# Integrated Ecological-Economic Modelling as an Estuarine Management Tool: A Case Study of the East Kleinemonde Estuary

## Volume I:

## *The Economic Value of the East Kleinemonde Estuary and Impacts of Changes in Freshwater Inputs*

Report to the
Water Research Commission

by

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# PREFACE, ACKNOWLEDGEMENTS AND CAPACITY BUILDING REPORT

This study was conducted as part of the WRC research project K5/1679: "*Integrated ecological-economic modelling as an estuarine management tool: a case study of the East Kleinemonde estuary*" and co-funded by the University of Cape Town. The aim of the WRC project was to develop an integrated ecological-economic model of the East Kleinemonde which will enable the assessment of different water flow and management scenarios in both ecological and socio-economic terms. This project aimed to collect the economic data necessary to complete the economics component of the model.

This project formed the main capacity-building component of the broader research project. The economics project was used as a teaching project for the resource economics module of the taught MSc course in Conservation Biology offered by the Percy FitzPatrick Institute of the University of Cape Town. Students were involved in the workshopping of ideas, development of the survey instruments, collection of data, and the analysis and write-up. Their write-ups were used as far as possible in the compilation of this report, although the data and reports have been reworked for accuracy where necessary, edited for style and rearranged to suit the flow of this report. Whilst different groups of students were involved in writing different sections of the report, all were involved in most aspects of data collection, and thus they are jointly acknowledged for all of the work.

The student project was co-supervised by Jane Turpie and Alison Joubert. We would also like to acknowledge the contribution of Barry Clark during the design and execution of the project.

Thanks to the home owners association for helping to notify the residents of the survey. Thanks in particular to the residents and holiday home owners at East Kleinemonde and Kasouga who participated in the survey, as well as to the numerous people in Ndlambe Municipality who agreed to be interviewed. We are also grateful to the estate agents for their time and information. We would also like to thank P.D. Cowley, A. Shelley and Jenny Currie for information and advice.

# VOLUME I
# The economic value of the East Kleinemonde estuary and impacts of changes in freshwater inputs

## EXECUTIVE SUMMARY

### Introduction

This study forms part of a broader research programme on the ecology and economics of the East Kleinemonde estuary and forms part of a study which will culminate in an ecological-economics model to assess the potential impacts of changing river flows and management on the estuary. The main aim of this study was to investigate the economic value of the East Kleinemonde estuary and how this value might change with a change in estuary condition. In particular, the study concentrated on the direct use value (mainly recreational value) and the non-use (or existence) value of the estuary, since indirect use value (nursery value) is dealt with elsewhere.

The main objectives of this study were as follows:

- To determine the direct use value of the East Kleinemonde estuary
- To derive a model which can be used to predict changes in direct use value as a result of change in estuary characteristics
- To determine the non-use value of the estuary
- To determine how willingness to pay to prevent a loss of biodiversity changes with magnitude of loss
- To determine whether alternative water saving measures would be viable and their extra costs justified.

### Study area

The East Kleinemonde estuary is situated approximately 15 km north-east of Port Alfred and opens to the Indian Ocean at 33° 32' S, 27° 03' E. It is a small estuary with a small catchment area. Due to the low flows from the catchment, the estuary is mainly closed, breaching only occasionally. Surrounding the estuary, the settlement of Kleinemonde comprises about 300 developed erven or which 200 are permanently occupied. The number of houses in the area is set to triple in the near future, leading to concerns about aesthetics, crowding, water supply and pollution.

**Direct use value of the East Kleinemonde estuary**

The direct use value of an estuary is reflected in visitors' willingness to pay to spend time there and residents' willingness to pay in terms of their investment in property. These values were estimated in terms of actual expenditure, excluding consumers' surplus, by means of a survey of 137 residents, holiday home owners and other visitors to the estuary and using the hedonic pricing method, which isolates the contribution that proximity to the estuary makes to property values.

Based on the average property value of R1.5 million, the total value of developed properties in Kleinemonde is about R450 million. Based on this, it was estimated that property owners are willing to pay a total of R10.5 million per year to make use of the area. Including expenditure by visitors, the total annual recreational use value of Kleinemonde was estimated to be at least R13.3 million per year. In terms of impact on the economy, use of the Kleinemonde area contributes an estimated R14 m and R7 million per annum to the real estate and trade sectors in the local area, respectively. Not all of this can be attributed to the estuary. Houses with estuary frontage command a premium of about R459 000 over other houses. The total property value attributed to the estuary is estimated to be R133 million (30% of overall value). Permanent residents and visitors claimed that the estuary accounted for 21% and 32% of their enjoyment of the area, which suggests that the total recreational use value of the estuary is in the order of at least R3.4 m per annum. Turnover in the local economy attributed to the estuary is at least R1.75 m per annum. This is a relatively small proportion of the use value of the area, largely because of the high value associated with the surrounding unspoilt beaches.

**Impact of changing estuary health on direct use value**

The value of the estuary is threatened by future development in the area which might lead to changes in the estuary characteristics. Such changes in value are best predicted using the Conjoint Valuation method, a stated preference technique in which respondents are asked to rate different scenarios in which the characteristics of a commodity or environmental amenity are varied. Four attributes of the estuary were varied in the scenarios presented to respondents: water level, water quality, numbers of angling fish and the amount of saltmarsh versus water weed. A generalised linear model was constructed which predicted a user's utility (on a scale of 1-10) on the basis of these characteristics. The utility scale was converted to a monetary scale using respondents' estimates of the degree to which property value or the amount of time spent at the estuary would change under the worst scenario. A high property of respondents felt that property values would suffer and this was echoed by estate agents. Visitors were more sensitive to degradation than residents. In the worst case scenario, expenditure by visiting users on goods and services in the local area could be expected to drop by 39%, or some R2.8 million per year.

**Existence value and willingness to pay to prevent a loss of biodiversity**

The existence value of the East Kleinemonde estuary is the value held by the public for the continued existence of the estuary and its biodiversity, expressed as a willingness to pay. This value is usually estimated using the contingent valuation method (CVM), a survey-based approach. A CVM survey was conducted throughout the Ndlambe district of the Eastern Cape Province, as well as in Kleinemonde. The prime focus was to elicit people's existence values of the biodiversity of the East Kleinemonde estuary, represented by their 'willingness to pay' (WTP) for the preservation of the rare and endangered estuarine pipefish *Syngnathus watermeyeri* in this estuary. Two different questionnaire versions were used: the first elicited WTP for paying an amount over and above their monthly water bill charges; the second elicited WTP a once-off payment for a water supply option that would reduce water demands on the estuary. The second version was asked of on-site users (at Kleinemonde) as well as elsewhere in the municipality. The degree of threat to the pipefish (% of population at risk) did not influence WTP. As expected, income was the main determinant of WTP. Other factors included the respondent's distance to the East Kleinemonde estuary, familiarity with the estuary, gender and race. Kleinemonde respondents were found to have a higher average WTP than those of the greater Ndlambe municipality. The type of payment vehicle used in the survey was found to cause significant changes in WTP, with the result that estimates of overall WTP within the district ranged from R1 m to R30 m. In general, respondents were reluctant to pay money to the Ndlambe municipality for the conservation of the estuarine pipefish due to issues concerning poor service delivery. For Kleinemonde respondents, WTP values exhibited a high degree of variability, which might suggest conservation efforts should focus on informing and mobilising the small, but influential, population of the Kleinemonde area.

**Are water-saving measures a viable alternative?**

Kleinemonde currently obtains most of its water from the Wellington Dam, which is located in the Kleinemonde River catchment. This water is mixed with brackish water from a groundwater source in order to boost the volume supplied, but at the cost of water quality. Nevertheless, water shortages already occur, particularly during the Christmas period when most houses are occupied. This will worsen when planned future developments materialise. One way in which Kleinemonde's water demands could be met is through the construction of another dam on the East Kleinemonde River. Another option is an off-channel storage option which has a lower impact on the river and estuary. Using a combination of key informant interviews, surveys and modelling, we considered the feasibility of increasing the reliance on rainwater harvesting in order to reduce potential impacts on rivers, and compared the cost of this option to the more conventional water supply options. Changing to larger tanks could potentially increase the proportion of water supplied from tanks, but this option necessitates water saving behaviour if the tanks are to supply most of the households' requirements. The Kasouga community has demonstrated that this is feasible with simple water saving measures. The cost of this option is similar to the off-channel storage option, both of which would cost about R4 million more than a conventional dam. Improved rainwater harvesting would minimise the environmental costs and improve household water quality. Whether investing in larger rainwater tanks will take off in Kleinemonde is an issue for debate, as it involves a financial cost of about R16 000 per household as well as behavioural adaptation. Although considerably more than what Kleinemonde residents claim to be willing to pay to ensure the survival of the estuarine pipefish in the East Kleinemonde estuary, this is a relatively small cost in the construction of a house. In order to make this option attractive to property owners, they need to be made more aware of the environmental benefits and water quality benefits that could be obtained.

Report to be cited as:

TURPIE, J.K., JOUBERT, A.R., BABIKER, H., CHAUDHRY, J., CHILD, M., HEMPSON, T., HUMPHREY, G., JOSEPH, G., LA GRANGE, R., LIPSEY, M., MANN, G., OKES, N., PUTTICK J. & WISTEBAAR, T. 2008. Integrated ecological-economic modelling as an estuarine management tool: a case study of the East Kleinemonde Estuary. Volume I. The economic value of the East Kleinemonde Estuary and impacts of changes in freshwater inputs. WRC Report No.1679/1/08

# VOLUME II
# Model construction, evaluation and user manual

## EXECUTIVE SUMMARY

### Introduction

Management decisions that affect the health and value of estuaries are currently taken based on the expert opinion of managers and scientists. A prime example is the Resource Directed Measures (RDM) process used to decide on the freshwater reserve. Specialists make predictions about the outcomes of alternative flow scenarios based on the collation of existing information and limited fieldwork. The assumptions made are not quantified or made explicit, and a different group of specialists may yield a different outcome. Modelling the interactions between different components requires quantification of the assumptions used in generating predictions, furthers our understanding of how estuaries respond to changes and highlights gaps in our understanding. Systems modelling also provides an excellent platform for integration of relevant socio-economic variables, which is important since management decisions increasingly need justification in economic terms.

The 35.7 ha East Kleinemonde Estuary provides an example of a common type of estuary in South Africa, and was particularly suitable for this study due to its being the subject of intensive research over the last decade.

This study aimed to develop an integrated ecological economics model of the estuary capable of estimating the ecological and economic implications of alternative management scenarios, and through its construction, improve the synergy among disciplines in estuary management, and highlight gaps in our current understanding and the assumptions made in predicting changes under past and future scenarios.

### Approach

This study was a collaborative effort involving the scientists that had worked on the 19-month field study of the East Kleinemonde Estuary (WRC Project K5/1581). In an initial workshop, a conceptual model of the system was constructed, and a prototype model was built in STELLA ® in order to identify data needs that could still be supplied by the above project analysis (Apr 2006). A series of modelling workshops was held (Feb-Mar 2007) in which the component sectors were built in sequence to create a rough model of the 19-month period for which most data were available, which was refined and completed after the workshops (Mar 2007 to Jan 2008). Economic data were also collected (Feb-Mar 2007). The model was then adapted to run over a longer time period (4-8 years) using modelled inflow data and calibrated against 10 years of daily mouth condition data (Jan-Mar 2008). Sectors were also added to generate outputs on estuary health scores and economic value, as well as to enable manipulation of mouth condition. The final phase involved evaluation of the model in terms of its accuracy, its potential usefulness as a management tool and its potential for adaptation for other systems. This involved presentation and feedback in a workshop session (Mar 2008) and finalisation of the model (Mar-Oct 2008).

**Conceptual model of the estuary**

The mouth condition of the estuary is affected by a combination of freshwater and marine inflows and the building up of the berm which is influenced by sediment availability and wave energy. The resulting balance between freshwater and marine inputs affects water levels, salinity, nutrient levels, water residence time, current speed and turbidity, all of which affect the productivity and community structure of the estuary. These conditions determine the balance between different types of vegetation communities in the estuary, as well as the production of phytoplankton. Food and habitat structure, coupled with the physical characteristics for which different organisms vary in their tolerance, determine the abundance and structure of the invertebrate, fish and bird communities. The nature of the relationships between different components is depicted in the conceptual model diagram.

**Data, assumptions and definition of model parameters**

The model was constructed as a series of sub-models (or sectors), each of which dealt with a different physical, biotic, economic or management aspect of the system. A daily time-step was used. This summary describes the basic structure of the model. Assumptions are described in detail in the report.

The physical dynamics sector simulates changes in water level, volume, height of the berm across the mouth, and mouth condition based on modelled daily freshwater inflow, measured daily tidal height maxima, and measured daily mean wave height. Water levels and volume were based on the bathymetry of the estuary. Sea water inflows were based on differentials between sea and estuary water levels. Evaporative losses were based on water area and average evaporation rates for the area, adjusted using relationships to salinity derived elsewhere. Based on measurements taken elsewhere, seepage across the berm was estimated to be negligible, and was omitted. Growth rate of the berm was related to wave conditions, and it was breached when water level in the estuary exceeded the height of the berm.

Salinity was modelled based on the input of salt from sea water and the loss of salt during breaching. It was assumed that the estuary was perfectly mixed.

Nutrient concentrations were represented in the model by dissolved organic nitrogen (DIN). DIN was added to the system by inflowing river and seawater, based on measures taken at the estuary, lost in outflowing water during breaching, and influenced by production or consumption by primary producers. Input rates were adjusted under natural conditions.

The microalgae sector considered the abundance of phytoplankton, epipelic microalgae (on sediments) and epilithic microalgae (on plants), based on measurements taken in the estuary and elsewhere. Stocks of these were grown in relation so concentrations of DIN and estimated carrying capacity (varying with food or habitat), and were lost during breaching and due to consumption. The latter was estimated as a varying proportion of standing stock.

The macrophytes sector determined the area (ha) of submerged macrophytes, reeds and sedges, intertidal saltmarsh and supratidal saltmarsh, as well as the area of mud- and sandbanks. This was based on current and previous maps of vegetation cover of the estuary and growth rates measured here and elsewhere. Growth of the stocks was determined on the basis of DIN and salinity as well as estimated maximum possible area, which varied with water level. Mortality (die-back) occurred in response to reduction in maximum possible area in relation to current area. In the case of submerged macrophytes, the area of the seedbank was taken into consideration because of the rapid response of the above-ground stock.

The invertebrate sector modelled the zooplankton and benthic macrofauna, based on data from recent studies on the estuary, as well as general understanding of abundance in Eastern Cape estuaries. Zooplankton was modelled as a stock which was influenced by phytoplankton concentration and carrying capacity, and which incurred losses during breaching events. The benthic macrofauna were modelled as trophic groups or subgroups that behaved in a relatively similar fashion: *Hymenosoma* crabs, *Callianassa* sandprawns, cumaceans, bivalves, peracarid crustaceans, predatory isopods, *Desdemona* polychaetes, *Prionospio* polychaetes, and predatory polychaetes. The model was based on measured densities in prolonged closed and open conditions in sand and in mud. Since there was no growth function, the abundance of these groups responds instantly to changes in habitats. In most cases, their response is expected to be fast. Nevertheless, there are interesting responses of some invertebrate species such as *Callianassa* to change in conditions which should be incorporated in future versions of the model.

Fish have received more research attention than other biotic groups at the East Kleinemonde Estuary with the result that there are detailed data on abundance, including seasonal and long-term inter-annual changes in abundance and recruitment, and the influence of breaching and timing of breaching on fish community composition. The fish sector simulated changes in the abundance of key species within two groups. Marine-spawning species included Cape stumpnose *Rhabdosargus holubi,* white steenbras *Lithognathus lithognathus,* mullet species and kob *Argyrosomus japonicas.* Estuary-spawning species included estuarine roundherring *Gilchristella aestuaria,* estuarine pipefish *Syngnathus watermeyeri,* and gobies (Gobidae).

For marine-spawning species stocks were grown as a result of recruitment (immigration) and diminished by way of losses as a consequence of mouth breaching (i.e. emigration) or natural mortality (Z) a function of either natural (N) or fishing (F) losses, accounted for by the inclusion of input parameters based on values obtained from the literature. Estimates for recruitment were based on density estimates multiplied by a concentration factor linked to a cueing response elicited by inputs of freshwater into the marine environment. For estuarine-spawning species the stock was modelled using a standard population growth equation and was based on food abundance, e.g. zooplankton stock and carrying capacity (based on measured maxima) as well as losses during breaching events.

The birds sector was based on regular counts carried out on the estuary from March 2005 to November 2006. Species were grouped into seven functional groups: resident diving piscivores (fish eagles, kingfishers), migratory diving piscivores (terns), pursuit swimming piscivores (daters, cormorants and grebes), wading piscivores (spoonbills, herons and egrets), resident waders (oystercatchers, stilts, thick-knees and resident plovers), migratory waders (greenshanks, ruff, numerous plover and sandpiper species) and herbivorous waterfowl (ducks). Birds were not modelled using a growth function. Abundance was based primarily on measures in relation to habitat area, water level and season, as applicable to each group, and adjusted in some cases by abundance in fish recruits or fish stranded during breaching.

The total economic value sector estimates the total net present value (NPV) of the ecosystem services provided by the estuary in 2007 Rands, calculated as the sum of the discounted values over the total run period of the model. This value is the sum of property sector and tourism sector turnover ascribed to the estuary, as well as nursery value and existence value. For recreational and aesthetic value, utility was calculated as a function of fish abundance, water quality, water level and vegetation. In the absence of any measurements for the estuary, water quality (from a human use perspective) was assumed to begin deteriorating if the estuary had been closed for long periods. Nursery value was calculated as the value of fish exported from the estuary. Existence value was based on the average population size of estuarine pipefish.

The Estuary Health Indicators sector produces average values over the run period of measures used in the RDM Estuary Health Score.

The Artificial Breaching sector allows the user to decide on whether artificial breaching will take place, and the rules for breaching, taking cumulative days closed, cumulative days closed in a particular season, or water level into account. The model checks whether the set thresholds are crossed, and if so, the berm is breached to the same level as during natural breaching events. Environmental cueing effects for recruitment of marine fish were set to be negligible during artificial breaching events.

**Ecological outputs and evaluation**

The level of congruence between the observed and simulated mouth condition was very good. Nearly all simulated opening events appear on or close to the actual date of occurrence, with few missed, and few unrecorded events being simulated. Simulated overwashing events also corresponded well with recorded events, and generally corresponded with periods of high waves and/or sea levels. Other physical and biotic variables for which long-term data were not available corresponded reasonably with expectations. While we are confident of the reasonable accuracy and validity of most of the model results, there is often unpredictable variation (noise) in the relationships between parameters that will reduce accuracy. These include biotic interactions such as competition and predation. The fact that the model is limited in terms of trophic balance can be considered a weakness, but is also an advantage in that errors in the lower taxa are less likely to be magnified up the trophic chain. In the case of the higher taxa, numbers were linked to the drivers about which most was understood. This meant that processes such as effects of salinity on *Callianassa* reproduction could not be incorporated. The invertebrate section was particularly weak due to a dearth in the understanding of the biology of most invertebrate groups, but it yielded reasonable results. Future research should be directed at collecting long term empirical data from the East Kleinemonde Estuary that can be used to validate or update the model.

**Economic outputs and evaluation**

The economic model suggests that utility of the estuary changes substantially within and between years, but that the effects on tourism and property value are derived from average utility over time, and vary much less. Not all factors influencing utility could be estimated directly: in the case of water quality, the period of closure was used as a proxy to provide categorical measures of water quality. Nursery value is generated in concentrated bursts associated with breaching events, and varies considerably between years. Existence value was based on a relatively weak model, and so a conservative estimate was used, and the results seemed to be in the right order of magnitude. The total net present value of the estuary over 8 years was estimated to be about R30.6 million, with a corresponding annualised value of R5.3 million per year.

**Management outputs and evaluation**

There was a fairly high degree of congruence between the health scores generated by the model for the present day and a low flow scenario, and those derived from expert opinion in the RDM study of the East Kleinemonde Estuary, once the effects of non-flow related factors were corrected for (the model assumes the same anthropogenic conditions under natural flow conditions apart from nutrients). Mouth condition, salinity and DIN were scored similarly for present state, but the model predicted a stronger effect on mouth condition and salinity under low flow conditions and predicted a further deterioration (increase) in DIN rather than the improvement predicted in the RDM study. Change in intertidal area was scored more extremely in the model which took average exposure time into account. Modelled microalgae scores were predicted to change in response to changed nutrient levels, whereas the RDM scores predicted little change. There was good congruence between modelled and RDM scores for macrophytes. Modelled scores conflicted with RDM scores for zooplankton, due to discrepancies in prediction regarding food and habitat. Discrepancies between modelled and RDM scores for fish were traced to the fact that the RDM specialists tend to concentrate on marine migrants, whereas the model took all species into account, and numbers are dominated by estuarine residents. The exercise thus highlighted differences in the way scoring was being interpreted differently by different RDM specialists.

Four scenarios were used to test the artificial breaching sector: status quo, breaching if the estuary remains closed for 250 days, breaching in November if the estuary had been closed for 90 days, and breaching when water levels exceed 1.8 m. The behaviour of the model corresponded to expectations, with mouth condition, water quality and fish being the most responsive components. The implications of the four scenarios could be compared in terms of estuary health and economic value. Results suggested that breaching improved the overall health of the estuary, and increased its economic value. This is counter to the intuition among estuarine ecologists that artificial breaching creates more problems than benefits, and further research should be carried out to resolve this issue.

**Overall potential for management of estuaries**

STELLA ® is easy to use, and the model can be run entirely from the user interface. Results are exported to EXCEL ® which is more widely available. Run time for a simulation period of up to 4 years is under a minute, but generating longer runs is more difficult due to having to export and import data before beginning the next 4 year period, involving a complex sequence of actions. Future editions of STELLA ® will handle longer data sets.

The model was primarily designed for use in RDM and the Classification process. Three main advantages of using the model in these processes are: (1) specialists engage in systems thinking and have to evaluate their assumptions regarding linkages to other components; (2) where results differ from expected, these assumptions have to be revisited; and (3) once agreement between expert opinion and model results is obtained/calibrated, additional scenarios can be examined at little additional cost.

The breaching function provides the opportunity to explore the physical, biological and economic consequences of breaching, and to experiment with different options before actually embarking on such a programme. This may help to prevent making potentially damaging breaching decisions.

The model does not currently deal with management of consumptive and non-consumptive use of estuary resources, water pollution, and development in and around the estuary. Whereas the first two issues could be added in future, it is probably not a useful tool for evaluating development options around the estuary.

The ease with which the model could be adapted to other estuaries will depend on how similar they are to the East Kleinemonde. For other temporarily closed systems, this would be a matter of updating parameters and relationships in the model with information and expert opinion on the new system, but retaining the basic structure of the model. For larger, open systems, it would probably be necessary to use the STELLA ® model in conjunction with 3-D models of water quality. It is estimated that the adaptation of the model to other systems would cost in the order of R300 000-400 000 for a similar system, up to R500 000-700 000 for an open system. The more systems that are modelled, the easier it will be to adapt to others.

**User manual**

A user manual was developed for DEMIOS 1.2 and is appended to the Volume II report.

Report to be cited as:

TURPIE, J.K., CLARK, B.M., COWLEY, P., BORNMAN, T & TERÖRDE, A., 2008. Integrated ecological-economic modelling as an estuarine management tool: a case study of the East Kleinemonde Estuary. Volume II. Model construction, evaluation and user manual. WRC Report No. 1679/2/08

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# 1 INTRODUCTION

This study forms part of a broader research programme on the ecology and economics of the East Kleinemonde estuary, and forms part of a study which will culminate in an ecological-economics model to assess the potential impacts of changing river flows and management on the estuary. The main aim of this study was to investigate the economic value of the East Kleinemonde estuary, and how this value might change with a change in estuary condition.

The East Kleinemonde estuary is one of several small closed estuaries along the Eastern Cape coast, most of which have small resort developments associated with them. The area is currently undergoing unprecedented residential property development. Indeed, at Kleinemonde, the current number of houses (about 300) is set to triple in the near future. Increasing development is placing pressure on the estuaries as well as local water resources (Settlement Planning Services 2005). These pressures are becoming a threat to the future health of estuaries (Twiley *et al*., 1998; Branch, 1999; Jackson *et al*., 2001; Turpie *et al*., 2002; WSM Leshika, 2004).

Decisions on water allocation and management issues affecting the health of estuaries need to take the economic implications of changed estuary health into account. Estuaries, like other natural resources, can be seen to provide positive amenity values for the surrounding residents. There are spatial aspects (natural areas enforce preservation of an open area by the very virtue of their presence), recreational activities (fishing, swimming, canoeing, bird-watching), ecological value (an increase in biodiversity sustained by a functioning system) and livelihood values (estuaries act as spawning grounds for certain fish species) (Johnston *et al*., 2002) that contribute to quality of life of nearby residents (Lake Ripley Management District 2005). These benefits should be used as powerful incentives to conserve nature (Balmford *et al*., 2002). However, evaluating these benefits in the past has proved difficult because they are mostly not captured by conventional, market-based economic activity and analysis (Balmford *et al*., 2002).

The above values can be classified using the total economic value framework into direct use values, indirect use values and non-use values. In the case of the East Kleinemonde estuary, the direct use value is essentially its amenity value as a recreational site and as part of a beautiful environment. The indirect use value is mainly its value as a nursery area to fish that recruit into inshore marine fisheries, such as White Steenbras *Lithognathus lithognathus*. The non-use value comprises the existence and bequest value that people gain by just knowing that the biodiversity of the estuary is intact, and that it can be enjoyed by future generations. All three of these main types of value are potentially significant. In this study we concentrate on direct use value and non-use value, since indirect use value will be addressed in the model using existing information in Lamberth & Turpie (2003).

The degradation of estuarine health may be expected to impact on all of these values, leading to a reduction in social welfare though losses of utility and reduced economic activity. In the case of nursery value, the change in this function can be estimated on the basis of ecological responses to environmental change. Estimating the change in direct use and non-use value is more challenging, since it requires estimating changes in peoples' utility as a result in the change in an estuary's attributes, and this requires specially-designed surveys.

At the East Kleinemonde, water quality and overdevelopment are key issues that threaten the amenity value of the estuary (Martens & Fabricius, 2006). The recent detection of high levels of coliform bacteria, with its potential for gastrointestinal and systemic illness in humans, suggests that current water quality does not measure up to historical data (Martens & Fabricius, 2006). Other problems are seasonal water shortages and poor municipal water quality (Martens & Fabricius, 2006). It is feared that future developments will exacerbate the current situation.

The main objectives of this study were as follows:

- To determine the direct use value of the East Kleinemonde estuary
- To derive a model which can be used to predict changes in direct use value as a result of change in estuary characteristics
- To determine the non-use value of the estuary
- To determine how willingness to pay to prevent a loss of biodiversity changes with magnitude of loss
- To determine whether alternative water saving measures would be viable and their extra costs justified.

# 2 STUDY AREA

The East Kleinemonde estuary is situated approximately 15 km north-east of Port Alfred and opens to the Indian Ocean at 33° 32' S, 27° 03' E (Cowley & Whitfield, 2001a).

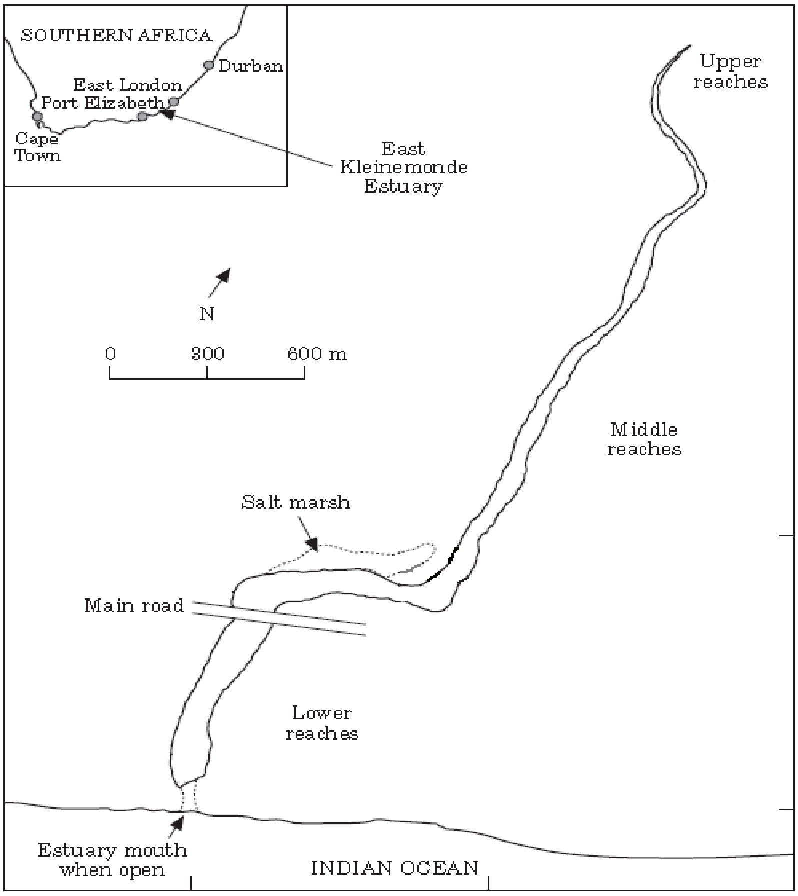



**Figure 2.1. The location and appearance of the East Kleinemonde estuary in the Eastern Cape, South Africa (adapted from Cowley & Whitfield, 2002).**

The estuary lies at the base of a small catchment of about 46 $km^2$, with a relatively small mean annual runoff of about 2 $Mm^3$ (Badenhorst, 1988). Classified as a temporary open/closed estuary (Whitfield, 1992), the estuary is closed for most of the time by a sand berm across the mouth, and is linked with the sea when the sand bar is breached and the mouth opens, which usually takes place after periods of high rainfall (Van Niekerk, 2006). The East Kleinemonde estuary is relatively small with a surface area of approximately 34 ha. It is mostly shallow, with the main channel depth ranging from 1 to 2 m. It is navigable for approximately 3 km and the widest portion (in the lower reaches) is 120 m (Bell *et al.*, 2001). During periods of extended mouth closure, the estuary water level can exceed that of mean sea level by 2 m due to extensive sand build up at the mouth. After a mouth opening event the estuary becomes shallow, with a maximum channel depth of approximately 1 m (Cowley & Whitfield, 2001a,b). Salinity varies from 0 to 25% depending on rainfall (Cowley & Whitfield, 2001a,b). Harrison *et al*. (1996) described the water quality of the estuary as good, although with slightly elevated *E. coli* levels. Although there is currently no evidence of pollution, attention has been drawn to the potential threat of microbial contamination of the estuary from septic tank overflow (Cowley & Whitfield, 2001b).

The settlement of Kleinemonde is a bourgeoning coastal community located between and around the West and East Kleinemonde Rivers (Figure 1), though most development is around the East River. There are currently 656 erven registered in Kleinemonde of which 300 are developed and of which 200 are permanently occupied (Martens & Fabricius, 2006).

# 3 DIRECT USE VALUE OF THE EAST KLEINEMONDE ESTUARY

## 3.1 INTRODUCTION

The direct use value of an estuary is reflected in two main ways. Visitors to the estuary spend money on visiting, at least partially reflecting their willingness to pay to spend time there. Others prefer to live at the estuary, expressing their willingness to pay in terms of their investment in property. In both cases, these payments reflect the value of the area as a whole. The estuary is just one of a package of attractions that draws people to visit or live in the area, and isolating this value presents a challenge. Another measure that is sometimes useful is the impact on the local economy. In this case we refer to the expenditure by visitors to the area that contributes to business incomes in the local area. Part of this expenditure is also attributable to the presence of the estuary as an attraction.

In the case of property values, the value that the estuary contributes to overall property value is not tradeable on the open market *per se*, and has to be estimated using a non-market valuation method. The method most commonly used in this context is the hedonic pricing method (Freeman, 1993), although expert opinion from estate agents may also be used (Van Zyl & Leiman, 2002). Residential properties are in essence composite goods, comprised of differing proportions of a broad host of characteristics. The market value of a property, as reflected in the price, demonstrates the worth of this cluster of characteristics. A comparison of price change with changes of certain characteristics (such as estuarine proximity), while holding all other characteristics constant, affords the opportunity to estimate the marginal value of a given characteristic (Mahan *et al*., 2000). Existing literature using the hedonic method to estimate added property value as a consequence of nearby water resources, suggests that frontage and proximity generally add to property value (Lansford & Jones, 1995).

In the case of value held by visitors, it is more difficult to isolate the contribution of a particular attraction of the overall area. One approach is to investigate the extent to which different attributes of the area contribute to visitor enjoyment, using questionnaire surveys.

This study aimed to determine:

1. the direct use value that permanent residents, holiday home owners and visitors place on East Kleinemonde;
2. impact on the local economy;
3. the proportion of these values that can be ascribed to the East Kleinemonde estuary.

## 3.2 METHODS

### 3.2.1 Overall approach

The use value was estimated in terms of users' expenditure on property and other costs involved in using the area. The economic impact on the local economy is also briefly described. The proportion of these values ascribed to the estuary was estimated in two ways: (1) hedonic pricing method and (2) stated contribution to enjoyment of the area.

A door-to-door questionnaire survey of households residing in Kleinemonde was carried out during the Easter holiday period 2007. The study included permanent residents, holiday home owners and visitors. All interviews were conducted face-to-face. A total of 137 households were surveyed. Many houses were unoccupied for the duration of the study, which limited sample size.

### 3.2.2 Property value of Kleinemonde

Homeowners were asked to estimate the current value of their properties. These values were extrapolated to the developed erven to estimate overall value.

### 3.2.3 Use value and economic impact of Kleinemonde

Use value was taken to be the willingness to pay to use the area. For property owners, this includes the investment in property. Annual expenditure on property was estimated using the estimated cost of capital, based on reported property values. For visitors it includes the expenditure on accommodation. For holiday home owners and visitors it also includes the cost of travel.

The local economic impact was expressed as the estimated total expenditure on goods and services (accommodation, activities, restaurants, goods) in the Ndlambe municipality by holiday home owners and visitors, as well as turnover in the real estate sector.

### 3.2.4 Isolating the value of the estuary - hedonic analysis and user survey

#### *3.2.4.1 Hedonic pricing analysis*

Homeowners were asked to provide information about their properties. This information included the number of bedrooms and bathrooms in the house, age of the house, whether the house had views of the sea or the estuary, in addition to the current market value of their property.

Distance to the sea and estuary were estimated in three ways:

1. Homeowners were also asked to estimate how long it took them to walk to the sea and the estuary. This information was used as a proxy for distance.

2. The location of the property was recorded on a local erf map. More detailed information on distances to these environmental amenities was gathered using local erf maps. The distance from all surveyed properties to the sea or East Kleinemonde estuary was measured on the map. Distances were measured along roads and paths to estimate the amount of effort it would take homeowners to get to both the sea and the estuary.
3. A third measure of distance was taken by counting the number of rows that all properties were away from the sea and the estuary. These were recorded separately for each property. A property that bordered the estuary was said to be in row one. Properties were measured up to five rows from each amenity. All properties that were more than five rows away were grouped together as six or more rows.

Hedonic analysis of property data was carried out using a generalized linear model. Generalized linear models are used to identify significant variables and factors that determine a response variable. Goodman & Thibodeau (2003) found this method to be useful in conducting hedonic analysis. Property value was the response variable. The number of bedrooms, number of bathrooms, age of the house, time taken to walk to the beach and the estuary, distance from the sea, distance from the estuary, number of rows from the sea and number of rows from the estuary were used as continuous variables. View of the sea, view of the estuary, sea frontage and estuary frontage were also considered as categorical variables. A maximal model was derived using all variables, and then this was refined depending on significance and inter-correlation of the above variables. These analyses were done using the GenStat statistical package. Other descriptive statistics were generated using Microsoft Excel.

#### *3.2.4.2 User estimates*

Respondents were asked what activities contributed to their enjoyment of the study area by assigning a percentage according to the amount of enjoyment gained from each. These activities included: fishing in the estuary; shore angling; birding; nature walks/horse riding; swimming in the estuary; swimming in the sea; relaxing at the house; water sports; beach walks; and other. It was then possible to assign an overall percentage of enjoyment to the estuary by drawing from those activities which rely on the estuary. We used this percentage to determine the proportion of the overall value of the study area which could be ascribed to the estuary. This was done separately for permanent residents and holiday home owners.

## 3.3 RESULTS

### 3.3.1 Respondent characteristics

A total of 132 useable responses were obtained in the household survey. Of these, 79 were permanent residents, 46 were holiday home owners and 7 were visitors (Table 3.1). Due to small number of visitors in the sample, their costs and general statistics were described but they were excluded from subsequent analyses. The majority of the holiday home owners came from the Eastern Cape (62%), 21% from Gauteng, 10% from the Western Cape and North-West Province, and 4% from the Free State and KwaZulu-Natal.

**Table 3.1. Summary of samples, household/group costs and expenditure.**

| | Residents | Holiday home owners | Visitors |
|---|---|---|---|
| Number of households/groups surveyed | 79 | 46 | 7 |
| Percentage of sample | 60 | 35 | 5 |
| Percentage of estimated permanent / holiday homes | 40 | 53 | |
| Average household/group size | 2.4 | 4.4 | 5.6 |
| Average no. visits in past 12 months | n/a | 10.2 | 2.6 |
| Average time spent in past 12 months (days) | n/a | 47 | 16 |
| Length of Easter visit (days) | n/a | 10.5 | 7.4 |
| Average cost of travel per trip | n/a | R1 460 | R1 569 |
| Average expenditure on accommodation per day | n/a | n/a | R571 |
| Average expenditure on recreation per day | n/a | 46 | 87 |
| Average expenditure on shops/ restaurants per day | n/a | 185 | 212 |

### 3.3.2 Property value

Information on properties was obtained from a total of 93 households. The houses surveyed had an average of 3.4 (± 0.9 S.D.) bedrooms and 2.4 (± 0.9 S.D.) bathrooms. 23% had sea frontage and a further 38% had a sea view. 28% had river frontage and a further 23% had a river view. 10% of those with river frontage also had a sea view.

Properties ranged from 1 to 100 years old, with an average age of about 15 years. Estimated current values of properties from R0.5 to R5 million (n = 84), with an average value of R1.5 m (± 0.84 S.D.). Based on the average value of properties, the total value of properties in the Kleinemonde area was estimated to be in the region of R450 million.

### 3.3.3 Total recreational use value

A minimum estimate of the total value of the Kleinemonde area to property owners was taken as their total investment in property. This equates to an average total annual cost of capital of some R35 000 per property or a total annual value of R10.5 million per year. This value represents property owners' annual willingness to pay to have property at Kleinemonde.

In addition to the investment in property, holiday home owners incur annual travel costs in visiting the area of some R15 000 per year. Holiday home owners also spend an average of R10 750 per year on activities, restaurants and shops.

Visitor groups spend an average of R17 500 per year on travel, accommodation, activities, restaurants and food (note this is a rough estimate based on a sample of only 5 groups). However, the number of visitor groups is unknown.

In total it is estimated that the use value of the Kleinemonde area, or total willingness to pay to use the area, is at least R13.3 million per annum (Table 3.2). The numbers of visitors may be underestimated and requires further research.

**Table 3.2. Rough minimum estimates of the total annual investment on spending time at the estuary by residents, holiday home owners and visitor groups. Note that the number of visitor groups is unknown and is estimated to be at least as high as the number of holiday homes.**

| | Residents | Holiday home owners | Visitor groups |
|---|---|---|---|
| Estimated no. households/groups | 200 | 100 | 100 |
| Total value of property | R300 m | R150 m | - |
| Annualised property value | R7 m | R3.5 m | - |
| Annual travel & accomm expenditure | | R1.5 m | R1.3 m |
| **Total annual use value** | **R7 m** | **R5 m** | **R1.3 m** |

### 3.3.4 Impact on the local economy

Investment in and use of the Kleinemonde area impacts on the local economy by generating turnover and value added in the real estate and trade sectors. Estimating turnover in the real estate sector requires an understanding of the average rate of turnover and the percentage cut taken by estate agents. While these data were not collected in this study, using the same ratio as in Turpie (2006), it could be estimated that property investment in Kleinemonde generates about R14 million per annum as turnover in this sector.

Expenditure by holiday home owners and other visitors on visiting the Kleinemonde area also results in turnover in the local economy. Based on the results obtained above, it is estimated that this expenditure amounts to at least R7 million per annum (Table 3.3). This excludes expenditure on fuel and other travel cost, part of which would be incurred in the local area. Thus Kleinemonde makes a small contribution to the economy of the local towns such as Port Alfred as well as in the immediate area of Kleinemonde.

**Table 3.3. Estimated total annual expenditure in the local area by non-resident users**

| | Holiday home owners | Visitor groups | Total |
|---|---|---|---|
| Estimated no. households/groups | 100 | 100 | |
| Accommodation | 0 | R889 000 | R889 000 |
| Recreational activities | R216 000 | R135 000 | R351 000 |
| Restaurants and retail | R859 000 | R329 000 | R1 189 000 |
| **Total economic impact** | **R1 075 000** | **R1 353 000** | **R2 428 000** |

### 3.3.5 Contribution of estuary to property value - Hedonic valuation

Data were analysed by means of generalized linear modelling to produce a maximal model (Table 3.4). Factors were estimated against the base value, which was that a property lacked that particular factor. The maximal model accounted for 39.3% of total variance (standard error = 657 899, F <0.001). Variables that were insignificant or correlated with other variables were removed to produce a minimal model (Table 3.5). The minimal model only contained those parameters found to have a significant impact on property value by the model. Of the insignificant variables, house age had the strongest effect, but it was not strong enough to give a significant result. The minimal model accounted for 36.5% of variance (standard error = 671 922, F <0.001).

The generalized linear model showed that the number of bedrooms in a house had a highly significant effect on property value. Properties lost value for every row of houses separating them from the sea. A property was also worth significantly more if it had river frontage. The results of this analysis can be summarised in the following equation:

*Property value (in 2007 rands) = R1 370 825 + R277 001(number of bedrooms) + R459 086(river frontage) – R176 061(rows from the sea)*

**Table 3.4. Maximal model containing all variables used to determine property value**

| | Estimated value | Standard error | T statistic | Probability |
|---|---|---|---|---|
| Constant | 2 258 740 | 562 820 | 4.01 | <.001 |
| Age of house | -15 560 | 9 082 | -1.71 | 0.091 |
| Number bathrooms | -105 430 | 143 429 | -0.74 | 0.465 |
| Number bedrooms | 348 066 | 141 051 | 2.47 | 0.016 |
| Distance to sea | -14 987 | 15 135 | -0.99 | 0.326 |
| Distance to estuary | -20 643 | 26 357 | -0.78 | 0.436 |
| Minutes to beach | 9 560 | 19 581 | 0.49 | 0.627 |
| Minutes to river | -32 421 | 29 516 | -1.10 | 0.276 |
| River frontage (Y) | 219 001 | 227 418 | 0.96 | 0.339 |
| Sea frontage (Y) | -491 641 | 403 919 | -1.22 | 0.228 |
| River view (Y) | -101 912 | 178 725 | -0.57 | 0.570 |
| Sea view (Y) | -150 929 | 167 949 | -0.90 | 0.372 |
| Rows from river | 28 442 | 75 404 | 0.38 | 0.707 |
| Rows from sea | -176 564 | 63 899 | -2.76 | 0.007 |

**Table 3.5. Minimal model containing variables and factors that had a significant effect on property value.**

| | Estimated value | Standard error | T statistic | Probability |
|---|---|---|---|---|
| Constant | 1 370 825 | 466 555 | 2.94 | 0.004 |
| Number bedrooms | 277 001 | 83 360 | 3.32 | 0.001 |
| River frontage (Y) | 459 086 | 183 924 | 2.50 | 0.015 |
| Rows from sea | -176 061 | 56 752 | -3.10 | 0.003 |

A total of 50 erfs along the East Kleinemonde estuary have river frontage. The estuary thus adds at least R23 million to the total value of property in Kleinemonde, if one considers the value of river frontage to these properties alone. This is only 3% of the estimated total value of properties. Note that this is a minimum estimate of the value contribution by the estuary, as it only considers the premium relative to the price without frontage. However the latter price also contains an element of value that can be attributed to the proximity of the estuary. This value is not reflected in the hedonic analysis because all properties are close to the estuary.

For small settlements around estuaries, Turpie & Clark (2007) based their estimates of the estuary premium on the average house price compared with an estimated base price of similar quality houses along the coast but not near an estuary. Using this approach, and an assumed base price of R1 million, the total premium associated with proximity to the estuary would be approximately R110 million. To this can be added the R23 million estimated above. Thus we estimate that the estuary contributes approximately R133 million to the value of property in Kleinemonde, of 30% of the overall value.

### 3.3.6 Contribution of estuary to use value (user survey)

Residents indicated that 21% of their enjoyment of the area could be attributed to the East Kleinemonde estuary, which they use for swimming (8%), fishing (7%) and water sports (5%; Figure 3.1). For holiday home owners and visitors, the estuary contributed to 32% of the value of the area. This value lay in the use of the estuary for swimming (16%), fishing (9%) and water sports (7%; Figure 3.2). Thus the use value of the estuary was estimated to be at least R1.4 m for residents and R2.0 m for other users, with a total use value of R3.4 m per annum.

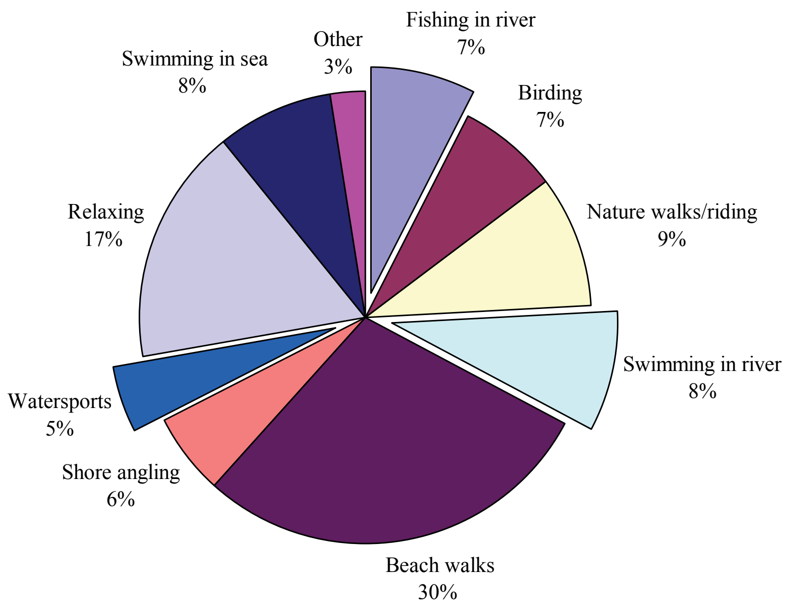



**Figure 3.1. Recreational activities of permanent residents.**

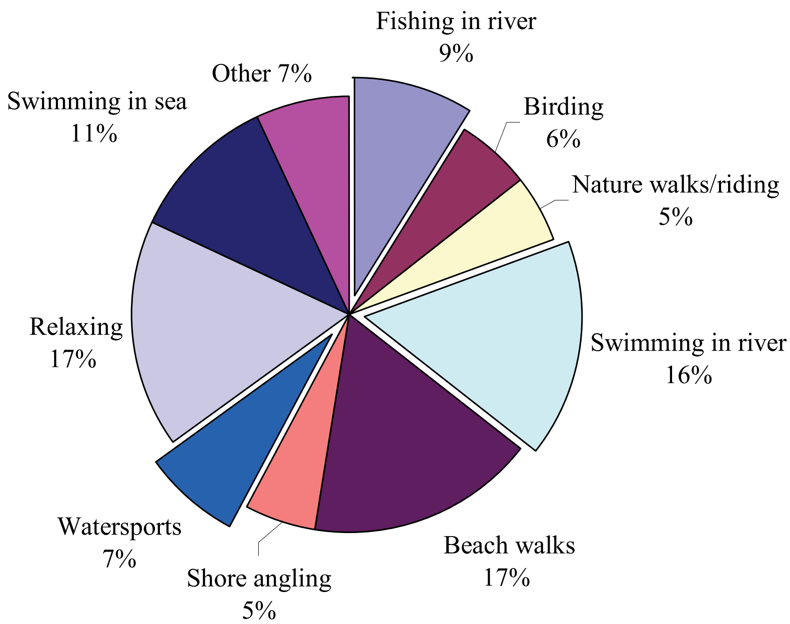



**Figure 3.2. Recreational activities of holiday home owners and visitors.**

## 3.4 DISCUSSION

### 3.4.1 The use value of Kleinemonde

Value is expressed in several ways, including willingness to pay, or contribution to the turnover or value added in the economy. In this study we produce estimates of willingness to pay and turnover, but both are rough estimates, aiming to produce accuracy at the order-of-magnitude level only. Willingness to pay estimates are based on actual expenditure and do not include consumers' surplus, which is the amount that people were willing to pay over and above their actual expenditure. This can be estimated using methods such as the travel cost method, but there were insufficient data on visitors to carry out a travel cost analysis in this study. Moreover, estimates of consumer surplus based on the travel cost method are fraught with difficulty and inaccuracy.

This study provides a rough estimate of the value of the Kleinemonde area to users, inclusive of property owners and overnighting visitors, but not day visitors. There was insufficient data available on property values based on recent sales, but obtaining property value estimates from owners is a common form of obtaining these data, as owners are expected to have a good idea of the current value of their property. In converting property value to an annual value, we used the opportunity cost of capital, based on current interest rates, which provides a rough annualised estimate of willingness to pay. Estimation of the number of developed properties varied, and thus the extrapolated values may be fairly rough, but likely to be in the right order of magnitude.

Estimation of the contribution made by non-property owning visitors was difficult because of a lack of information on the numbers of visitors to Kleinemonde. We made a conservative estimate that the number of visitor groups at least equals the number of properties. In reality, this number is probably higher, and thus our estimates of value are underestimated.

The recreational use value of Kleinemonde was estimated to be at least R13.3 million per annum. It was estimated that users of the Kleinemonde area contribute at least R7 million annually to turnover in the local economy.

### 3.4.2 Hedonic assessment of the estuary's contribution to property value

The analysis considered the effect of a number of variables and factors pertaining to property value. Results showed that of these, three were significant. In addition to the size of the property (number of bedrooms), property value is inversely related to the number of rows from the sea, and whether it has river frontage. Distance from the estuary did not have a significant impact on value. However it should be noted that all properties are in close proximity to the estuary (< 1 km). It would appear that beneath a certain threshold distance, good accessibility ensures little fluctuation in realty value. It is also possible that the relatively high value of proximity to the sea might eclipse the relative effect of estuarine proximity (measured as rows from river) on property value.

It is important to note that the total premium of R23 million obtained for river-frontage represents a minimum estimate of that part of the property value which is attributed to the estuary. Indeed this is only some 5% of overall property value (considering developed properties only). The point about all properties being in close proximity to the estuary is important in that there are no examples of a base price of a property in the area which neither has views of, nor access to, the estuary. Therefore analysis of the Kleinemonde property data alone must underestimate the value associated with the estuary. Thus it was necessary to use a hypothetical base price of similar quality properties near the coast but without access to an estuary. This plus the frontage premium yields a total value of R133 million, closer to 30% of the total property value, and perhaps better aligned with a gut feel estimate of the estuary's contribution. It is interesting to note that this is similar to the estimated percentage contribution of the estuary to people's enjoyment of the area. This is a rougher calculation but likely to be a better reflection of the value of the estuary.

It is important to note that these estimates of property value exclude the value of existing undeveloped plots and planned erven, which may eventually triple this value.

### 3.4.3 Isolating the value of the estuary based on the user survey

East Kleinemonde has a number of attractions that draw people to the area. The five main environmental components that attract visitors and holiday home owners are the beach, the estuary, the bush, the village itself and golf. Some people may be attracted to the area because of the peace and tranquillity, while others go to the area specifically to fish in the estuary. We used a direct measure of people's use of the river to approximate how much the estuary contributed to the total value of people's experience in East Kleinemonde.

Holiday home owners and visitors place a greater value on the estuary than residents (32% *vs*. 21% of enjoyment of the area). Holiday home owners were attracted to the area for numerous reasons, with swimming in the estuary being the most highly valued activity. Since the value of the estuary to holiday home owners lies largely in the use of the river for swimming, the overall economic value of the estuary might be expected to decrease should the water quality decline with future developments.

Based on the proportion of enjoyment that respondents obtained from the estuary, it was estimated that the total use value of the estuary to users was at least R3.4 m per annum. Turnover attributed to the estuary is at least R1.75 m per annum. This is a relatively small proportion of the use value of the area, largely because of the high value associated with the surrounding unspoilt beaches.

# 4 IMPACT OF CHANGING ESTUARY HEALTH ON DIRECT USE VALUE

## 4.1 INTRODUCTION

Of particular relevance in this study is understanding how the value of the estuary might be affected by a change in estuary quality. Indeed, it has been shown elsewhere that water quality affects property prices (Mahan *et al*., 2000), so it would follow that a change in estuary health may have an effect on values. While it is difficult to predict changes in property value (except by expert opinion) under hypothetical changes in environmental conditions, it is possible to estimate changes in utility or satisfaction, based on people's stated preferences. This can be achieved through stated preference methods such as contingent valuation (Mitchell & Carson, 1989) and conjoint valuation methods (Green & Rao, 1971). The latter method allows the construction of a model that allows the estimation of changes in value under multiple scenarios.

Conjoint valuation methods, or choice methods, were developed in the field of marketing, and seek to ascertain the way in which different components of a 'package' of goods, or in this case, the different attributes of a wetland, contribute to its overall value, and the way in which this overall value changes when certain attributes change.. This approach has now been widely applied to the valuation of environmental resources (Stevens *et al.,* 2000; Turpie & Joubert, 2001; Johnston *et al.,* 2002; Carlsson *et al,.* 2003; Hanley *et al.,* 2006; Birol *et al.,* 2006).

Building on the previous chapter, this study aimed to determine the way in which changes in the East Kleinemonde estuary's quality would affect its direct use value.

## 4.2 METHODS

### 4.2.1 Overall approach

The potential impacts on this value of a change in the quality of the East Kleinemonde estuary were modelled using the conjoint valuation method, based on respondents' ratings of different scenarios.

Information was collected in the survey of Kleinemonde households described in the previous chapter. This section of the questionnaire is described in more detail below.

Information was also gathered from five estate agents in Kleinemonde and Port Alfred.

### 4.2.2 The impact of changing estuary quality on value

To understand how the value of the estuary might change with different allocations of water, we determined how four different attributes of the estuary (namely, water level, water quality, numbers of angling fish and estuarine vegetation) contribute to its value. In addition, to determine the impact holiday home owners and visitors had on the local economy, the total annual expenditure was calculated, as well as the potential loss of expenditure with any change to the estuary worse than present.

The impact of estuary quality on the estuary value was determined using the conjoint valuation method (e.g. Hanley *et al*., 1998; Farber & Griner, 2000; Stevens *et al*., 2000; Turpie & Joubert, 2001). This method was used to ascertain the relative value of different components (attributes) of the estuary. Respondents were asked to score a range of scenarios which differed in the state of their attributes. Scores ranged from 0 to 10, with 0 indicating a scenario yielding no satisfaction, and 10 a scenario providing the most satisfaction. For this study, a multi-factor evaluation approach was taken, where respondents were presented with a combination of all attributes at one time. Four attributes of the estuary were selected, namely: water level, water quality, angling fish and estuarine vegetation. Three levels were defined for each attribute except estuarine vegetation which had two levels (Table 4.1).

**Table 4.1. Summary of estuary attributes and attribute levels**

| | **Water level (WL)** | | **Water quality (WQ)** | | **Angling fish (F)** | | **Estuary vegetation (V)** |
|---|---|---|---|---|---|---|---|
| WL1 | Full less of the time (Mouth open more than twice a year ) | WQ1 | Clean | F1 | Twice as many fish | V1 | More salt marsh |
| WL2 | Fluctuating levels (Mouth open twice a year) | WQ2 | Some *E.coli* and pollution (present state) | F2 | Current stocks | V2 | More water weed |
| WL3 | Full more of the time (Mouth permanently closed) | WQ3 | Twice current *E. coli* and pollutant levels | F3 | Half as many fish | | |

A total of 56 possible scenarios could be derived from the attributes and levels used in this study. One of these scenarios reflected the current situation in the estuary. All other possible scenarios were randomly generated using MicroSoft Excel's random number generator, and nine of these scenarios were included in the questionnaires. The nine scenarios represented all estuary attribute levels. One of these was the worst case scenario (all attributes most ecologically undesirable) and one was the best case scenario (all attributes most ecologically desirable), and the remaining seven were intermediate combinations (better and worse than the current situation).

The nine scenarios were distributed among three questionnaire versions, each questionnaire version also including the current scenario. Each respondent therefore rated four scenarios (three hypothetical scenarios relative to the current scenario). The worst case and best case scenarios were each only included in one of the three questionnaire versions.

The relationship between the different levels of the attributes and respondent scores was examined using a generalized linear version of multiple regression (e.g. Turpie & Joubert, 2001) using GENSTAT 8.1. The four attributes (water levels, water quality, angling fish and estuarine vegetation) were entered as terms to be fitted to the response variable which was the score (Z) given to the scenario, as follows:

$$\textit{Utility index } (Z) = \textit{constant } (K) + {}_{1}WL + {}_{2}WQ + {}_{3}F + {}_{4}EV$$

where WL is water level, WQ is water quality, F is angling fish abundance, and EV is estuarine vegetation state.

Permanent residents were asked to indicate whether they thought that their worst case scenario would affect the value of their property. If so, they were requested to indicate a percentage of how much their property value would decrease if their worst rated scenario were to occur. Similarly, holiday home owners were requested to indicate a percentage of how much less time they would spend at East Kleinemonde if their worst rated scenario were to occur. It was then possible to calculate a mean percentage decrease in property value or time spent at East Kleinemonde for each scenario.

Utility scores were then regressed against mean percentage decrease in property value (for permanent residents) and time spent (for holiday home owners). The functions from these two regressions enabled the prediction of the percentage decrease in property value and time spent according to any utility scores. Percentage loss in property value or time spent could then be converted to monetary values using the proportional values calculated for the estuary (as described in the previous section).

### 4.2.3 Translating change in utility to change in value

Respondents were asked whether they would spend less time at East Kleinemonde if the estuary was in a state as described by their lowest rating for the conjoint analysis. The economic activities of respondents, who said that a decline in estuary condition would diminish their time spent at the estuary, were analysed. An average loss in expenditure was calculated and extrapolated over the population, to get a percentage loss to the local economy.

### 4.2.4 Estate agent interviews

Estate agents were asked to supply information on any future plans for development in and around East Kleinemonde. They were also asked whether these future developments would have any impact on property values in the area, and if they felt there were any limits to future development in Kleinemonde. Finally, they were asked if they felt that a decline in water quality and fish abundance in the East Kleinemonde River would have any impact on demand for property in the area.

## 4.3 RESULTS

### 4.3.1 Determining the impact of estuary quality on the estuary value

The mean scores recorded for the ten scenarios included in the questionnaires ranged from 1.5 for the lowest-scoring scenario (V2S3) as identified by respondents, to 6.9 for the highest-scoring scenario, which corresponded with the present estuary state (Table 4.2). The most ecologically desirable scenario (V3S1) scored a slightly lower utility value (6.2) than the current state (6.9), despite representing an improvement in estuary health. This suggests there is a general resistance to change.

The utility score (Z) was predicted by the following generalized linear model ($R^2$ = 0.40) on the basis of the four estuary attribute levels (see Table 4.2 for attribute codes):

$$Z = 1.727 + [-0.550(\text{if } WL1) \text{ or } -0.249(\text{if } WL2)] + [3.129(\text{if } WQ1) \text{ or } 2.035(\text{if } WQ2)] + [1.452(\text{if } F1) \text{ or } 3.009(\text{if } F2)] + 0.412(\text{if } V1)$$

The utility scores predicted by the model closely approximated the mean scenario scores obtained from respondents ($R^2$ = 0.999, $P < 0.001$, Figure 4.1).

There was a significant relationship between utility scores for the different scenarios and the perceived potential percentage decrease in property value (permanent residents) or time spent in East Kleinemonde (other users) as follows (Figure 4.2)

Permanent residents:
*% Decrease in property value = -3.5873*Z + 25.909* ($R^2$ = 0.80)

Holiday home owners:
*% Decrease in time spent = -7.8087*Z + 49.529* ($R^2$ = 0.91)

Using these regression equations the expected decrease in value could be calculated for the utility score of any given scenario. For example, the most ecologically undesirable scenario (V2S1) from this survey scored a utility value of

1.8, which equates to a decrease of 15% in permanent residents' property values or R1.1 m per annum. Similarly, this scenario would result in a 39% decrease in the amount of time spent in East Kleinemonde by holiday home owners, or a potential decrease in value of R7.3 m per annum. There would also be some impact on the local economy. For example, in the worst case scenario, expenditure by visiting users on goods and services in the local area could be expected to drop by 39%, or some R2.8 million per year.

**Table 4.2. Description of all scenarios used in the survey, together with the mean scores obtained in the survey. Individual scenarios are coded according to the questionnaire version (e.g. V1) and scenario number (e.g. S2).**

| Scenario code | Water level (WL) | Water quality (WQ) | Angling fish (F) | Estuary vegetation (V) | Mean score |
|---|---|---|---|---|---|
| Present | Mouth open twice a year (present state) | Some *E.coli* and pollution (present state) | Current stocks | More salt marsh | 6.9 |
| V2S2 | Mouth permanently closed (full more of the time) | Clean | Twice as many fish | More water weed | 6.3 |
| V3S1 | Mouth open more than twice a year (fluctuating water levels) | Clean | Twice as many fish | More salt marsh | 6.2 |
| V3S3 | Mouth permanently closed (full more of the time) | Some *E.coli* and pollution (present state) | Half as many fish | More salt marsh | 5.6 |
| V1S2 | Mouth permanently closed (full more of the time) | Clean | Half as many fish | More salt marsh | 5.3 |
| V1S1 | Mouth permanently closed (full more of the time) | Twice current *E. coli* and pollutant levels | Twice as many fish | More water weed | 3.2 |
| V1S3 | Mouth open more than twice a year (fluctuating water levels) | Some *E.coli* and pollution (present state) | Half as many fish | More water weed | 3.2 |
| V3S2 | Mouth open twice a year (present state) | Twice current *E.coli* and pollutant levels | Twice as many fish | More water weed | 2.9 |
| V2S1 | Mouth permanently closed (full more of the time) | Twice current *E.coli* and pollutant levels | Half as many fish | More water weed | 1.8 |
| V2S3 | Mouth open more than twice a year (fluctuating water levels) | Twice current *E.coli* and pollutant levels | Half as many fish | More salt marsh | 1.6 |

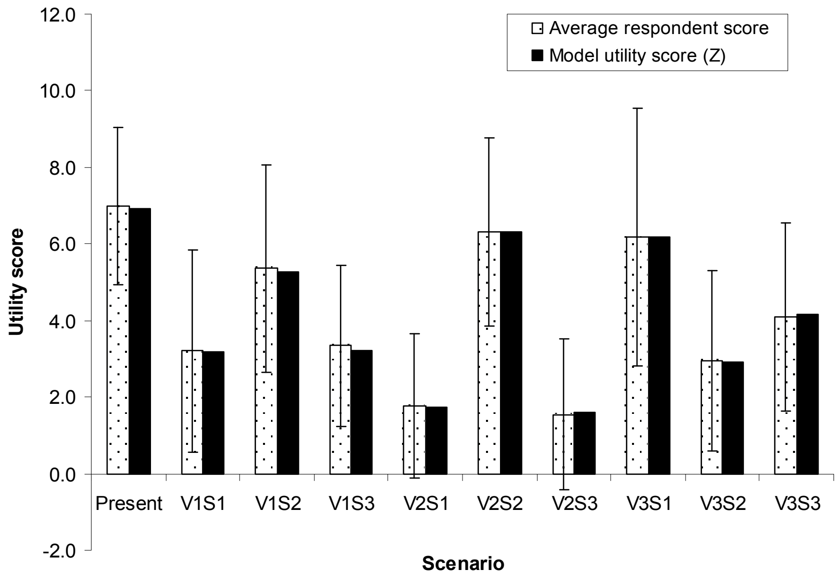
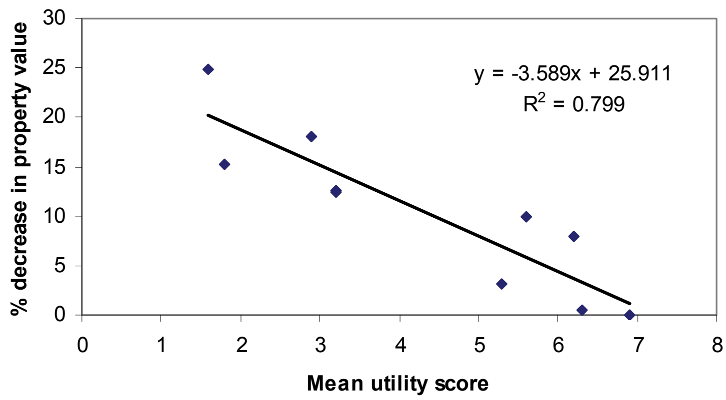



**Figure 4.1. Comparison of mean actual respondent scores (+ standard deviation) with utility scores predicted by the model for all scenarios used in the questionnaires.**



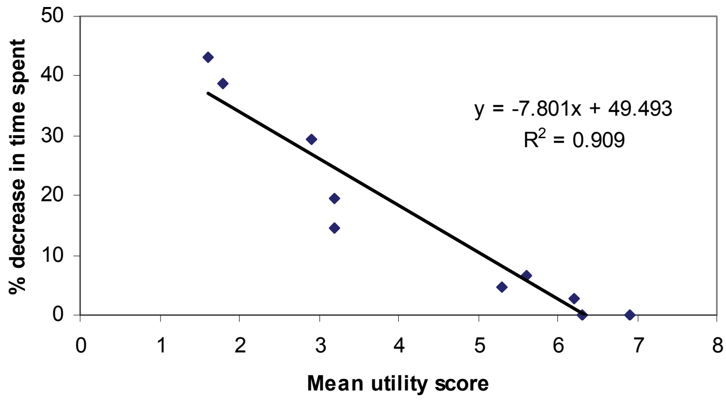




**Figure 4.2. Relationship between utility scores and (a) percentage decrease in property value (as perceived by residents) and (b) percentage decrease in time spent in Kleinemonde by holiday home owners**

### 4.3.2 Owner perceptions of the impact on property value

Of the 76 homeowners who responded to the question, 24% felt that the worst case scenario would have no impact on the value of their property, while 76% felt that their property would lose value if the condition of the river deteriorated. The response was not affected by location in terms of number of rows from the river (Figure 4.3). The mean estimated loss of property value was 24% (n=76). Estimates of property value loss were highest on riverside plots and tended to decrease in rows further back from the river. However, this trend was poorly defined (Figure 4.4).

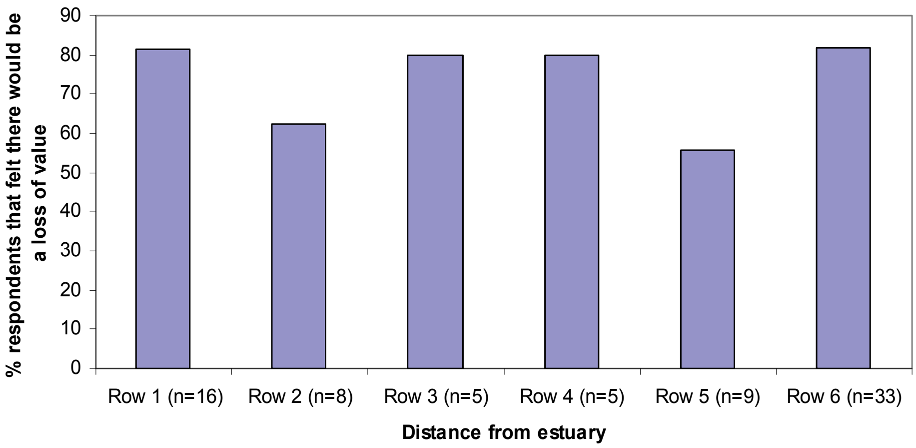



**Figure 4.3. The percentage of homeowners in each row who felt that a deterioration of the East Kleinemonde Estuary would cause their property to lose value.**

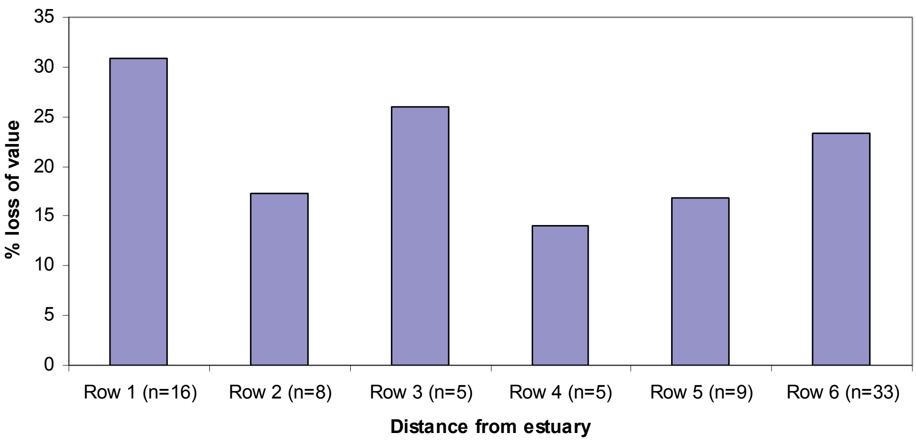



**Figure 4.4. The mean estimated loss of property value per row.**

## 4.4 DISCUSSSION

### 4.4.1 Estimating the changes in utility

The conjoint analysis identified improved water quality as the strongest factor affecting the utility score of a given scenario. This is an important finding for developers and decision makers to bear in mind, as it emphasizes the potential decrease in users' perceived value of the area should such a change occur.

Values predicted by the conjoint model closely approximated the actual results obtained from respondents. In conjunction with the regression equations obtained, it thus provides a potentially useful tool with which to calculate the potential change in the perceived value of the estuary in the East Kleinemonde area, an approach which was successfully used to value a watershed in the U.S.A. (Farber & Griner, 2000). This could then be used to inform decisions on the impacts of potential water abstraction schemes or hydrological management plans.

The importance of investigating the potential impacts of any changes in the estuary's attributes is highlighted by the fact that in general, few respondents scored any scenarios higher than the present state. This clearly indicates that, while people in the area would prefer cleaner water, they are resistant to any change in the estuary's current condition.

Holiday home owners and visitors placed a higher proportional value on the estuary than residents, and were also more sensitive to changes in estuary condition. The perceived value of the estuary by holiday home owners is therefore of great importance to the economic value of the estuary. This group is also important due to the contribution they make to the local economy of the Ndlambe Municipality via their expenditure.

### 4.4.2 Will property values change? Perceptions of owners and realtors

While it stands to reason that reduction in the utility provided by the estuary might be reflected in a change in demand for property, this is by no means a certainty, since the area may simply begin to attract people for whom the estuary is relatively unimportant. Nevertheless, property owners did indicate that they wary of changes to the estuary from a property value perspective. Degradation to the estuary (through a drop in water level, increased pollution of the water, and / or a decrease in fish populations) was perceived by property owners as a potential causative agent for property devaluation.

This perception was also held by local realtors. All of the five estate agencies interviewed were of the opinion that decreased estuarine water quality and a decrease in fish abundance would result in a lowering of property demand.

Regarding the scope for future developments (with its potential for estuarine degradation and possible 'worst case scenario' effect), it is noteworthy that only one agency believed further development in the area would have a positive impact on East Kleinemonde. All five realtors mentioned water as a limiting factor to new development, three noted inadequate sewerage disposal as an additional issue, while two included lack of infrastructure (roads, traffic control measures).

All noted that developments in the area had to date led to an increase in property values. Yet four of the five realtors felt that further developments are actually contributing to the current market slow-down, and three commented that ongoing development is undesirable and might ultimately cause devaluation. Realtors were concerned that future developments (which in their view will aggravate water shortages and sewerage difficulties) might not add value if they negatively affect estuarine water quality or fish abundance.

# 5 EXISTENCE VALUE AND WILLINGNESS TO PAY TO PREVENT A LOSS OF BIODIVERSITY

## 5.1 INTRODUCTION

In addition to their direct use value, estuaries may yield value to people by virtue of the existence of the biodiversity within them. This 'existence value' or 'bequest value' is the value that people derive from knowing that some environmental amenity exists and may be appreciated by future generations. It is independent of whether the person is a direct user of the estuary. Nevertheless, while they may not actually see it, users of the estuary may take greater interest in and have a higher existence value for elements of the estuary's biodiversity.

The East Kleinemonde estuary is not particularly unique in a biodiversity sense. It is one of numerous small closed estuarine systems along the Eastern Cape coast most of which are in a fair state of health with ample undisturbed natural habitat. It supports a small compliment of birds (some 34 species; Terörde & Turpie, 2006), but a relatively high diversity of fish, with some 30 fish species belonging to 17 families (Cowley & Whitfield, 2001b). Of particular interest, however, is that the estuary is home to the critically-endangered estuarine pipefish *Syngnathus watermeyeri*. This species is found only in a few small estuaries between the Bushman's and East Kleinemonde rivers in the Eastern Cape, although little is known of these populations apart from in the Bushman's and East Kleinemonde estuaries (Cowley & Whitfield, 2001a; 2002), where considerable research has been carried out over the last decade (Cowley *et al*., 2006).

This study aimed to ascertain the existence value held by the public for the biodiversity of the East Kleinemonde estuary. However, bearing in mind that other aspects of its biodiversity are fairly common over a wide area, the study focused on the value of the pipefish population that is supported by the estuary (albeit very rare since the last major flood destroyed its vegetated habitat – P. Cowley, pers. comm.).

Existence value is best estimated using stated preference techniques, particularly the Contingent Valuation Method (CVM; Arrow *et al*., 2001). Indeed, CVM is one of the only ways to assign a monetary value to a 'non-use value' (Arrow *et al*., 2001). This method involves posing a hypothetical scenario in which the availability of the resource in question is affected, and eliciting the respondent's willingness to pay to prevent such a change (Adamowicz *et al*., 1993; Arrow *et al*., 2001). Their willingness to pay thus provides an estimate of the value that would be the lost if the change did occur. It is important to distinguish between estimating the total value of the amenity (WTP to prevent a total loss) versus the value of some change.

The CVM approach is an appropriate technique because it allows one to gauge the 'existence value' of particular species that otherwise have no direct economic market place. The CVM approach is based on the direct elicitation of these values from individuals within the public arena in the form of sample surveys. For practical reasons, the study was restricted to the Kleinemonde area and the surrounding Ndlambe municipality, which includes the small urban centres of Alexandria, Port Alfred and Bathurst as well as several coastal resort villages. e.g. Kenton-on-Sea.

## 5.2 METHODS

### 5.2.1 Data collection

Two CVM surveys were carried out: one in East Kleinemonde, as a second part of the questionnaire described in Chapter 3, and one in the rest of the Ndlambe Municipality, which only contained questions pertaining to the CVM study.

Respondents were asked about their origins, their knowledge of the area and the estuary, and their interest in nature. After providing some information on the estuary and its biodiversity, a hypothetical scenario was posed that the estuarine pipefish in the East Kleinemonde was under threat due to demand for water from the catchment. The degree of threat was varied between the different questionnaires, threatening the loss of 25%, 50% or 100% of the population if nothing was done, so that different respondents responded to different degrees of threat.

Two different questionnaire versions were used in the Ndlambe Municipality survey which differed in terms of the way in which this could be prevented, and differed in the payment vehicle (PV) used.

Version 1 (Monthly water bill) elicited WTP for paying an amount over and above their *monthly* water bill charges, as follows:

> *If current trends continue we stand to lose some <u>50%</u> of the population of the Pipefish in the EK in the near future, along with loss in estuarine plants and animals generally, making it more vulnerable. We'd like to know if you would be in favour of a policy which involves increasing water charges in the Ndlambe Municipality in order to reduce water demands and prevent the degradation of this estuary. Yes No*
>
> *If in favour, how much would you be prepared to pay over and above your current monthly water bill in order to achieve this? Please take a moment to think about this, bearing in mind your budget constraints and all the other causes you would like to spend your money on. R____ per month*

Version 2 (Off-channel dam) elicited WTP a *once-off* payment for a water supply option that would reduce water demands on the estuary, as follows:

> *"In order to meet the future water demands on the catchment a dam will have to be built on the East Kleinemonde River. If this happens we stand to lose some <u>50%</u> of the population of the Pipefish in the East Kleinemonde in the near future, along with loss in estuarine plants and*

*animals generally, making it more vulnerable. Alternatively, an off-channel storage facility would meet the water demands while having a relatively negligible impact on the estuary. This option is far more expensive, however. We'd like to know if you would be prepared to contribute to a fund that would enable the construction of this second option and prevent degradation of the estuary.* ☐ *Y* ☐ *N*
*If no, why?* ________

*If in favour, how much would you be prepared to pay into this fund as a once-off payment? Please take a moment to think about this, bearing in mind your budget constraints and all the other causes you would like to spend your money on.* *R_________"*

Both versions were administered in the Ndlambe municipality, while only the second version used in the survey of on-site users (at Kleinemonde). It should be noted that the CVM section in the Kleinemonde survey was embedded within a far broader context.

Respondents were reminded that donating to this cause necessarily reduced the other goods, services or cause that could be purchased or allocated towards in order to reduce the mental accounting bias (Hosking & Du Preez, 2004).

Finally, respondents were asked to indicate their income category, and profile information was gathered on respondents' sex, age and race.

### 5.2.2 Data analysis

The data were first cleaned by removing any outliers. This was done by analysing frequency distribution of WTP values for each income bracket and discarding any that are a) unrealistically high for that level of income or b) differ from the majority of the values by an order of magnitude. Seeing as the data were not normally distributed, the geometric mean of WTP was used. The geometric mean of a sample can be approximated by log-transforming the data and calculating the arithmetic mean as usual (Zar, 1999). This transformation also served the purpose of reducing the influence of extreme values. All of statistical analyses were performed in Statistica (Statistica 7, StatSoft Inc., 2004).

At the broadest scale, the total existence value of the estuarine pipefish was estimated by extrapolating the average WTP of, firstly, the immediate Kleinemonde residency (because the sample was unrepresentative of the Ndlambe region) and secondly that of the greater Ndlambe municipality (a more representative sample). The data were then subdivided in several ways so as to detect any potential significant differences in WTP between Kleinemonde respondents and greater Ndlambe respondents between the two different CVM questions (Monthly water bill versus Off-channel dam). The latter analysis was restricted to respondents surveyed in the greater Ndlambe municipality.

Additionally, any differences in response to the possible fate of the estuarine pipefish after development were tested. For this analysis a Kolmogorov-Smirnoff (K-S) frequency distribution test was performed so as to avoid the problem of different magnitudes of payments. This is used because one can test whether the observations come from a population with similar distributions of values (Quinn & Keough, 2002). Only freestanding questionnaires (non-Kleinemonde questionnaires) were used in order to reduce the possibility of the embedding effect as a confounding variable.

In all the above analyses, 'protest' bids (WTP values of 0 given for reasons other than a zero value being placed on the resource) were excluded (Hosking & du Preez, 2004). This was done so as to focus on the 'real' values of the WTP data. Total existence values (TEV) were for the estuarine pipefish were estimated by extrapolation. This was done using the following formula:

*TEV= Average WTP * Total number of households * Proportion of people WTP*

For the Kleinemonde area, total population size was taken as 300 households. According to the 2001 census, the Ndlambe municipality has a total population of 55 715 people in 15 728 households. Of these, 12 833 are income-earning households. The latter was used for extrapolation of values.

To determine which profile variables most readily predicted a respondent's WTP, Generalised Linear Models (GLMs) were fitted to the data. These were performed in Genstat (GenStat 8th edition, Lawes Agricultural Trust, 2005) using methods described in Crawley (2002). This included model simplification through the backward elimination of insignificant terms and all plausible interactions being included in the model. For WTP overall (Kleinemonde and greater municipality) both a continuous (magnitude of WTP) and binary response ('yes' or 'no' to WTP) variable was used. This was done because of the possibility that variables responsible for how much people pay might be different from the variables affecting whether people will pay. Even though GLMs are able to assess both continuous and categorical data, they are still built on the assumptions of parametric models (Khuri *et al*., 2006). Thus, the data were log-transformed to increase linearity error homoskedasticity. Furthermore, the zero-truncation problem associated with the protest bids was alleviated by using the $y=\log(x+1)$ transformation of the data (Quinn & Keough, 2002). The data were analysed both with and without protest bids.

Correlations between explanatory variables in the models were assessed post hoc to scan for potential confounding effects. These data were modelled using an identity link under the assumption of a normal distribution of error variance (Quinn & Keough, 2002).

Different explanatory variables were included for different models, depending on whether the variable was common to all subsets of WTP data and whether it was appropriate. For example, the factor 'race' was excluded from all models analysing the Kleinemonde subset of data as this area had an extremely strong bias towards white respondents. Models using binary code as a response variable were investigated using a logistic regression. In this case, the 'yes' or 'no' values were converted into a 'dummy' variable where 'yes' values = 1 = 'successes' (situ Zar). In these analyses, a probit link was used under the assumption of a binomial distribution of error terms (Quinn & Keough, 2002).

## 5.3 RESULTS

### 5.3.1 Respondent characteristics

Overall, 137 questionnaires were completed by respondents in the Kleinemonde area and 311 by people in the Ndlambe municipality area. It was assumed that the 137 households interviewed in Kleinemonde were representative of the population there, since this represented a large proportion of households (46%).

Since the dataset for Ndlambe had to be extrapolated to the whole district, it is important to consider how representative the sample was. The Ndlambe sample was not representative of race groups, with a sampling bias towards White and against Black respondents (Figure 5.1). This is relevant if there is a racially-based difference in people's preferences regarding biodiversity conservation that is independent of income. The sample was far more representative of the income of people of the district (Figure 5.2), but there was a significant bias ($X^2$ = 15.1, d.f. = 4, p < 0.01) towards poorer households and against wealthier households. In other words, the sample has a lower average income than the district. This is not adjusted for in the following analyses, so the results may err on the conservative side.

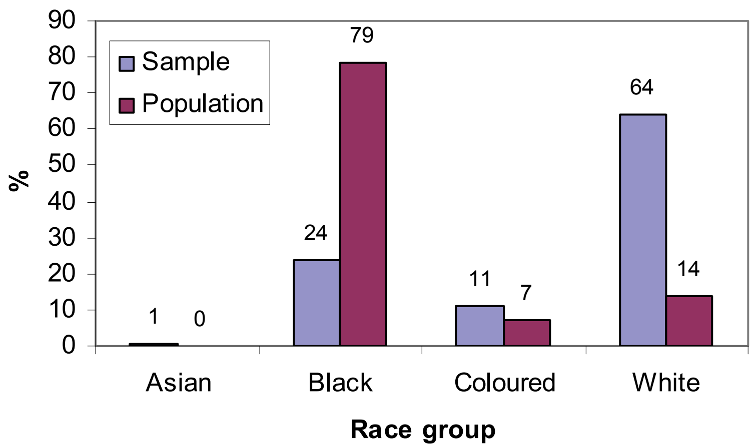



**Figure 5.1. Percentage composition of race groups in the Ndlambe district sample versus the actual composition of the district according to census data.**

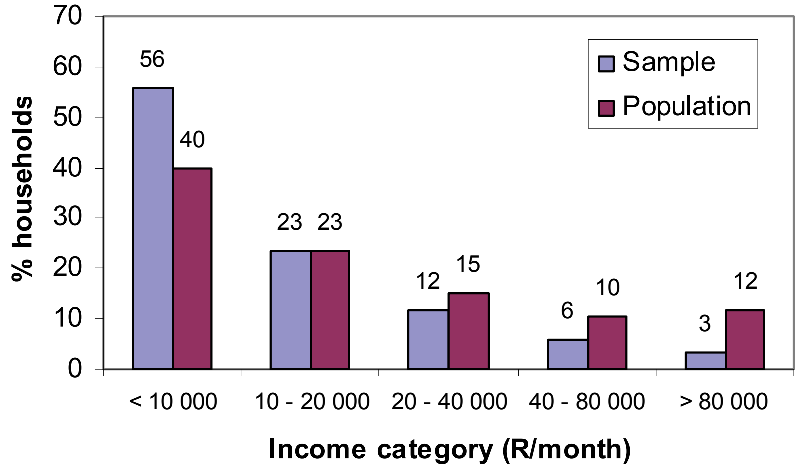



**Figure 5.2. Percentage composition of income groups in the Ndlambe district sample versus the actual composition of the district according to census data. Excludes households with no income.**

### 5.3.2 Willingness to pay

About half respondents of the Monthly water bill version were willing to pay extra to save the pipefish. Among those respondents, the average WTP was an added R45 per month (Table 5.1), or R540 per year. Taken over 20 years, and extrapolated to all the earning households in the municipality, this translates to a total WTP (taken over 20 years, and discounted at 10%) of about R30 million.

For the Off-channel storage version, some 42% of Ndlambe respondents and 52% of Kleinemonde respondents were willing to donate towards the construction of a dam to reduce the impact on the pipefish (Table 5.1). Of these, their average WTP was R151 and R767, respectively. The WTP by Kleinemonde respondents was significantly higher than that of Ndlambe respondents (Mann-Whitney: $U=-3.95$, $p<<0.05$, $n=154$). This yields a total WTP of just over R1 million.

**Table 5.1. Average and total WTP of respondents for two localities and questionnaire versions in the CVM study. Total WTP is expressed as a present value over 20 years at a discount rate of 10% in the case of the monthly water bill in order to make it comparable to the once-off payment.**

| | n | % WTP | Geometric mean | Total WTP (NPV) |
|---|---|---|---|---|
| **Monthly water bill version** | | | R per month | |
| *Ndlambe municipality* | 192 | 50.5 | 16≤**45**≤124 | 29 794 000 |
| **Off-channel storage version** | | | Once-off | |
| *Ndlambe municipality* | 119 | 41.9 | 32≤**151**≤713 | 986 000 |
| *Kleinemonde* | 136 | 52.1 | 163≤**767**≤3599 | 96 00 |
| *Total* | | | | 1 082 000 |

There were no significant differences between WTP for different degrees of threat to the pipefish (20%, 50% or 100% of population lost; Kruskal-Wallis: H=.20, p=0.90, n=154).

### 5.3.3 Potential explanatory variables

In order to discern the main factors influencing WTP, Generalized Linear Models (GLMs) were fitted to the data. Table 5.2 is a summary of the GLM model output of total WTP data (both Kleinemonde and the greater Ndlambe municipality) with and without protest values of zero. The 'Total WTP' model, that included zero values, accounted for a small amount of variance overall ($r^2$=0.11, p<0.05, n=224). Furthermore, the model fit, as revealed by a normal probability plot, was inadequate. When the zero values were excluded, however, the model fit was far better ('Positive values' model: $r^2$=0.58, p<0.05, n=112). The income bracket of the respondent was the strongest predictor of WTP in both models (both p<<0.01, n=112). As revealed by the minimal models, the higher the income of the respondent the more money they are likely to donate (refer to the parameter estimates of Table 5.2). Income bracket 1 (<R10 000 per month) is not shown in Table 5.2 because it is fixed as a reference level with which to compare the other income factors. Similarly, the Kleinemonde factor of 'Area of interview' is fixed. In the 'Positive values' model, the area in which the interview was held is also a significant factor: greater Ndlambe respondents tend to donate less money than Kleinemonde respondents (Parameter estimate=-0.46, t=-4.57, n=99, p<0.01). The general form of the equation for the 'positive values' model is:

$$WTP = 2.24 + 0.28*(Income\ 2) + 0.91*(Income\ 3) + 1.07*(Income\ 4) + 1.22*(Income\ 5) - 0.46*(greater\ Ndlambe\ residency)$$

In an attempt to discern more fine scale patterns, GLMs were fitted to the Kleinemonde and greater Ndlambe municipality datasets individually. For both analyses, the zero values were omitted to produce a better model fit. The Kleinemonde dataset was relatively impervious to any variable other than income level (Parameter estimate=1.24, t=3.80, n=62 p<0.01; Table 5.3). Overall, the model accounted for 48% of the variance in the sample ($r^2$=0.48, p<0.05, n=62).

Income level was also highly significant in WTP values from the greater Ndlambe municipality respondents (Parameter estimate=0.79, t=2.19, n=91, p=0.04; Table 5.4). In this analysis however, race was also found to be significant (Parameter estimate=0.71, t=2.39, p=0.02), with white respondents donating more than either black or coloured respondents (White respondents, parameter estimate=0.58, t=3.33, n=91 p<0.01).

**Table 5.2. GLM output using total WTP data across both Kleinemonde and the greater Ndlambe municipality. Zero values were included in the combined 'Total WTP' model whereas they are omitted in the 'Positive values' model. In both models income was the strongest predictor of WTP.**

| ***Total WTP*** <br> **FULL MODEL** | **Parameter estimate** | **Standard error** | **Test statistic** | **P-value** |
|---|---|---|---|---|
| Income | 1.30 | 0.39 | 3.32 | <0.01 |
| Area interviewed | <0.01 | 0.20 | -0.01 | 0.9 |
| Resident status | -0.10 | 0.20 | -0.5 | 0.62 |
| Nature interest | 0.01 | 0.23 | 0.06 | 0.95 |
| Age | 0.17 | 0.97 | 0.18 | 0.86 |
| Gender | -0.16 | 0.17 | -0.93 | 0.35 |
| **MINIMAL MODEL** | | | | |
| Constant | 0.70 | 0.13 | 5.27 | <0.01 |
| Income 2 | 0.52 | 0.22 | 2.35 | 0.02 |
| Income 3 | 0.98 | 0.22 | 4.39 | <0.01 |
| Income 4 | 0.79 | 0.27 | 2.96 | <0.01 |
| Income 5 | 1.42 | 0.37 | 3.83 | <0.01 |
| ***Positive values*** | | | | |
| **FULL MODEL** | | | | |
| Income | 1.18 | 0.22 | 5.41 | <0.01 |
| Area interviewed | -0.48 | 0.12 | -4.08 | <0.01 |
| Resident status | 0.06 | 0.12 | 0.47 | 0.64 |
| Nature interest | 0.02 | 0.12 | 0.15 | 0.88 |
| Age | 0.42 | 0.56 | 0.75 | 0.46 |
| Gender | 0.15 | 0.10 | 1.50 | 0.14 |
| **MINIMAL MODEL** | | | | |
| Constant | 2.24 | 0.12 | 19.04 | <0.01 |
| Income 2 | 0.28 | 0.14 | 2.06 | 0.04 |
| Income 3 | 0.91 | 0.13 | 6.89 | <0.01 |
| Income 4 | 1.07 | 0.16 | 6.69 | <0.01 |
| Income 5 | 1.22 | 0.20 | 6.25 | <0.01 |
| Ndlambe | -0.46 | 0.10 | -4.57 | <0.01 |

Slightly different variables were responsible for a respondent's binary response of 'yes' or 'no' to paying for the estuarine pipefish. Although there was no significant variable found at the broadest level of analysis when the data were pooled (n=254), subdividing the data proved more revealing: for Kleinemonde respondents alone, both income and gender were significant in influencing the WTP decision (Table 5.5). As expected, increased income levels increased the likelihood of respondents willing to donate. Men, however, were significantly less likely to donate than women

(Parameter estimate=-0.82, t=-2.05, p=0.04, n=104, Table 5.5). For the respondents of the greater Ndlambe municipality, however, the only significant factor was familiarity with the East Kleinemonde estuary: respondents that had never heard of the estuary were far less likely to be willing to donate (Parameter estimate=-2.42, t=-2.57, p=0.01, n=81; Table 5.5).

**Table 5.3. GLM output from Kleinemonde WTP data only. 'Protest' bids were omitted. Only the income level of the respondent was found to be significant in predicting WTP.**

| FULL MODEL | Parameter estimate | Standard error | Test statistic | P-value |
|---|---|---|---|---|
| Income | 1.24 | 0.33 | 3.80 | <0.01 |
| No. children | -0.05 | 0.06 | -0.90 | 0.37 |
| Resident status | <0.01 | 0.17 | 0.02 | 0.98 |
| Nature interest | 0.00 | 0.40 | 0.01 | 0.99 |
| Age | -0.31 | 0.37 | -0.84 | 0.41 |
| Gender | 0.19 | 0.16 | 1.19 | 0.24 |
| **MINIMAL MODEL** | | | | |
| Constant | 2.07 | 0.19 | 10.82 | <0.01 |
| Income 2 | 0.49 | 0.23 | 2.18 | 0.03 |
| Income 3 | 1.08 | 0.23 | 4.81 | <0.01 |
| Income 4 | 1.15 | 0.26 | 4.40 | <0.01 |
| Income 5 | 1.49 | 0.28 | 5.30 | <0.01 |

**Table 5.4. GLM output from greater Ndlambe WTP data only. 'Protest' bids were omitted. Both income level and race of the respondent was found to be significant in predicting WTP.**

| FULL MODEL | Parameter estimate | Standard error | Test statistic | P-value |
|---|---|---|---|---|
| Income | 0.79 | 0.36 | 2.19 | 0.04 |
| Race | 0.71 | 0.30 | 2.39 | 0.02 |
| Resident status | -0.10 | 0.25 | -0.4 | 0.69 |
| Nature interest | 0.20 | 0.21 | 0.96 | 0.34 |
| Familiarity | 0.12 | 0.23 | 0.52 | 0.60 |
| Age | 0.19 | 0.63 | 0.31 | 0.76 |
| Gender | 0.16 | 0.17 | 0.99 | 0.33 |
| **MINIMAL MODEL** | | | | |
| Constant | 1.56 | 0.13 | 12.31 | <0.01 |
| income 2 | -0.17 | 0.20 | -0.88 | 0.38 |
| income 3 | 0.53 | 0.19 | 2.83 | 0.01 |
| income 4 | 0.87 | 0.21 | 4.17 | <0.01 |
| income 5 | 0.63 | 0.30 | 2.11 | 0.04 |
| race C | -0.05 | 0.30 | -0.17 | 0.86 |
| race W | 0.58 | 0.17 | 3.33 | <0.01 |

A general form of the logistic regression equation for Kleinemonde respondents is:

$$WTP = -1.05 - 0.85*(Male) + 1.76(*Income\ 2) + 1.72*(Income\ 3) + 1.13*(Income\ 4) + 2.51*(Income\ 5)$$

where WTP is in the form of the natural log of odds of a respondent answering 'yes' relative to answering 'no' to a donation question (Quinn & Keough, 2002).

**Table 5.5. Minimal models of logistic regression analyses using Kleinemonde and greater Ndlambe municipality WTP data.**

| ***Kleinemonde*** **MINIMAL MODEL** | **Parameter estimate** | **Standard error** | **Test statistic** | **P-value** |
|---|---|---|---|---|
| Constant | -1.05 | 0.51 | -2.05 | 0.04 |
| Gender M | -0.85 | 0.46 | -1.87 | 0.04 |
| Income 2 | 1.76 | 0.64 | 2.75 | 0.01 |
| Income 3 | 1.72 | 0.64 | 2.68 | 0.01 |
| Income 4 | 1.13 | 0.70 | 1.62 | 0.11 |
| Income 5 | 2.51 | 0.97 | 2.59 | 0.01 |
| ***Ndlambe*** **MINIMAL MODEL** | | | | |
| Constant | 1.80 | 0.50 | 0.03 | 0.04 |
| Familiarity N | -2.42 | 0.94 | -2.57 | 0.01 |

## 5.4 DISCUSSION

The results of the survey yielded some expected trends, which help to confirm that the survey was reliable, as well as revealing some strong biases. These are discussed below.

### 5.4.1 Income effect

The first was that WTP was positively correlated with income. This is to be expected since income affects ability to pay. Generally, respondents earning less money were less likely to say 'yes' to a donation and also less likely to pay more for a donation. This result probably arises from the axiom that poorer respondents do not possess the 'luxury' of being able to buy themselves the 'warm glow effect'; they place far greater emphasis on short-term interests. Over and above all else, the income level of the respondent bounded any likely estimate of WTP across all subsets of data. This was discerned using GLM modelling, which is an appropriate technique when known explanatory variables exist other than bid level data (Langford, 1994). That income is important in influencing WTP of respondents is intuitive (Adamowicz *et al*., 1993). However, that it dominates WTP despite purportedly 'passionate' interests in nature, residency status and all most potential explanatory variables included the model is not. A reason why these variables may not have correlated with WTP is perhaps because increases in income may produce a non-linear effect on WTP: as the disposable income of a household increases disproportionately to other linearly increasing costs of living, so too might a household's willingness to donate to seemingly altruistic causes. Thus, people earning higher salaries have a disproportionately large capacity with which to donate.

When the greater Ndlambe data were looked at independently, it was found that not only income, but race too had an effect. Here, white respondents had a higher WTP to than either black or coloured respondents. This result may be due simply to the general disparity of wealth within South Africa; to the fact that Kleinemonde is perceived to be a white elitist holiday destination with not much on offer or available to other ethnic groups; or merely an insidious sampling bias during the interviews. Of course, these reasons are not mutually exclusive. Gender and age were not found to be significant in explaining any divergence in WTP within either the Kleinemonde or the greater Ndlambe municipality.

### 5.4.2 Familiarity with the estuary and interest in nature

The second expected result was that people that were more familiar with the estuary had a higher WTP. This was clearly shown by the logistic regression for the greater Ndlambe respondents, where respondents who had never heard of the East Kleinemonde were significantly less likely to donate money to its preservation. Moreover, respondents of the Kleinemonde area had a significantly higher WTP than those of the rest of the municipality. These respondents were more directly affected by the loss of the estuarine pipefish and the proposed development occurring in Kleinemonde.

### 5.4.3 Degree of threat and embedding bias

A third result, that WTP was not influenced by the degree of threat to the estuarine pipefish population (20%, 50% or 100% of population lost) is counter-intuitive. However, this type of 'embedding effect' (situ Diamond & Hausman, 1994), whereby WTP is not scaled to the size of the change, is common. In this case it would appear that respondents simply express their maximum WTP for the estuarine pipefish regardless of the immediate level of threat.

### 5.4.4 Payment vehicle bias

Despite the expected results obtained above, the use of two different versions has demonstrated the very high level of bias that can be introduced through design of the payment vehicle. People were WTP quite a lot when the payment was proposed to be on a monthly basis, but appeared to have an upper limit to what they would pay as a once off. When reduced to equivalent values by discounting, the Monthly water bill version yielded a much higher total WTP. The average annual WTP, over R500, seemed particularly high, suggesting that respondents may not have thought the problem through. The range of estimates for the existence value of the pipefish thus lay between R1 m and R30 m, which is a very large margin of error.

### 5.4.5 Protest bids

Despite most peoples' admonition of being 'passionate' or at least 'actively interested' in nature, between 41% and 58% of respondents (in all subsets of the data), were not willing to pay towards this cause at all. This might be because they did not feel that the money they contributed to rates and taxes in the Ndlambe municipality met the services rendered by the municipality in the first place. Thus, they were not willing to contribute further money, even though it was for the conservation of the estuarine pipefish. This point raises an element of distrust between the public and the municipality, and hence, a lack of transparency between services and the payment of rates and taxes in the Ndlambe municipality. This highlights the importance of where the money, which is offered by respondents in response to WTP, is deposited (i.e. the payment vehicle).

Both income and gender influenced whether respondents were WTP at all. Women were more likely to answer in the affirmative than men. This may be due to the fact that they are more likely to want to please the respondent, as a form of 'yeah-saying' bias.

### 5.4.6 Sample size and question type

People are highly variable in their preferences, and large samples sizes are generally needed to detect fine scale patterns in valuation. The total sample size for this study was 447, but subdivision of these data probably reduced the explanatory power of any single analysis (Quinn & Keough, 2002). The biggest problem, however, was probably in the inaccuracy of the stated willingness to pay that was highlighted by the large difference in responses between the two questionnaire versions. These problems might have been averted to some extent by a closed-ended questionnaire design, but that would have required at least double the sample size. Part of the reason for the uncertainty in the data can probably be ascribed to complications caused by peoples' attitudes to the Ndlambe municipality, which seemed to be far more important to respondents than biodiversity conservation. Water is a highly contentious and controversial subject in and around the Ndlambe district and respondents often failed to disassociate their evaluation of the estuarine pipefish from their complaints of the water quality and supply problems.

### 5.4.7 Conclusion

The pipefish of the East Kleinemonde estuary are worth at least R1 million to the public, but could be worth as much as R30 million. The large discrepancy in interest between users of the area and the surrounding populations suggests that the best method of preserving the East Kleinemonde estuary, and thus hopefully the estuarine pipefish, might be to better inform and coordinate the residents of the area. The mostly higher income earners of Kleinemonde, if acting as a unified and well-informed community might be in a better position to stem uncontrolled development than any other members of society.

# 6 ARE WATER-SAVING MEASURES A VIABLE ALTERNATIVE?

## 6.1 INTRODUCTION

River flows are important for the functioning of estuarine systems, particularly in closed systems which only open periodically, such as the East Kleinemonde estuary. In this, as in other small closed estuaries, the catchment is small and dry season base flows make a relatively small contribution to the ecological functioning of the estuary. Medium flows, however, are important for maintaining baseline ecological processes and preventing hypersalinity through the introduction of fresh water into the system, as well as occasional breaching. High flows primarily serve to breach and flush the estuary (Van Niekerk, 2006).

The settlement at Kleinemonde currently comprises 620 plots of which 300 are developed. The existing population obtains most of its water from the Wellington Dam, which is located in the East Kleinemonde River catchment. This water is mixed with brackish water from a groundwater source in order to boost the volume supplied, but at the cost of water quality. As a result, the municipal water is not potable. Nevertheless, water shortages already occur, particularly during the Christmas period when most houses are occupied. The situation is set to worsen, as future developments have been zoned, allowing for an additional 390 plots (P.D. Cowley, in litt.). This could result in a 336% increase in developed plots and a similar increase in the demand for water supply to Kleinemonde in the near future.

Given this situation, the question has been posed as to whether Kleinemonde could meet its water needs with less impact on the environment. The nearby settlement of Kasouga provides an example of a community that has no municipal water supply and is wholly reliant on rainwater harvesting.

This study aimed to determine whether the demand on rivers could be alleviated to a significant degree by reducing the growing demand for abstraction caused by the proliferation of coastal developments through rainwater harvesting. It is possible that future demands of Kleinemonde may be met from the East Kleinemonde River, but there are alternative options such as water transfers from the Fish River (which would have downstream impacts elsewhere). Nevertheless, for the sake of comparison of the potential costs and benefits, we have considered the hypothetical situation in which the best alternative for supplying additional municipal water would be to obtain the water from further water supply developments on the East Kleinemonde River. Two water supply options have already been evaluated in terms of their potential impact on flows as part of a process to determine the freshwater requirements of the estuary (Hughes, 2007):

1. a 1 $Mm^3$ (million metres cubed) dam on the East Kleinemonde River, and
2. a weir in the river linked to an off-channel storage reservoir, as a more expensive option that has a lower impact on flows.

Option one, building a dam in the river, would potentially have the greatest impact on the estuarine environment. The catchment area of the existing Wellington Dam is 9% of the total river catchment area, whereas that of a new dam that would be required to supply an expanded settlement would be some 67% of the total catchment area (Hughes, 2007). Such a dam would most likely impact low, medium and high flows, as well as requiring stringent monitoring and management in order to reduce impacts on the East Kleinemonde estuary. For option two (off-site reservoir) it has been predicted that most of the low and medium flows will be trapped behind the weir and pumped to the reservoir with very little impact on the high flows (Hughes, 2007).

In this study these options were compared with a decentralised water supply, where households install sufficient rainwater collection systems to supplement, or be entirely independent of, municipal water. This option would have the lowest impact on the estuarine ecosystem and eliminates the potential degradation of the estuary associated with an increased municipal water supply.

## 6.2 METHODS

### 6.2.1 Current reliance on rainwater in Kleinemonde

In order to assess the current level of rainwater usage in Kleinemonde, door-to-door surveys were conducted of 137 residents and holiday-home owners in the village over a period of three days (4-6 April 2007). Each respondent was asked whether they had a working rainwater tank on their property, and what the total capacity of their tanks was. Respondents were also asked whether they ever experienced water shortages in Kleinemonde. For those reporting water shortages, they were asked during which periods of the year water shortages were most severe or frequent.

### 6.2.2 Feasibility for total reliance on rainwater

In order to assess the feasibility of option three (reliance on rainwater), a model of a household with rainwater tanks was produced using modelling software (ISEE systems, Stella® version 9). The model simulated water levels in collection tanks for a typical household in Kleinemonde using actual daily rainfall data. Daily rainfall data were obtained for a weather station in Port Alfred (South African Weather Service, Station number 0037696 8) over a 12 year period from the 1st of January 1993 to the 27th of April 2005. Roof area was assumed to be 250 $m^2$.

Tank capacity, household water consumption and period of house occupancy were variables in the model.

The model was run using two potential rainwater tank capacities per household: 30,000 litres (L) and 50 000 L.

The Ratepayers Association estimated the present total daily water consumption in Kleinemonde to range from 120-160 $m^3$ out-of-season and 200-350 $m^3$ during peak times (Hughes, 2007). On average then, the peak season consumption is 140 $m^3$ and out-of-season consumption is 275 $m^3$ of water per day. From these values current water consumption in Kleinemonde was estimated to be 916 L per day per household (L/day/HH), both in peak and off-peak periods. This estimate assumes that approximately 43% of the developed plots are occupied out-of-season and 91% are occupied during peak times. However, to understand how the feasibility of option three would change with varying levels of water consumption (e.g. increased water efficiency); the model was run using a range of daily consumption values from 100 to 1000 L per household per day.

The overall percentage of time spent with no water in the household's tank was calculated under each scenario. A scenario was considered to be feasible if tanks were empty for no more than 5% of the simulation run-time.

### 6.2.3 Reliance on rainwater tanks in Kasouga

Eight permanent residents of Kasouga were interviewed in order to gain an understanding of how the village operates without municipal water.

### 6.2.4 Costs of maximising use of rainfall

We estimated the costs of rainwater harvesting using prices of collection tanks from a local hardware store (D&A Timbers, Port Alfred). Unfortunately, without inspection of houses by a plumber, it is impossible to determine the costs of installing rainwater tanks to interface with household plumbing. We determined the costs for a range of most viable tank capacities, but subtracting the average investment that is already made in rainwater harvesting. Tank costs were calculated for the 710 proposed new developments. Annual expenditure on maintenance (0.25% of the capital cost) was applied to all three options (Allan Shelley, in litt.).

### 6.2.5 Potential costs of water supply infrastructure

Costs for the water supply infrastructure options were provided by an employee of Ninham Shand, a consulting engineering firm (Allan Shelly, in litt.). These costs are simply order of magnitude figures since these two options are entirely hypothetical and multiple factors may influence the actual costs of construction. Labour costs were excluded from the financial estimates.

For the dam option, the ratio of embankment to water volume is likely to range from three to ten (Allan Shelley, in litt.). To determine the potential costs of this dam we assumed an intermediate ratio of five. Thus, our hypothetical 1 $Mm^3$ dam would require 200,000 $m^3$ of fill (i.e. building materials). Dam fills are dependent on the topography of the catchment, the size and shape of the dam, the size of the dam wall, the foundation conditions (earth fill, rock fill or concrete) and the size of floods in the river (determines the spillway required). Fill costs could range from R30 per $m^3$ to R50 per $m^3$.

The off-channel reservoir option is more complex, and was more difficult to assess. There is little information available on difference in costs of building an off-channel reservoir as opposed to a dam. In some situations, an off-channel reservoir can be cheaper (Allan Shelley, in litt.). However, in a small catchment with low flow periods, the off-channel reservoir would have to be much bigger than the dam as it would only be able to take water under fairly high flow conditions. In addition to building a large storage reservoir, costs would include the pipeline/diversion facility which may amount to up to R5 m. We derived the cost of option two by adding this cost and to the estimate for option one, but allowing for savings on the spillway construction.

## 6.3 RESULTS

### 6.3.1 Current use of rainwater

Nearly all surveyed residents of Kleinemonde (96%) have working rainwater tanks on their property, which they use to supply their drinking water. A few households rely on bottled water for drinking water. In general, however, existing tanks are relatively small, with an average capacity of 13 000 L per household, and most houses having 10 000 L tanks. These tanks are generally only used for drinking water and as backup during municipal shortages rather than as primary household water sources. However, since the water reportedly shortens the lifespan of household appliances, some households have installed enough capacity to also divert rainwater to these appliances.

The majority of residents in Kleinemonde (63%) reported experiencing water shortages. Of those reporting shortages, the majority (76%,) reported that shortages were particularly severe/frequent during the peak summer holiday season (December and/or January).

### 6.3.2 Feasibility for reliance on rainwater

According to the simulation model, households in Kleinemonde cannot be completely dependent on rainwater unless daily water consumption is substantially reduced (Figure 6.1). In order to have a completely reliable source of rainwater (i.e. 0% days with an empty tank), household consumption would have to be less than 300 L/day (with a 50 000 L tank) or less than 200 L/day (with a 30 000 L tank). The latter is similar to the situation with a 10 000 L tank. With a feasibility cut-off of no more than

5% of days spent without water, this household consumption allowance could be increased slightly to about 320 and 400 L/day with the two tank capacities, respectively. This requires a reduction of water consumption to 35-44% of the present average consumption of some 916 L/day. However, with a 10 000 L tank, consumption would have to remain below 230 L/day, some 25% of present consumption. Changing from a 10 000 L to a 30 000 L tank makes a considerable difference to the percentage time that the tank is empty, at all rates of consumption. The difference between a 30 000 and a 50 000 L tank is much smaller, particularly if rates of consumption are high.

Further increases in tank capacity would make little difference, due to the limitations of rainfall. In higher rainfall areas, bigger tanks may have a much bigger impact.

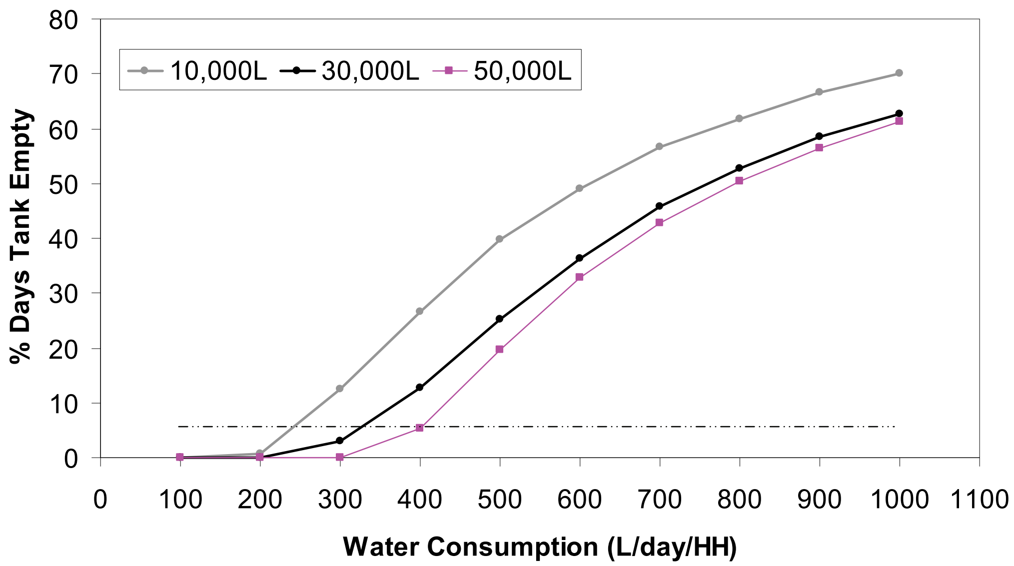



**Figure 6.1. Percentage of time that rainwater tanks are empty under varying consumption levels and for three levels of tank capacity. The model uses actual daily rainfall data from Port Alfred for a 12-year period and assumes a constant roof size of 250 m$^2$.**

At current average household consumption rates in Kleinemonde, water tanks could supply about 40% of household water, irrespective of whether they have a capacity of 10 000 L or 50 000 L (Figure 6.2). However, the proportion that can be met by water tanks increases markedly with reduced household demand, and tank size makes a difference at modest consumption rates (Figure 6.2). At modest daily consumption levels, larger rain tanks can supply in the order of 130-140 000 L per year (Figure 6.3).

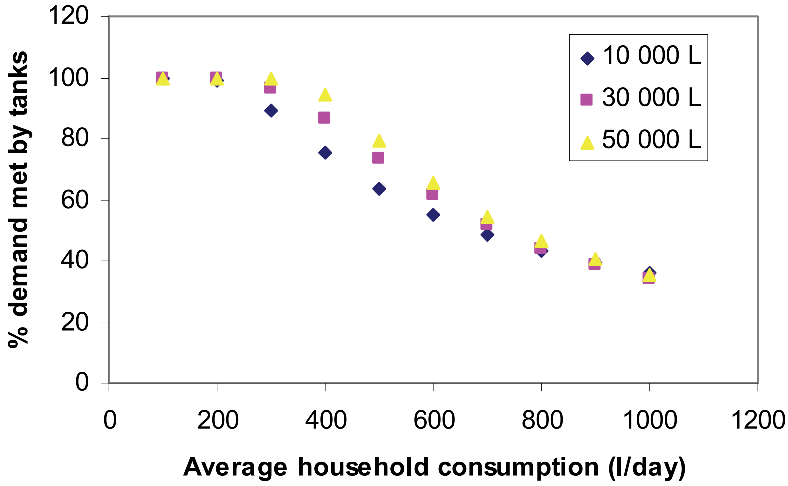



**Figure 6.2. Percentage of the total annual household demands met by rainwater tanks in relation to average daily consumption, for three levels of tank capacity.**

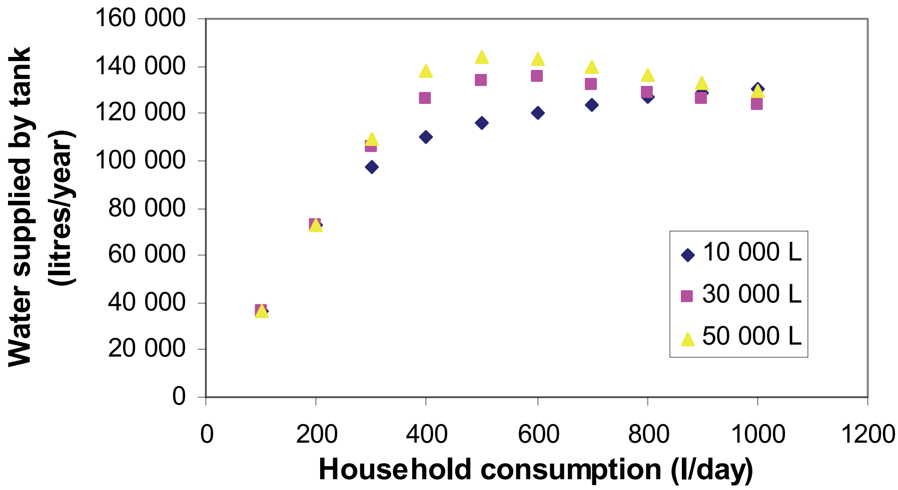



**Figure 6.3. Average quantity of water supplied by rainwater tanks per year in relation to average daily consumption, for three levels of tank capacity.**

### 6.3.3 Meeting water needs in Kasouga

Kasouga is a small settlement at the mouth of the Kasouga estuary, comprising about 150 houses. The majority of these are holiday residences: at the time of this study only 13 houses were occupied by permanent residents (Jenny Currie, local estate agent, pers. comm.).

According to surveyed residents and the local estate agent, a small number of households in Kasouga have access to borehole water and some occasionally buy water from Port Alfred's municipal supply, but for the most part the village is completely dependent on rainwater. All houses in Kasouga are equipped with several rainwater collection tanks, ranging in capacity from 5 000 to 90 000 L per household. Although two of the eight surveyed residents did report occasional shortages of rainwater, none expressed a desire for a municipal water supply to the area.

When asked about water-saving behaviour, residents of Kasouga most commonly cited the recycling of shower and dish water for use in watering gardens. Perhaps surprisingly, five of the eight residents interviewed in Kasouga reported having non-indigenous gardens. Of these, however, all reported using recycled water for maintaining them. This strategy probably accounts for a large part of the high water efficiency in Kasouga. Additionally, several respondents emphasised the increased awareness of water use and efficiency that comes with dependence on rainwater. Such awareness can lead to minor behavioural changes that can have a collectively-large impact on daily household water consumption rates. Some examples given by residents included: shutting off taps while brushing teeth and rinsing sandy feet in a shared basin rather than from a running hosepipe.

### 6.3.4 Potential costs of alternative water supply options

It was estimated that an on-site dam large enough to meet the future water demands in Kleinemonde would cost some R6.14-R10.24 million (including maintenance costs discounted over 20 years), whereas an off-channel storage option would potentially cost about R4 million more (Table 6.1).

Rainwater storage tanks with a capacity of 10 000 L cost approximately R5 500 (including VAT), whereas 20 000 L tanks cost about R19-22 000 and 30 000 L tanks cost about R33-40 000. Installation per tank ranges from R1 500 (tank 50% sunk into the ground) to R3 200 (tank on cement base). Maximising the use of rainwater is a fairly costly option. Universal installation of 50 000 L capacity would incur an extra cost of about R20-R25 m. However, if this was reduced to 30 000 L, it is potentially slightly cheaper than the off-channel storage option. Note that the costs might be slightly higher if house designs are enlarged to accommodate tanks out of sight.

It is assumed that the property owners would bear the costs for all three options, either through payment for water in the first two options, or through incurring the costs of installation of tanks.

**Table 6.1. The range of start-up and maintenance costs of the three proposed options to supply water to the additional developments zoned for the Kleinemonde area**

| Scenario | Start-up costs (excluding labour) | Annual maintenance expenditure |
|---|---|---|
| 1) on-site dam | R6-R10 m | R15 000-R25 000 |
| 2) off-site reservoir | R10-R14 m | R25 000-R35 000 |
| 3) Rainwater tanks* | | |
| 30,000L | R9.8-R12.2 m | R24 500-R30 600 |
| 50 000L | R19.7-R24.5 m | R49 200-R61 200 |

* over and above the current cost of installing 10 000 L tanks

## 6.4 DISCUSSION

Increasing coastal development along the Eastern Cape coast may eventually take a toll on river systems due to the concomitant increases in demand for water, especially during peak holiday periods. These demands, unless managed, can lead to increased abstractions from river systems, reducing the freshwater flows that are required to maintain the health of river and estuarine ecosystems. The burgeoning development at East Kleinemonde provides a useful case with which to compare the potential environmental costs of increasing water supply with the costs of alternative water supply solutions that reduce these environmental costs.

The potential costs of a reduction of river flow to the East Kleinemonde were described in Chapters 3 and 4. In particular, these findings suggested that degradation of the ecosystem could have a significant impact on the direct use value of the system, manifesting itself in potential losses of millions in property value, as well as losses of turnover in the local economy.

In this study we considered the possibility of reducing or eliminating the need for impoundment and abstraction from the East Kleinemonde River (or other rivers) through maximising rainwater harvesting. The feasibility of this option was considered in terms of household water demands and rainfall constraints. The cost of this option was compared to the cost of a conventional dam solution and an alternative water supply option which would have a lower environmental impact.

Existing data suggest that residents of Kleinemonde are fairly liberal in their use of water. Tanks currently have the capacity to supply about 40% of water needs. A change from a 10 000 L to a 30 000 L tank makes a big difference to the assurance of supply, but there is not a strong argument for increasing tank capacity further than this. Given the rainfall of the area, water tanks can potentially supply a high proportion of water requirements, but only if households curb their use of water. Changing water user behaviour is thus a critical component of encouraging dependence on rainwater harvesting. The only way that rainwater harvesting could obviate the need for additional municipal supply is if households reduced their consumption to below 400 L per day. The community of Kasouga demonstrates that this is feasible with simple water saving measures.

Whether investing in larger rainwater tanks will take off in Kleinemonde is an issue for debate, as it involves a financial cost as well as behavioural adaptation. The additional cost of installing larger (30 000L) tanks is about R16 000 per household. Although considerably more than what Kleinemonde residents claim to be willing to pay to ensure the survival of the estuarine pipefish in the East Kleinemonde estuary, this is a relatively small cost in the construction of a house. The cost of ensuring that the future expanded Kleinemonde settlement has minimal impact on rivers is similar whether this is done using an off-channel storage option or larger water tanks, although the latter would result in the lowest impact. However, the former would require less of a behavioural change and thus potentially be more attractive to property owners, unless they are made more aware of the environmental benefits and water quality benefits that could be obtained.

Although the development of better rainwater collection systems in Kleinemonde would not eliminate the need for a communal/municipal water source, the water demand from the municipal supply would be greatly reduced. Most likely, such communal/municipal water would be used primarily for backup during dry periods and periods of high use (such as over the summer peak season). It could, therefore, be provided by a dam or reservoir of a much smaller magnitude and lower environmental impact than would otherwise be necessary.

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