributes that influence eucalypt nursery production. It shows the most important attributes, their relative importance, and gives realistic price sensitivities to changes in attribute levels. The price sensitivities can be used as a benchmark for determining what the selling price should be, depending on the package and the choice of attribute levels.

In general, conjoint research could ultimately provide information that can help producers and service providers to know: where they should focus their attention to provide the best value to their clients, where the most cost-effective changes can be made in relation to the chosen attributes, and which the most significant financial drivers in their systems are. It can provide an indication as to how they should price their products or services, depending on attributes such as: the quality of the products or services, their productivity or efficiency, and their production or service costs. Otherwise stated, it can assist resource owners or managers with high-level marketing, a pricing system and competitive-strategy planning.

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The Effects of Construction on the Environment : A Case Study

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ABSTRACT

Environmental issues and concerns have recently gained importance world wide. Concerns mainly focus on :

atmospheric emissions
environmental deterioration
depletion of natural resources
energy issues
sustainability, in various contexts
environmental conservation versus development
the effects of the abovementioned and other factors on ecological systems, and
the economic implications of environmental issues and concerns.

Construction is a change agent, its nature being to alter the environment, beneficially in some respects and detrimentally in others. Construction is also an economic activity, providing facilities, while consuming energy and other resources. Tensions thus exist between construction and developmental processes *vis-à-vis* environmental and conservation issues.

This paper reviews South African legislative and regulatory mechanisms and other construction-related issues concerning environmental conservation, reports on a survey on conservation and environmental issues and examines the recent development of a tourism and leisure project. The monitoring of its construction processes in accordance with environmental conservation mechanisms is described, thus demonstrating the interaction between development, construction and the environment. The lessons learnt are discussed and proposals about future actions are made.

Key words : Construction; conservation; development; environment; pollution.

1 INTRODUCTION

The transformation of South Africa into a democratic, multi-faceted nation has given rise to far-reaching changes in almost every aspect of society and will continue to affect every citizen for some time to come. Change is occurring in respect of the economy, education, finance, commerce, health services, employment, cultural concepts, historical perceptions, developmental and national priorities, environmental issues and other societal factors.

A feature of the country is the imbalance between indigenous and cosmopolitan cultures, very basic and very advanced education, survival and a comfortable existence, internal development and global competitiveness. On the one hand, the country is part of the developing world, exhibiting features such as subsistence farming and other basic means of survival, a large informal economy, drastic shortages of housing and other facilities, a large degree of illiteracy, considerable unemployment, etc. On the other hand, South Africa is on a course to become part of the global village and is addressing many of the abovementioned inhibiting factors through various development programmes and projects. A beneficial factor in the development process is that the country has at its disposal considerable sophistication in many spheres such as the professions, sciences, technology, manufacturing processes, business and finance and a progressive formal economy. (McLachlan and Eksteen, 2000).

Against the backdrop of contemporary South Africa, the first part of the paper outlines the effects of construction and development, as processes of economic significance, on the environment. Some realities of these processes are discussed, as well as the legislation and regulations available to align these realities with environmental and economic considerations.

The second part of the paper is an assessment of the implementation of the Environmental Impact Regulations in an actual project situation. Many of the general characteristics of construction and development, as identified in the first part of the paper, are verified.

2 OVERVIEW OF CONSERVATION AND ENVIRONMENT-RELATED ISSUES

According to McLachlan and Eksteen (2000), current conditions of underdevelopment and relatively low education levels of a large proportion of the population lead to conflicts and paradoxes.

Environmental and conservation issues are addressed in the Bill of Rights section of the *Constitution of the Republic of South Africa* and in other legislation and regulations, such as legislation pertaining to forestry, hazardous substances, township development, mining, roads and traffic, pollution, water, fishery and others, including the *Environment Conservation Act of 1989* and, as from 1998, the Environmental Impact Assessment Regulations.

However, burgeoning urbanisation and population growth, scarce resources, greed, perceived economic priorities, ignorance, lack of concern, lack of awareness, competition, cavalier attitudes and other factors result not only in environmental pressures and deterioration but also in the fact that environmental and conservation issues often do not enjoy high priority.

The means for promoting environmental conservation and sensitivity thus exist but practical conditions and realities often predominate.

The future of built, natural and other environments in developing countries is uncertain. In developed countries the sophistication and the means and resources to preserve, restore and conserve such environments exist and thrive. In the developing world, however, important natural, cultural and other resources are threatened by pressures to provide for the basic needs of rapidly expanding populations and by shortages of funding. In Southern Africa, much of the built and other aspects of the environment are of European settler or Colonial origin and may be politically unfashionable to defend in the rapidly changing cities and towns, with the growth of urbanisation and changing demographics. In addition, many new inhabitants of the cities are essentially rural people who may have little experience or understanding of the complex nature of urban environments. Environmental sensitivities may not be fully understood or appreciated, thus conservation of certain environments may be considered to be of little value or merely an obsolete nuisance, or of greater value to use as fuel or building material. Governments in Southern Africa are also increasingly involving the private sector to a greater degree in stimulating development, growth, job creation and entrepreneurship. While there are many positive aspects to creating these opportunities for the private sector, competitive business conditions, market capitalism and commercial developments may lead

3 RESEARCH OBJECTIVES AND METHODOLOGY

The purpose of this study was to investigate general aspects about the effects of construction and physical development activities on the environment and to monitor and evaluate the execution of a major project in terms of the requirements of the relevant legislation and the previously undertaken environmental impact assessment.

The method adopted includes a review of literature, observations of the general environmental effects of construction and development, a survey conducted among construction industry role players, to determine perceptions and opinions regarding environmental and conservation issues, and specific observations (by one of the Authors, who was the Environmental Control Officer) regarding the project forming the subject of the case study, to monitor and compare the performance of the process against the criteria set in the Environmental Impact Assessment.

4 CONCEPTS

According to Griffith (1994 : 4), *environmental management encompasses those aspects of policy, strategy, procedures and practice that form the organisation's response to its environmental situation.*

Conservation is defined as *preservation, especially of the natural environment*, and may include such concepts as *protection, safe keeping, maintenance, upkeep, environmentalism*, etc. (Tulloch, 1994 : 304).

Environment is defined by Tulloch (1994 : 493) as *physical surroundings and conditions, especially as affecting people's lives; conditions or circumstances of living; external conditions affecting the growth of plants and animals*. Associated terms are *surroundings, atmosphere, climate, habitat, territory, biosphere, ecosystem, nature*. The term also may include aspects such as cities, towns and villages (the urban or built environment), culture in all its manifestations, history, lifestyle and quality of life, i.e., not solely the natural environment but also previously developed and built structures or outdoor areas.

5 REGULATORY ISSUES

The *Constitution of the Republic of South Africa* (1996 : 11) entrenches environmental rights by stating that all persons have the right to an environment that is not harmful to their health or well-being and to have the environment protected for the benefit of present and future generations. Provision is made for legislative and other measures to deal with the prevention of pollution and ecological degradation, promote conservation and *secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development*.

As mentioned earlier, there exists an array of legislation relevant to environmental issues. It is somewhat beyond the scope of this study to elaborate on all of these, hence mention will be made only of the legislation specifically directed at environmental issues.

The *National Environmental Management Act no. 107 of 1998* sets principles for decision-making on environmental matters and emphasises the value of sustainable development. The *Act* provides a guide to ensure the integrated environmental management of activities encountered during the process of development, including design and construction. Aspects directly relating to construction include compliance, enforcement and protection.

The goal of the *Environment Conservation Act No 73 of 1989* is the effective protection and controlled utilisation of the environment. The *Act* comprehensively provides for formulation of a policy for environmental conservation, the establishment of the Council for the Environment and other relevant statutory bodies, protective measures for the natural environment, control of pollution and environmentally

detrimental activities, the formulation of regulations, offences, penalties and forfeitures and includes various general provisions.

The Environmental Impact Regulations are part of the provisions of the *Act*. These are contained in the *Guideline Document* of April 1998 and include a large number of developmental, construction, land use and waste disposal activities. It is required that an Environmental Impact Assessment (EIA) be undertaken in respect of proposed projects included in the list. Application procedures and formalities and the roles and responsibilities of various role players are also prescribed. The EIA essentially forms the criteria and monitoring process for projects.

6 CONSTRUCTION AND DEVELOPMENT vs. THE ENVIRONMENT – GENERAL OBSERVATIONS

Eksteen and Steenkamp (2000) have noted that construction and development

are agents of environmental change. Construction is an important contributor to the economy. It is a job creator, delivers facilities and infrastructure and uses other products generated by the economy. Little of economic value can occur unless preceded by construction. The industry is driven by entrepreneurial opportunities or social responsibilities arising from identified needs and wants in the market, and is fiercely competitive, especially during periods of relatively low activity in the economic cycle. The common practice of obtaining work by means of the bidding (tendering) system, among other inefficiencies, adds to this fierce competitiveness and can lead to excessive risk-taking and ignoring environmental and other considerations.

involve a spectrum of role players and stakeholders, from professional consultants and other specialists to workers with only rudimentary education and skills, to ordinary citizens. Role players are multi-disciplinary and fragmented – a characteristic which may inhibit environmental sensitivity, hence environmental and conservation issues may often be ignored or neglected. The process is complex and largely characterised by separations between need identification, design, production and marketing.

processes involve a multitude of inter-related activities, materials and other resources and are usually undertaken subject to considerable time constraints resulting from competitive and economic pressures. Throughout the process, from concept through feasibility, design, construction, commissioning, finalisation and operating the facility, numerous opportunities exist for environmental factors to be positively or negatively influenced.

utilise a spectrum of materials, many, such as aggregates, occurring in their natural form and undergoing only basic processing. Quarrying and the use of timber, for example, have direct and lasting environmental effects. Other materials undergo a variety of manufacturing processes, all consuming energy and requiring transportation. All these processes contribute to the depletion of natural resources, produce waste products which have to be disposed of and produce atmospheric emissions. Opportunities for recycling of materials are limited and extremely rare, although recycling of constructed facilities is more common, through refurbishment and adaptation of use.

Other environmental effects of construction and development include

permanent, visible scars (road works, cuttings, etc.)

temporary dust, noise and other pollution during operations

disposal of construction waste, some of which can be hazardous

destruction or damage to ecosystems, e.g., in rivers, estuaries, etc.

injudicious demolition of facilities or removal of trees and other vegetation

the needs of a growing population and urban development, including the concentrated and voluminous production and disposal of urban waste.

7 SURVEY OF CONSERVATION PERCEPTIONS AND OPINIONS

A survey on aspects of urban conservation was conducted among a sample of construction and development organisations and individuals in Port Elizabeth during 1999 (McLachlan and Eksteen, 2000). A total of 54 questionnaires were distributed and 39 were returned, of which 3 were incomplete. The 36 completed questionnaires represent a return rate of 66.6%.

A selection of salient findings and comments is as follows :

77.7% of respondents considered conservation of the urban environment to be important or extremely important.

A large majority of respondents perceived a great deterioration since 1990 regarding monitoring of buildings, urban cleanliness, social behaviour, vagrancy and crime. Air quality was perceived to have remained largely unchanged while conservation policies had retrogressed to some degree. This perception conflicts somewhat with the reality of legislation and regulations in effect since 1998.

Available resources for urban conservation were considered to be inadequate by 83.3% of respondents.

About 60% of respondents viewed urban conservation as an important overall influence on and not as a hindrance to development.

Natural site features and surrounding conservation-worthy buildings were considered to be relevant or highly relevant to development by over 80% of respondents.

Responses to questions about whether advice on urban conservation issues was readily accepted by clients were only marginally positive. This may indicate that other development considerations may enjoy higher priorities than conservation issues, notwithstanding respondents' convictions about the essential nature of conservation.

97.2% of respondents perceived that a link exists between urban conservation and tourism. The S.A. tourism industry is in a stage of relative infancy and is considered to be not only a growth industry but also a job and wealth creator.

Approximately 90% of respondents perceived historical buildings and precincts, nature conservation areas within the city and cleanliness of urban areas to be extremely important to tourism. This consideration can be extended to apply also to the general environment and nature conservation, scenic and leisure areas outside cities, such as national parks, trails and travel routes such as roads and railways.

Respondents' perceptions about the sensitivity of the development and design professions and the advice they give to their clients concerning urban conservation issues resulted in a more or less neutral tendency. This may indicate that, although the awareness of urban conservation exists, the commitment thereto may not always be present.

75% of respondents considered that construction contractors were insensitive to urban conservation issues.

About 75% of respondents were of the opinion that construction contractors do not advise clients on the conservation impact of demolitions, alterations and refurbishment, construction operations or waste disposal, dust, noise and other constructional nuisance factors that affect conservation.

It may be concluded that, although urban conservation and thus also conservation in general, are acknowledged to be important cultural and economic issues and are seen as having highly significant influences on tourism and other economic activities, there appears to be a lack of commitment from construction industry, design and development role players in this regard.

The active role of legislative and regulatory mechanisms, as introduced over the past few years, thus assumes great importance.

8 THE CASE STUDY

Background

Since the early nineties the S.A. Government has launched initiatives aimed at economic and social development, job creation, and equity considerations such as empowerment, skills upgrading and transfer, in order to expand, improve and maintain the country's infrastructure, raise living standards and create greater opportunities for participation in the economy. These initiatives include developments such as roads, and facilities such as health care, prisons, offices and tourism amenities and are aimed at the private sector for realisation. Generally, Government invites development bids from private sector joint ventures to conceive, finance, design, construct and operate such facilities. There are various alternatives to these types of projects, popularly called Public / Private Partnerships (PPPs), Public / Private Funding Initiatives (PPFIs), Build, Operate and Transfer projects (BOTs) and others.

In general, bids for such projects are required to conform to an array of criteria, including financial, empowerment, training, equity, environmental, land use and other factors. In recent years, in order specifically to expand the country's tourism and leisure infrastructure, a number of casino developments have been undertaken in South Africa.

One such casino was designated for Port Elizabeth, South Africa. Initially, three developers submitted bids, each according to a concept related to their selected site, one bid being withdrawn prior to adjudication.

Project description

The site : A land area ca. 15 ha in extent, previously leased by the Municipality to a private operator for use as a caravan park and holiday chalet area.

Situation and surroundings : On Marine Drive, along the beachfront, in the tourist and leisure area of the city; in the vicinity were existing single and multi-storey residential buildings, hotels, restaurants, a small shopping centre, a petrol station, a tennis stadium, a community hall, a nursery school, a primary school and a military base.

The development :

Demolition : The small shopping centre and community hall.

Demolition and relocation : The petrol station, as part of the new development; the tennis stadium, to elsewhere in the city; the nursery school, to a site adjoining the primary school.

New facilities : The casino; retail and related outlets; restaurants; cinemas; two new hotels; a conference centre; theatre facilities; other entertainments; extensive parking space; gardens; a man-made lake; play areas for children; reconstruction of fencing to the primary school.

Refurbishment : One existing hotel, adjoining the casino site.

Access : Considerable upgrading of access roads in the area was required to cope with the anticipated increase in traffic volumes.

Project team : The developer; various firms of consultants and construction design professionals, to undertake the project management, concept and detail architectural, engineering and other design work and budgetary control.

Contractual arrangements and construction team : Tenders for various sections of the project were called for, adjudicated and awarded, in compliance with the award criteria (empowerment, skills development, etc.). The construction team included several established and emerging contractors, in joint ventures and in collaboration with numerous sub-contractors, many of whom were labour-only sub-contractors and / or emerging contractors. *Project duration and value* : The project commenced in mid-1999 and was to be operational in October / November 2000, in time for the holiday season. The value was approximately R 650 million. These factors resulted in a fast-track project with extreme budget and work pressures and insufficient time to optimise design, construction and environmental problems.

The Environmental Impact Assessment

An EIA was undertaken in terms of the Environment Conservation Act . The environmental consultant was a member of a private firm also engaged in EI Assessments for similar projects in other cities in South Africa. The consultant was from elsewhere and did not have intimate knowledge of local conditions. Not being resident in Port Elizabeth, the consultant appointed a locally based Environmental Control Officer (ECO) to oversee the implementation of the Environmental Management Process (EMP) during construction. The EIA involved extensive public participation which elicited opposition to the project from many local residents. Their objections were largely that, being a residential area, a commercial complex of the magnitude envisaged was inappropriate.

Local residents were also concerned about undesirable elements being attracted to the area because of the amount of money changing hands, the potential for an increase in general crime and an increase in the potential for drugs trade in the area. Despite the objections voiced by the local residents, the Municipal authorities and Department of Economic Affairs, Environment and Tourism (E. Cape) approved the project.

(In fact, the area was not solely a residential area but included other aspects, as previously noted. Also, some undesirable activities, such as drugs trading, occasional violence, etc., already occurred at some of the existing night spots and parking areas in the vicinity.)

A Traffic Impact Assessment was undertaken and the local residents questioned whether there was adequate parking in the area outside the casino complex. This might result in an overflow of vehicles into normally quiet back streets. To accommodate this concern, the casino developer agreed to provide 200-300 additional parking spaces for beach visitors who probably would not visit the casino.

Monitoring

The ECO monitored the construction activities against the EIA by means of visits to the site, assessment of prevailing or anticipated situations, reporting thereon and requesting rectification or other appropriate action.

Design aspects

The development bid had been based on a concept design. After acceptance of the bid, the detail design of the project and all its facets to a considerable extent still had to be developed. Considering the time and other pressures pertaining to the project, coordinating all the different project aspects was a real challenge. Construction and design were thus concurrent activities, a characteristic of fast-tracking. Design information was often not available when required, and changes to design decisions were ongoing, almost until the end of the construction process. In fact, the end result turned out somewhat differently from the original concept. Disruption of the construction sequence and schedule was thus a regular feature.

During the construction phase, it became clear that not only should the ECO have been involved during the early planning phase, so that local environmental factors could have been fully integrated during concept planning, but he should also have been included in the detail planning team. Because the ECO was not part of the planning function, he had no insight as to what was going to take place next at any time. This meant that each visit to the site was a new experience, with roads and other features changing by the day and new environmental problems having to be resolved continuously.

With hindsight, it would have been appropriate to have halted construction, until the problems of design implementation had been sorted out. However, the contractors were obliged to meet a very strict completion date with no allowance for error and were being held contractually responsible by the developers for some problems that were not of their making.

Construction aspects

Construction traffic :

Although construction vehicles were originally required to use an alternate access route to the site and strictly prohibited from using Marine Drive, so as to not create added traffic problems and disrupt local and tourist traffic, the fast track nature of the project and the schedule disruptions meant that traffic was

eventually obliged to use Marine Drive, since there was no suitable alternative access to certain positions on site. The EIA thus contained no provision for the implementation of this aspect.

Excavation and disposal of excavated material :

A large amount of earthmoving was required during the early stages of construction. The soil was comprised of unconsolidated dune sand with some underlying rock. The EIA specified that all spoil be removed to the only approved site, Port Elizabeth municipal dump at Arlington, some distance from the casino site. However, at least one of the contractors decided, on his own initiative, to utilise an alternate site. Once this was discovered, it was quickly stopped, but this serves as an example to illustrate the lack of understanding by contractors regarding the purpose of an environmental management process. It also identifies a gap in the application of EMPs in that many of the contractors and sub-contractors accepted the environmental restrictions written into the contract without understanding the consequences of their actions. During the construction phase it became clear that the requirements of the EMP were not being adequately implemented due either to ignorance or lack of interest. The ECO was reluctant to impose fines on contractors who were probably ignorant of the requirements. Whenever the contractors' attention was drawn to each problem they were quick to 'apparently' take action. It also became clear that main contractors were not adequately briefing their sub-contractors on the requirements written into their contracts.

Adjacent to the casino site is a disused portion of a military base, which had, some years previously, been used as a source of sand. Following negotiations, the government approved the use of the disused sand pits as a dumping site for construction spoil from the casino site, provided it was levelled and fully rehabilitated. This provided two benefits: firstly it relieved local residents from a great deal of heavy traffic leaving the construction site and disrupting local traffic and it considerably lowered the cost of the early earthworks. However, although verbal permission was received for this activity, no written permission had been received by the time the site was handed over.

No trace can be found of legislation in South Africa or elsewhere that requires sites, used for landfill, to have the title deeds endorsed. This has future land use implications and is clearly a legislative matter that needs attention in all countries where the purchaser needs to "beware" of what he / she is purchasing.

Hazardous substances :

Hazardous substances comprised mainly paints and solvents and constituted a problem that was not adequately handled. The EIA required that adequate arrangements be made for the collection of all these substances and their removal to the municipal hazardous waste site. No visible evidence of such facilities was ever seen on site. However, there was only a low level use of such substances and they were therefore difficult to detect by the ECO.

Working conditions, health, safety and sanitation :

Working conditions for labour were generally good and all labourers were required to undergo environmental awareness education. This was implemented at the beginning of the project but mainly reached the labour force controlled by the main contractors. The sub-contractors, especially those who arrived on site near the hectic closing months of the contract, did not receive any awareness training.

Issues of safety were well implemented by the main contractors but poorly by many of the sub-contractors. The use of safety equipment, especially hard hats, seemed to be a consistent problem. The contractors became quite desperate about hard hats, because their absence was immediately apparent but the labourers were reluctant to use them on hot days. To avoid wearing them they would become "lost", which involved the contractors in continual replacement costs that were not written into the original contract. This is a further example of the importance of clearly stating the environmental and safety conditions, issue by issue, in the contracts before they are awarded. Many of the problems encountered during this project might have been avoided had it not been one of the first cases of a large construction activity being undertaken under the conditions of the National Environmental Management Act.

The adjoining military base area was covered with invasive Australian vegetation (*Acacia* spp) and was used

from where labourers were working and, in addition, their state was below acceptable standards. The invasive bush vegetation provided excellent cover and the labour found the bush preferable, despite continual protestations from the ECO that this type of activity in the middle of a residential area was unacceptable. When the construction was drawing to a close, the ECO refused to declare the military base area as environmentally acceptable and it is not known whether DEAET has taken the matter further.

Other aspects of environmental significance

Wind effects :

Port Elizabeth lies on Algoa Bay and is one of the southernmost places in South Africa. This area is renowned for gales, often in excess of 40 knots, generated by South Atlantic and South Indian Ocean low-pressure systems. One of the design features that caused a considerable amount of unpleasantness for local residents was that wind and dust problems were largely related to the orientation of the main parking area. This area was essentially a rectangle with the long axis running down-wind. This meant that the winter SW gales picked up the fine dune sand and blew it directly onto apartment buildings and private houses.

A further illustration of the error of not consulting local knowledge was the inclusion of fountains within the complex. When the wind is blowing, water from the fountains is blown over passers-by. Because winds of the order of 20 knots, from the SW in winter and SE in summer, are a regular feature, the design should have allowed for these local conditions.

Algoa Bay is a relatively pristine area that suffers pollution from secondary treated sewage effluent and little else. The international conference "Dunes '94", held in Port Elizabeth in 1994, declared the Alexandria dune field, an area in excess of 100 km² on the northern edge of the bay, as one of the best examples of a coastal dune field in the world.

The Alexandria dune field lies downwind, across the bay from Port Elizabeth and litter blown offshore from the city accumulates on its beaches. With this in mind, an important environmental problem addressed early on was litter that would be blown off site, into the sea and would find its way to the Alexandria dune field. The litter comprised plastic wrapping from brick loads delivered to site, paper, plastic containers and other light material that would float. The EIA required that all litter be picked up daily to be taken to the Arlington dumpsite. This was not adequately implemented and there was always litter on site. The main contractor complained that, although it was being removed on a daily basis, it accumulated faster than it could be removed. The matter came to a head after the single small storm that occurred. Litter had not been removed from drains recently constructed. When the storm water began to flow, the accumulated litter was carried down the storm water drains and deposited on the beach. This caused an outcry from the local residents. The contractors collected much of the litter, but most of the low level accumulation was not an immediate problem and went unnoticed.

Water feature and garden layout :

The design included a large man-made lake as a central feature. It was not initially planned to include fish in the system and a large filtration plant was built to keep the water clean by means of filtration and chemicals. However, during construction a large amount of pollution entered the lake from dust, floodwater and fertiliser used during the establishment of the surrounding gardens. The lake was constructed with a plastic base with very little sediment, and thus it was not possible to use plants to function as a wetland. The filtration plant was unable to handle the algal growth and so fish were introduced to feed on the phytoplankton. However, the fish could not be carnivorous nor should they be capable of breeding. For these reasons, the choice of fish was marine mullet (*Lisa richardsonii*), which normally live in estuaries or in the surf zone but breed only in marine water, not in fresh water. Mineral nutrients could be removed from the water by harvesting the fish. However, the fish, although fast growing, have not initially been able to control the algae, resulting in turbid water which develops scum under windy conditions, requiring skimming in order to maintain a reasonable appearance. If the scum is an inevitable consequence of design, then skimmers can be located in suitable locations to remove it during the most prevalent wind conditions.

The gardens close to the lake are kept in excellent condition as a result of good species selection but the

fertilise and water the vegetation, and the fertiliser runs into the lake and aggravates the algal problem. This illustrates how sound environmental management considerations at the design stage can prevent problems and save money during operation. It also illustrates that environmental management is not only about “bunny hugging” but includes sound financial management.

Potential flood effects :

During the construction phase, little attention was paid to the potential for damage that might be caused by flooding. The site lies on a slope, with run-off accumulating over a distance of several hundred meters. In the event of a heavy storm, for which Port Elizabeth is renowned (and a storm in the hundreds of mm of rainfall is overdue, according to statistics), water would have run off, eroding the bare soil, and would have flowed over Marine Drive, depositing soil on one of the two arterial roads serving the area before flowing into the sea. The ECO advised that a berm be constructed on the seaward edge of the main platform of the site, along Marine Drive, with pipes to carry water down to the road. During construction, a small (50mm) rainfall event occurred and the berm performed perfectly. However, it is unlikely that these measures would have handled a large storm event. When apprised of the probability of a storm, the owners responded by taking out appropriate insurance.

Lessons learnt

Some of the lessons learnt from the case study, and hence issues requiring attention, are :

The mechanisms for sound and integrated environmental management exist but are not yet fully implemented. The concept is at an early stage in South Africa and all role players are not yet adequately informed or committed to EM process and procedures.

The ECO should have the authority to participate in the overall and detail design and execution, issue and enforce instructions, and issue fines for non-compliance with predetermined requirements. However, in order to be fair about fines, the ECO should have direct contact with all contractors and sub-contractors prior to the commencement of construction. A set of “no go” rules need to be established at the start of the contract as do the value of fines, an appeal system and where the fines will be deposited – clearly the fines cannot be returned to the developer, not can they go to the ECO.

Projects at the concept stage should be approached from an integrated environmental management process point of view.

EI Assessments should be carried out with full incorporation of local conditions.

The future use of landfill sites and other areas affected by development should be considered.

All development and construction project stakeholders (authorities, developers, consulting professions, construction teams, materials manufacturers, raw material suppliers, etc.) should be comprehensively educated about the benefits of environmental management and the consequences of not doing so.

9 CONCLUSION

The main conclusion arising from this study is that South Africans have much to learn about the environment and how to prevent nuisance factors and environmental damage resulting from construction and development activities. The importance of recognising cumulative effects on the environment is necessary and if some parties place personal interest and gain above the greater good of society and the environment, then suitable measures are required to change such attitudes. Probably the greatest need, however, is to educate the population on the importance of a sustainable environment.

The case study has served to illustrate many of the issues which were identified in the first part of the paper and has also demonstrated that, although adequate mechanisms exist, the implementation of environmental control measures in practice seem to be overshadowed by economic and time pressures, lack of attention to detail and lack of formulation of procedures and monitoring measures.

It is thus recommended that developers, construction design professionals, contractors and other role players should attend to translating the EIA criteria as contained in the regulations into procedures that can be

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A Philosophical Inquiry in to Sustainability Assessment as Applied to Agriculture

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ABSTRACT

This paper explores the philosophical and scientific contexts wherein sustainability assessment, with the emphasis on agriculture, is carried out. This is done with the aid of an agricultural case study. In the complex and contested arena of sustainability interpretation and assessment, science and therefore, the resulting policies, have an inordinate influence. In other words, the call for sustainable development, and more specifically sustainable agricultural development, appears to be technocratic. Are the criteria and indicators (C&I) for sustainability in agriculture, in reality, technocratic products? If, for the sake of this debate, we accept that farmer's have little or no influence on the development of C&I then it logically follows that C&I are indeed driven by a technocracy. Agriculture is, however, an economic activity. Therefore, the calls for agricultural and economic sustainability are confounded, indicating the inclusion of the plutocratic context in the discourse. This approach is obviously more suited to a thesis than a paper. As a result, this discussion does not venture beyond mentioning the plutocratic influence on technology and policy. The technocratic assessment of sustainable agricultural development and the resulting C&I spring from various scientific domains, most notably the biophysical, social, economic, political and institutional sciences. Furthermore, these C&I are formulated within the peer-restricted dogmas of scientific domains and subjected to the overarching influence of value systems. In addition, on a deeper level, what philosophical issues should be taken note of when accepting the virtues of Western worldviews? Moreover, if we accept the notion that values precede the development of any theory, what are the implications for the development of C&I to assess sustainability? Despite the great deal of effort expended in developing the plethora of C&I to assess sustainability, or the lack thereof, it has proven difficult to verify these, produce C&I useful to policy makers, and land users. Solutions are repeatedly sought in the development of better science for better C&I. Further questions asked in this paper are the following: Will more of the same lead to improved C&I? What are the boundaries of science in the first place? Is environmental science the appropriate scientific domain within which to develop C&I for sustainability assessment of agriculture? Can sustainability assessment progress whilst environmental science develops the assessment tools but agricultural science develops the technology disseminated via agricultural extension? If we assume that the calls for agricultural alternatives are valid, then will agriculture (technology, extension and assessment tools) be better served by applied ecologists (agroecologists) than by environmental and agricultural scientists?

Key words: oikonomia, oecology, value systems, criteria and indicators, sustainability assessment

1 INTRODUCTION

The word sustainability was recently added to the scientific lexicon. However, sustainability or the lack, thereof, is not a new concept. For the purposes of this paper, sustainability refers to the concerns, of a sector of society with long-term perspectives, that we will not be able to maintain economic activity through time,

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in the face of long-term ecological constraints and socio-economic pressures. The underlying debate of growing population and technological advances versus finite resources has been ongoing since the inception of the Western civilisation (Malthus, 1798; Faulkner, 1934, Russel-Smith, 1950; Meadows, Meadows, Randers & Behrens, 1972; Mollison, 1988; Meadows, Meadows & Randers, 1992; Flannery, 1994; Maser, 1994; Diamond, 1998) and most probably also in earlier civilisations.

The Brundtland Report (WCED, 1987) appears to have revived and intensified the calls for alternative approaches to economic activity. Furthermore, this report appears to have advanced the wish to assess progress concerning the sustainability of economic activity. The generic approach to the assessment of sustainability has been and still is through the development of indicators and criteria for these indicators.

However, sustainability remains a complex and contested concept (Swift & Woomer, 1993). It implies many things to many different scientists and it logically follows that there are major problems in the assessment of a concept upon which there is so much disagreement. Invariably, solutions are sought in the development of better science for the development of better C&I. The question asked in this paper is if this tendency is, at least in part, responsible for the lack of progress with the assessment of sustainability.

In the complex and contested arena of sustainability assessment, certain absolutist scientific approaches have an inordinate influence. This is largely evident through the emphasis on the technocratic development of criteria and indicators. These indicators are developed within the current paradigms of the various scientific domains, which are, in turn, plutocratic and or technocratic interpreted products of the development of (Western) thought, primarily since the Renaissance and the Enlightenment.

Hierarchically, the next question concerns the boundaries of science. Does current Western thought acknowledge any scientific boundaries? Moreover, since science developed within a certain philosophical context, what issues should be taken note of when accepting the virtues of Western worldviews? In addition, if we accept the notion that values precede the development of any theory, what are the implications for the development of C&I to assess sustainability?

Therefore, the objective of this paper is to explore the influence of conflicting values, as manifested in science, on sustainability assessment. Throughout this discussion, agriculture is used as an example of economic activity. It is hoped that this approach will somewhat elucidate the unexpected lack of progress with sustainability assessment

2 PHILOSOPHY AND PERCEPTIONS OF REALITY, SCIENCE AND ECONOMIC THEORY

How we perceive reality is a determining factor concerning our response to and the resulting manner in which we choose to assess and manage real world issues. This question concerning our perceptions of reality has been a persistent theme in Western philosophy. Beginning with the natural philosophers, the quest to determine what the world's basic fixed substances are, and how these relate to things that change, have gripped the imagination of philosophers. Substance philosophers, such as Democritus (460-370 B.C.), agree that reality consists of fundamentally, unchangeable things. Process philosophers, such as Heraclitus (born ca. 540 B.C.), on the other hand, all agree in seeing time, process, change and historicity as among the fundamental categories for understanding reality (Rescher 1996).

Apart from substance and process philosophers a third complementary, perception is that there are aspects of reality that are not comprehensible to mankind. Reality, in other words, is larger than we can comprehend, regardless whether substance or process philosophy is followed. This approach implies that neither the substance philosophers, nor the process philosophers have succeeded, or will succeed in finding a true philosophy of everything. This interpretation is followed by philosophers such as Kierkegaard (1813-1855) and Dooyeweerd (1894-1977).

The interactions between fixity and change, between substance and process, have been interpreted differently throughout history. Plato (427-347 B.C.), for instance, argued that absolute fixity could only be achieved in another world, but that the world experienced by our bodies is in continuous process. He placed substance in a metaphysical realm, but did argue that human happiness in the physical world closely corresponds to imitations of stability, such as the city-states. Aristotle (384-322 B.C.) argued that absolute fixity is not something otherworldly, but that fixity and change are both engrained in physical reality. Both these philosophers agreed that the search for absolute fixity could only be achieved through reason.

The Stoics, founded by Zeno (c. 355-263 B.C.) argued that not the Platonic ideal of finding absolute fixity in other worlds, but an acceptance of physical, and changeable, reality is the most important for the ultimate ideal of living well. Reason should be employed in planning to achieve such a life. They effectively disregarded any reference to Platonic metaphysics and focused on sensory reality only. They also disregarded the Aristotelian search for absolute fixity within sensory reality in favour of a more hedonistic worldview.

St. Thomas of Aquinas (1225-1274) attempted to create a synthesis between faith and knowledge by placing each in its own domain. He argued that the only absolute can be found in divine law, namely the Scripture and the tradition of the church, and that this is a matter of faith. However, he also stated that the natural law is the nature of man and is perfectly rational and unchangeable, but grounded in the divine law. Reason can be employed to search for absolute fixity in the physical world, but the results should be traced back to the revelation of God as its first cause (Matson 1987).

Thomistic philosophy proved to be a watershed between medieval thought and the Renaissance (ca. 1300-1600) and subsequently the 18th century Enlightenment. It was increasingly believed that through *reasoning* autonomous individuals would understand and control their natural and societal realities. It was in this worldview that modern science made its headway. Following Arab influence in Europe at that time, the atomistic approach to science found fertile ground in a philosophy receptive to the virtues of reason. This early rationalism has been widely influential, and initially led to disparagement of observation and the natural world (Attfield 1994). At this stage in the development of the Western civilisation, science came to be equated with the philosophical understanding of reason and with the objective to understand and control reality (Petulla 1987).

However, influenced by the Aristotelian emphasis on the observation of nature, the later 17th century British philosophers of experience came to the fore. They emphasised that reality has to be observed, experimented with and controlled. Referring to the distinction between substance and process, Descartes and the Enlightenment philosophers of reason and the British philosophers of experience had substantivism in common. The Platonic ideal of finding a constant, timeless and unchanging truth had now been pursued through both reason and experience, but only in the physical world.

Kant (1724-1804) attempted to integrate substance and process in one framework. At this stage, substance took the form of substantivist scientific ideals whether, pursued through reason or experience, while process was interpreted as the ideals of autonomous individual beings. However, post-Kantian philosophy did not follow such an integrated approach, but developed mainly into two broad schools of thought: the substantivist-positivistic rationalism and the processional historical dynamicism (Gide & Rist 1915). Positivist rationalism has been developed by philosophers such as Comte (1798-1857), Smith (1723-90) and Mill (1806-73), while historical dynamics have been developed by philosophers such as Hegel (1770-1831). After the split between positivist rationalism and historical dynamics, these different schools of philosophy continued to work within their own interpretations of reality. On the one hand those with the Democritian search for the character of reality in the fixity of substance (things): the search for universality, condition, and stability, and on the other hand the Heraclitian search for the character of reality in processes: novelty, activity and fluidity.

3 DEVELOPMENT OF SCIENCE

Each school of thought has its disciples in the different scientific domains. Newtonian physics accepted the premise that the world is governed through unbreakable laws or mechanisms and that every natural change can be calculated with mathematical precision (Gaarder 1997). Later on, Heisenberg's uncertainty theorem, the development of quantum physics and Einstein's general theory on relativity paved the way for a more contextual interpretation of reality and ultimately to what is known today as complexity theory⁷. These scientific revolutions demonstrate that the search for absolute, unchangeable things have not superseded or substituted for the processional aspects of reality. The world is essentially dynamic, even at its most fundamental level, and as evident from the tendency in scientific revolutions, a search for absolute things that fully explain reality, as we can perceive it, is a futile undertaking. Some aspects, such as the laws of gravity, for instance, would have high relevance in their context, but the underlying philosophy cannot be equated to an entire worldview. The latest developments in science point to the importance of acknowledging the complexity of reality, thereby implying a more limited role for absolutism in science and a humble approach in attempting to understand and control complex systems in an *ex ante* way.

4 DEVELOPMENT OF AGRICULTURAL SCIENCE

As with philosophy and science, agriculture has been revolutionised three and perhaps four times (Pretty, 1995; Baker, 1996). However, there has only been one revolution in agricultural science. The first major food production developments, later referred to as agriculture, preceded the recorded philosophical era by several thousands of years. Furthermore, the second agricultural revolution preceded the first scientific revolution [Newtonian (1642-1727) revolution], occurring during medieval times (c. 500 - 1300 A.D.). From an agricultural point of view, these ages were everything but dark (Baker, 1996).

Agriculture, as a scientific domain, came about many centuries after the second agricultural revolution and played a major role in bringing about the third agricultural revolution, i.e. the "Green Revolution". Justus von Liebig (1803 - 1873) launched the development of the agricultural sciences with the publication of his work on chemistry applied to agriculture in 1840. After World War 1, agricultural research centres were established and university faculties opened

Furthermore, the effects of climate on this rapid implementation (third agricultural revolution) of the technologies provided by the first revolution in agricultural science should not be ignored. The "benign" climate from about the late 1940's to the early 1970's, with decreased annual yield variation, was an unusual feature (Barker, 1996).

5 DEVELOPMENT OF ECONOMIC THEORY

Neither philosophical, nor scientific historical developments have yielded a comprehensive understanding of and thus ability to control reality. The development of the Western worldview was mainly influenced by a philosophy that emphasises the search for absolutes through scientific reasoning. It comes as no surprise that economic theories are following similar lines as they have been developed within this particular worldview.

Positivistic rationalism became the basis of modern mainstream economic thinking. The early twentieth century revival in economic positivism through the works of Walras (1834-1910), Jevons (1835 - 1882) and Menger (1840-1921), were all based on a mechanistic and reductionistic world-view governed by economic laws (Pribram 1983). The work of the rational positivist Vienna Circle was classic-scientific and anti-metaphysical in thought, and yielded the verification principle. This means that all statements are either analytic or synthetic. Either true by virtue of the definition of their own terms, or true, if true at all, by virtue of practical experience. Furthermore, the Vienna Circle pronounced that all synthetic statements are

meaningful if, and only if, they are capable, at least in principle, of being empirically verifiable (Blaug 1980). Reason and, by preference, experience became the only valid norms to search for truth in reality. This school developed into various branches of modern conventional economics, among them the neoclassical school, marginalism, mathematical economics, monetarism, Keynesian economics and welfare economics. The key ideas of these different schools are well documented in the literature on economic history and economic systems (Oser 1970; Pribram 1983). The important point is that economic theories mostly used in the assessment and management of economic problems (incl. the sustainability of natural and environmental resources) is based on a certain partial interpretation of reality.

Historical dynamism developed further into economic theories such as institutional economics, the Austrian school of economics and recent applications of complexity theory and non-linear dynamics to economic problems. According to Hodgson (1999), this variety of approaches can be referred to as evolutionary economics. This approach emphasises that the economic system is a continuous changing process in space and time, and needs to take account of feedback through continuous learning. The processional aspects of reality, as captured in these theories, have not been successfully integrated with the substantivist mainstream approaches.

The third interpretation of reality, namely that there are aspects of reality that are not implicated by human perceptions of reality, has yielded a separate body of economic literature. Just as there will be no true philosophy for everything, following either substantivist or processional approaches to reality, or even a combination of the two, there will be no single economic theory that can assess and manage real world problems. External norms and guidance, often granted in ethical aspects such as stewardship, care and justice, have to set the boundaries wherein economic assessment can be carried out. The resulting political debate centres on who and how these norms should be set.

We have now established that our perceptions of reality shape the philosophies we embrace, the theories we devise, and the way we assess and manage problems. It has been shown that the development of mainstream economic theory followed the substantivist interpretation of reality. The next question is how the substantivist approach to reality has translated itself into economic theory used to assess economic sustainability. The substantivist, positivistic approach to economics accepts the scientific objectivity and ethical neutrality of economics (Bromley 1991). This philosophy was taken a step further by the equation of Pareto optimality to scientific objectivity and ethical neutrality. This, however, is a controversial jump in logical thinking. Blaug (1980), concluded that *the concept of Pareto optimality...should not be confused with theorems of positive economics...immense confusion has been sown on matters of "efficiency" without committing ourselves to value judgements*. Pareto optimality and efficiency are value-laden words, implying that value-judgements are at the heart of mainstream economic theory - as they will be for any other economic theory.

The important points are that reality is larger than any one philosophy or theory is likely to encompass and that value judgements play an important role in the formation and application of economic theories. This needs to be taken into account when sustainability assessment and management is carried out.

6 IMPORTANCE FOR SUSTAINABILITY ASSESSMENT OF AGRICULTURE

Sustainability and sustainable development are terms that cannot be easily defined. A substantivist interpretation would be to define principles for sustainability within positivist scientific orientations only, while those that emphasise process aspects of reality would be more concerned with sustainability as a structural problem that takes account of changing institutions, value systems and power relations (Bergstrom 1993). Building on the three-tiered approach to interpretations of reality, the last group would seek assessment of sustainability not within theories that are developed based on either substantivist or processional interpretations of reality, but to seek external value-judgements prior to the assessment of sustainability. A full interpretation of reality is beyond the human pale, so the assessment of certain aspects of reality also needs to take account of external values to judge sustainability.

The importance for sustainability assessment and more specifically an assessment of the sustainability of agriculture, can be summarised as follows:

It has been argued that value judgements need to be made, even if substantivist or processional philosophy and theories are used. Value judgements on norms that define sustainability and theories followed to populate these norms need to be made explicit before assessing for sustainability.

Furthermore, the acknowledgement that no single one philosophy or theory is likely to give a full picture of sustainability, would suggest that a broad-based and lateral approach is used when defining the boundaries of assessment in the early stages of such an assessment. Sustainability is a concept that cannot be captured in a single set of generic principles, at best maybe on a very high level. A broad-based interaction process should ideally take place early in a sustainability assessment process, between not only like-minded theoretists, but also those that can fundamentally challenge existing ways of thinking through different interpretations of reality. A useful tool that has and can be used is to map complex existing and alternative systems (Giaoutzi & Nijkamp 1994). An interactive process is needed to define a picture of sustainability within a particular context and to challenge existing interpretations of reality before assessment is carried out. The development of technocratic indicators follows mainly the mainstream interpretation of reality and resulting scientific theories. In such a setting, the indicators and the criteria developed, would only measure changes within a particular pre-determined system and will not challenge to change the system itself in any fundamental way.

There are inherent tensions between different scientific interpretations of sustainability. An example is agriculture's implied compliance with an assessment tool that measures biotic diversity (polyculture) on the farm and simultaneous compliance with economically optimal industrial farming practice. The latter relies on biotic simplification, i.e. monoculture. In a study done in Nepal on sustainable agricultural development, Lancker & Nijkamp (2000) concluded that *a conclusive and unambiguous policy strategy for future sustainable development...is hard to achieve because of the mutually conflicting nature of sustainability constituents in the region considered*. One of the main problems experienced here is the degradation of natural resources, closely linked to agricultural activities. Specific areas of tension in the assessment of sustainability, as based on indicators in environmental sciences and industrial agricultural sciences, are that indicators developed within environmental sciences will always point towards unsustainability of industrial agriculture. The technology for industrial agriculture comes from agricultural science and the technologies promoted have consequences in conflict with environmental concerns.

There are commonalities between certain other scientific interpretations of sustainability. For example, industrial agriculture and economic optimality is in no apparent conflict, both fuelled by an interpretation of sustainability that is based on economic efficiency and short-term gains. This conflict between elements of sustainability assessment in agriculture is illustrated in Figure 1.