# THE ECONOMIC VALUATION OF BIODIVERSITY IN OMAN

## A WORKING PAPER FOR PREPARING THE BIODIVERSITY CONSERVATION STRATEGY OF OMAN

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# ***NOTE***

THIS IS A SUMMARY AND UPDATED VERSION OF THE ORIGINAL WORKING PAPER PREPARED FOR PRESENTATION PURPOSES IN THE ECONOMICS OF BIODIVERSITY WORKSHOP HELD BY ***IUCN*** IN ECUADOR DURING 20 – 22/JUNE 2001

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# SCOPE OF WORK

One of the key requirements of the ratification of the UN Convention on Biological Diversity is to prepare a National Biodiversity and Action Plan for Oman. The Ministry of Regional Municipalities and Environment, as a responsible Agency, drafted the Strategy in March 2000. Since one of the principal component of the Strategy is the economic valuation of Biodiversity in Oman, I was called upon by the National Coordinator of the National Biodiversity Strategy to conduct a study in this respect in conformity with the following Scope of Work.

1- To conduct a technical paper identifying the most important natural resources which have essential economic values to the society in general and to the national economy in particular.

2- To calculate mathematically the tangible and non-tangible economic benefits of the species chosen from the following aspects.

   - GDP share
   - Export
   - Wages
   - Self-sufficiency in major edible food products.

3- Estimating suitable criteria to identify non-tangible benefits.

4- Integrate tangibles and non-tangibles in a matrix or simplified model to approximately assess the true value of the examined resources.

5- Identify suitable projects for the Action Plan and clearly indicate justifications, location, backstopping for each project.

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# INTRODUCTION

During the last three decades, the economic significance of biological resources has gathered utmost attention from governmental agencies as well as NGOs. The concrete belief today is that development has to be both people-centered and conservation–based. Development must not come at the expense of other groups of later generations, nor threaten other species' existence. This implies that there is "economic benefit" attached to all species but it is not yet economically estimated. Biodiversity's benefits are in large part "public goods" and they are so abundant that they cost less or have no marginal value. Correctly valued, biological resources are major economic assets. But because they are undervalued, biodiversity conservation is seen as a cost rather than an investment. This is a very dangerous misunderstanding of the economic value of biological resources since it almost always manifested in lessening investment for conservation purposes. In fact many of the effects of the reduction in biodiversity are characterized by incomplete information. When policy-makers value biodiversity they often do so in the knowledge that their understanding of the effects of loss is imperfect. Nowadays there are several empirical evidence to prove that conservation of biodiversity is fundamental to the success of development process.

This technical paper endeavour to highlight the economic significance of biodiversity in Oman throughout a simplified quantitative model (EVAMOB) which attaches true value to selected species showing their contribution in the national economy. Since some data are not available in the ordinary Statistical Bulletins, the author calculated them mathematically. Technically speaking, the aim of valuation is to determine the vital role of biodiversity on the well being of the nation which is not taken into account in the formulation of development policies.

# I CONCEPTUAL FRAMEWORK

## *1.1 The Economic Value:*

Biological diversity, or as commonly known, bio-diversity, means the entire variety of life on earth from mammals to micro-organism, namely terrestrial and marine species, soil, water, woodlands, rangelands, livestock, crops, vegetation, wildlife and all other renewable resources. Besides non-renewable resources like oil, gas, and minerals are also part of the biological diversity. Therefore, one may advocate the idea that bio-diversity is essential for our survival.

Using biological resource for consumption and production is simply the economic value of biodiversity. Although biodiversity has economic value to individuals and societies, yet, this does not mean that all species have market price. Indeed, their value stems from the significance that different individuals and different societies place on resources. So the value is derived from the willingness of individuals and societies to forgo the benefits of alternative uses for the same resources. "The value of biological resources in use may be direct (they are used in consumption or production) or indirect (they support resources which have direct value). Biological resources also have non-use values stemming from the fact that we may care about others (or other species). … In other words, direct values stem from the direct consumption of resources. Indirect value stem from the fact that some resources, though not directly consumed, are nevertheless necessary to the production of resources that are directly consumed" [(1)]. It should be stressed that the economic significance of biodiversity refers to its contribution to human welfare. Any loss in human welfare is a cost. Any gain is a benefit.

## *1.2 Conservation Criteria*

The species and ecosystems that form the national bio-diversity are part of the natural resources of the society, and their value stems from their usefulness in production and consumption, from their cultural importance, or merely from their right to exist. This " usefulness " determines how much bio-diversity should be conserve all biological resources, hence, the emphasis should be placed on certain species and habitats. We ought to have a set of criteria to help identifying the species and habitats, that have the highest priority to be conserved. The following criteria are suggested.

- Habitats and species most at risk and threatened (precious) and/or those with special genes.
- Scarce and prone to extinction.
- Highly commercial
- Essential for production and local people consumption
- Have high ecological, social and cultural values.

[(1)] C. Perrings and others, "The Economic Value of Biodiversity" in, "Global Diversity Assessment" UNEP, Cambridge University Press, 1995, P.829,832.

It should be noted that these criteria never assume that some species have positive economic value and some have a zero value, rather the assertion is that species have relative values determined by social preferences and scientific knowledge, therefore their conservation and their allocation between different uses depend on their relative values. In Oman, for example, where there are thousands of flora and fauna, it is not socially nor is it economically viable to conserve such a tremendous quantity of species irrespective their current and potential uses and their existence attributes. Therefore, certain species have to be chosen for conservation depending on their impact on the socio-economic welfare of the society. Practically, there should be specific set of species to be conserved for each specified period of the conservation strategy.

## II ECONOMIC SIGNIFICANCE OF BIO-DIVERSITY IN OMAN

As stated in the National Conservation Strategy of Oman, the renewable resources currently under consideration are as shown in table (1) and as follows:

### *2.1 Land:*

According to Soil Reconnaissance Survey carried out by Ministry of Agriculture and Fisheries in 1991, the total area suitable to cultivation recorded as 2 million hectares representing only 0.06% of the total area of the Sultanate. The actual cultivated area amounted to 70 000 ha. Land degradation has been a dominant problem through the past two decades. Most land in Oman is either desertified or vulnerable to desertification. The main reasons for desertification and soil loss are overgrazing and inappropriate use of land irrigation water which has resulted in salination. Therefore, if land is not conserved, and its productivity is not raised, food production for present and coming generation will not be secured.

### *2.2 Water:*

Oman is an arid country with limited water resources. Water resources cannot satisfy all completing demand The economic evaluation of alternative policies of water resources indicates two facts:

- Low returns to agricultural use of water.
- The present high cost of desalination of sea water.

Therefore, the Master Plan stresses the need for conservation policies to curb demand for potable water and improve efficiency of agriculture without increasing water use.

It can be said that water is an economic good, when we use it purposefully, that means we allocate it rationally and fairly among people and uses. Oman is almost exclusively dependent on the very limited rainfall for its supply of fresh water. Groundwater is of crucial importance for most of the Sultanate's irrigation and domestic supplies. Yet ground water resources are in critical conditions because the volumes withdrawn exceed the natural recharge rate, this has caused a continuous decline in ground water levels and a deterioration in water quality. Data for the period (1990-2010) shows a clear imbalance between water supply and demand for water for various uses. As was shown in Table No. (1) total water supply in 1990 was about 1.5 mcm/y specifically for agricultural and livestock uses. Table No. (2) reveals

a decline of about 233 mcm/y between 1990 and 1999 as the available supply is 1,267 mcm/y in the latter year. Water deficit reaches 378 mcm/y.

**Table No.1**
**A Summary of Renewable Resources Projection in 2000**

| Resource | Unit | Potential Gross | Utilization and Potential Promotion | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1990 | 2000 | 2010 | 2020 | |
| I **Land** | | | | | | | |
| 1- Total Area: | (000)ha | 308000 | - | - | - | - | |
| (a) Suitable to cultivation | | 2220 | 2220 | 2220 | 2220 | 2220 | |
| (b) Actually cultivated | | 175 | 75 | 100 | 175 | 175 | |
| 2- Suitable to agriculture with maximum water for irrigation | | 250 | 125 | 170 | 250 | 250 | |
| II **Water** | Billion | | | | | | |
| Underground water suitable for agriculture and livestock | $M^3$ | 2.25 | 125 | 170 | 250 | 250 | |
| III **Fisheries** | Million | | | | | | |
| 1- Maximum expected landing | T/Y | 156000 | | | | | |
| 2- Planned landing | | 316275 | 118640 | 175616 | 259955 | 216275 | |
| IV **Cattle** | (000)heads | | | | | | traditional |
| 1- Cows | | | 588 | 1060 | 1066 | 1434 | & dairies |
| 2- Sheep & goats | | | 8 | 12 | 18 | 26 | |
| V **Woodlands** | | | | | | | |
| 1- Open natural | (000) ha | 5000 | 2000 | 3000 | 4000 | 5000 | |
| 2- Protected | 000 ha | 10 | 1 | 2 | 4 | 7 | |
| VI **Rangelands** | 000 ha | 1000 | 500 | 510 | 530 | 600 | |

*Source: National Conservation Strategy of Oman (in Arabic), 1995 Appendix 4, Table (1) P.119*

**Table No. 2**
**Water Balance in 1999 in Oman**

| Groundwater $MM^3/Y$ | USES $MM^3/Y$ | | Total Use $MM^3/Y$ | Deficit $MM^3/Y$ |
|---|---|---|---|---|
| | Agriculture | Household & Industry | | |
| * | 1487 | 158 | 1645 | 378 |
| 1267 | | | | |

***Source: Summarized from Table No.1 in (A Report of Water Resources in Oman, Ministry of Water Resources Table No. 1, P.3, April, 2000)***
**** Rainfall is estimated as 9481 $MM^3$ I 1999 over the Sultanate***

## *2.3 Agriculture:*

Development strategy of Oman places high emphasis on the central role of agriculture in diversifying and stabilizing the nation's economy. This inevitably requires a comprehensive agriculture policy that is fully integrated with the biodiversity conservation strategy in order to protect land from degradation. It has become evident in recent years that soil deterioration has accompanied the expansion of cropped area due to increase use of pumps which resulted in over-drafting of groundwater and subsequent salt water intrusion. This situation has led to the following.

1- The farmed (cultivated ) area has been very slightly increased from 170 feddan in 1994 to 172 feddan in 1998 – production of the major crops was almost stable, too. (Table No.3).

**Table No. 3**
**Estimates of Cultivated Area and Production by Crops**

| Type of Agricultural Crops | 1998 | | 1997 | | 1996 | | 1995 | | 1994 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Production | Area | Production | Area | Production | Area | Production | Area | Production | Area |
| | Area in Feddan/Production (000)Ton | | | | | | | | | |
| Vegetables | 186.5 | 16,367 | 201.4 | 16,792 | 164.1 | 14,568 | 153.5 | 14,200 | 146.3 | 13,763 |
| Fruits | 281 | 99,572 | 241.7 | 102,370 | 232.8 | 102,282 | 234.7 | 102,200 | 234.6 | 102,198 |
| Field Crops | 18.1 | 14,149 | 23.3 | 14,043 | 22.3 | 13,689 | 21.4 | 13,200 | 20.7 | 12,810 |
| Perennial Fodder Crops | 731.7 | 41,523 | 766 | 42,300 | 762.6 | 42,218 | 711.4 | 42,000 | 696.7 | 41,280 |
| **Total** | - | **172,211** | - | **175,505** | - | **172,757** | - | **171,600** | - | **170,051** |

*Source: Statistical Year Book, The Twenty Seventh issue, August 1998*

2- Area per capita is almost stable about .08 ha. During 1990-2000 (Table No.4).

3- Share of agriculture sector in GDP for the last ten years. Increasing crop productivity would guarantee the attainment of the major goal of agricultural development which is food-self- sufficiency, self-sufficiency level ranges between 43.0% to 50.4% during 1982-1995 and is expected to be about 54.7% in the year 2000 (Table No.5).

**Table No. 5**
**Trends and Prospects for Integrated Self-Sufficiency Rates of Edible Agricultural Products of Oman**

(R.O., %)

| Item \ Year | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|
| Import Value (1) | 101,978 | 109,834 | 123,863 | 126,674 | 131,579 | 128,513 | 148,472 | 138,542 | 154,560 |
| Export Value (2) | 6,254 | 8,115 | 9,574 | 11,453 | 11,026 | 12,882 | 15,963 | 4,347 | 4,896 |
| Net Import Value (3) = (1) -(2) | 95,724 | 101,719 | 114,289 | 115,221 | 120,553 | 115,631 | 132,509 | 134,195 | 149,664 |
| Crop products value (4) | 30,428 | 32,436 | 34,444 | 37,307 | 39,779 | 42,536 | 46,155 | 67,209 | 78,253 |
| Animal products value (5) | 41,707 | 47,410 | 52,186 | 54,167 | 56,411 | 55,566 | 56,321 | 69,075 | 102,532 |
| Total products value (6) =(4)+(5) | 72,135 | 79,846 | 86,630 | 91,474 | 96,190 | 98,102 | 102,476 | 136,284 | 180,785 |
| Self-sufficiency rate (7)= (6)* 100/ [(3)+(6)] | 43.0 | 44.0 | 43.1 | 44.3 | 44.4 | 45.9 | 43.6 | 50.4 | 54.7 |

*Source: "The Study of a Master Plan for Agricultural Development", Draft Final Report, Vol.1, Main Report, JIACA, Sept. 1998, Table 5.1.1, P.193*

**Table No. 6**
**Projections of Crop Productivity (m.tons/ha)**

| Crop Type | Productivity (M. Tons/Ha) | | | |
|---|---|---|---|---|
| | 1980 | 1990 | 2000 | 2010 |
| A- Traditional Crops | | | | |
| Dates | 3.5 | 4.1 | 4.9 | 6.0 |
| Fruits | 10.0 | 11.0 | 12.5 | 14.5 |
| Vegetables | 10.0 | 12.0 | 15.2 | 19.7 |
| Fodders 1/ | 3.5 | 4.5 | 6.0 | 8.1 |
| Other Crops | 4.0 | 5.0 | 6.4 | 8.6 |
| B- New Crops | | | | |
| 1- Fodder Maize 1/ | --- | --- | 4.0 | 5.0 |
| 2- Sunflower Seed 2/ | --- | --- | 4.0 | 5.0 |
| 3- Soya Bean Seed 3/ | --- | --- | 3.0 | 4.0 |

***Source: National Conservation Strategy / Oman, 1992, Vol. 11, Supporting Annexes P.95***
***1/ Dry matter equivalent***
***2/ Sunflower seed contains about 30 – 35% oil and 35 – 40% oil cake***
***3/ Soya beans seed contains about 40 – 45% oil and 55 – 60% oil cake***

## *2.4 Livestock:*

The role of livestock in the national economy stems from its significant contribution to the nation's meat and milk supply. Livestock products constitute a major staple of the Omani diet, but productivity is low due to inadequate feed resources.

During 1979-1992 animal products recorded considerable increase and contributed positively in food-sufficiency [(1)]. This remarkable contribution in food supply was a result of increase in growth rate ranges between 2% - 5% for all kinds of livestock up to the early nineties. The increase in livestock is proportionally related to the increase of sufficient feed supply. The later is supplied mainly by rangelands from which most necessary nutrients for livestock are obtained. But rangeland, which is the most extensive feed resource in Oman are gradually degrading and have become unable to provide livestock with vital nutrients. It will be safe to say that livestock is under severe threat and its role in the national economy is declining. Accordingly, the objective of food self-efficiency will not be attained. Therefore, one of the main tasks of the Biodiversity Conservation Strategy for the Sultanate of Oman should be mitigating rangeland degradation and protecting livestock number from declining.

## *2.5 Fish Resource:*

Fisheries of Oman represent a major asset which is only partly exploited. Fish resource is considered to be one of the most natural resources of Oman after oil and gas. The fish resource is expected to be eroded if over fishing and loss of small pelagic continue, It could be stated that by careful harvesting the resource can offer a significant contribution to the economy and continue to do so, on a sustainable basis.

[(1)] Agriculture Sector: Executive Summary, A Report for (Vision Oman's Economy – Oman 2020) Ministry of Agriculture and Fisheries, June 1995, P.4

### *2.6 Wildlife:*

The deserts of Oman are rich in biodiversity. Natural vegetation (flora) in Omanis highly diversified and plant species are counted by thousands. The same is said with regard to fauna: Leopard, Arabian Tahr, Arabian Gazelle, Birds, Rodents, Feral Donkeys, Red Fox, Oryx and hundreds of insects and much of terrestrial species lie outside protected areas. There is an open access to most biological resources and almost everyone is entitled to exploit these resources. People living in deserts still depend heavily on native flora for grazing, fodder for domestic livestock, fuel, building materials, herbs, remedial medicines and other plant products.

Over-hunting of wildlife normally lead to severe declines in population of a number of species particularly terrestrial mammals. Overgrazing in rangeland has led to threatening the livelihood of the local population, while uncontrolled tourism has vandalized and degraded the value of the cultural heritage. Other threats to wildlife species come from the uncontrolled killing of turtles for their meat and shells. Over-harvesting of herbs may deplete these important species to the point of extinction, although international research has yet to discover which plants may prove useful in the future as drugs to treat illnesses.

Despite the overwhelming importance of wildlife as genetic diversity to be preserved, its role in consumption and production is economically important. Thus the killing and harvesting of wild animals and plants is still largely practiced and efforts must be taken to ensure that this exploitation is sustainable. Non consumptive wildlife use could also provide considerable returns from tourism and hence raise living standard of local and urban people alike. .

For example, in some countries, marine mammals have been considered for a long time of considerable economic value for their meat and oil. Several coastal people and local communities have in the past particularly depended on them for subsistence, and a few still do so. Commercial hunting has however reduced the populations of highly valued species to the point that their harvesting could not be sustainable. In Oman, whales are not hunted and together with dolphins and coral reefs they contribute to the tourism revenues. In fact nature-based tourism development in Oman depends heavily on wild flora and fauna, desert mountainous areas, traditional lifestyle and cultural sites.

Coral reefs are the richest of all marine habitats in Oman. They are distributed over the entire coast of the Sultanate which extends for about 1700 km, with increasing extensiveness and diversity in Musandam coast.

Even if they are not directly exploited or used for consumption, coral reefs are extremely important for the fishing industry since they provide shelter for fish to breed, live and grow. Therefore the degradation of coral reefs will disrupt not only corals habitat but fish habitats as well. Protecting corals from quality deterioration would also ensure the sustainability oftourism revenues resulting from scuba diving.

# III ECONOMIC VALUATION OF BIODIVERSITY

### *3.1 Quantification Approach: A Step Forward*

In the previous sections, an attempt was made to establish that biological diversity is economically significant. Generally, species and ecosystems bring economic benefits, hence, they should be conserved for the welfare of the society. What is left is to quantify these benefits. Indeed, the fact that many biological resources are unpriced has forced environmental economics to refine innovative methods to investigate the preferences of the people regarding the environment to determine the value of resources that many people may never directly experience This makes the use of these approaches being the subject of considerable controversy. Practically, biodiversity is almost always perceived in descriptive and scientific terms rather than in quantitative and economic measures. This is basically due to difficulties of quantifying the socio-economic benefits of conserving biological resources. It should be stressed that the problem of pricing and quantifying the economic value of biological resource is engendered by the current National Account System which does not include the costs and benefits of the ecosystems for various production activities. However, this paper endeavour to apply a quantitative approach to the economic valuation of some selective renewable biological resources in Oman. This task is essential in any conservation strategy since "Putting an economic value on biological resources is important because conservation trade-off represents very real choice for allocating scarce resources … spending on items perceived as providing little or zero return will be minimum [(1)]."

### *3.2 The Economic Valuation Model of Oman Biodiversity (EVAMOB):*

To assess the economic significance of biological resources, a simplified mathematical approach is adopted. The following steps comprise the main feature of the EVAMOB:

1- Six resources are chosen for economic assessments, They are: agriculture, fisheries, livestock, water, land, and wildlife, as they form the main species/ecosystems in the national macro economic system (Table No. 7)

**Table No. 7**
**Tangible and Non-Tangible Benefits of Natural Resources (RO. Million)**

| Benefits / Resources | Tangible Benefits | | | | | Non-Tangible | Overall Benefits |
|---|---|---|---|---|---|---|---|
| | GDP | Consumption | Exports | Wages | Total Tangible | | |
| Agriculture | (1) 80 | (7) 35 | 45 | (12) 20 | 180 | (13) 300 | 480 |
| Fisheries | (2) 50 | (8) 50 | 27 | 10 | 137 | (14) 1 | 187 |
| Livestock | (3) 100 | (9) 20 | 43 | 10 | 173 | (15) 30 | 203 |
| Water | (4) 150 | (10) 110 | - | 20 | 200 | (16) 200 | 450 |
| Land | (5) 40 | (11) 400 | - | 20 | 400 | (17) 200 | 660 |
| Wildlife (Tourism) | (6) 500 | - | - | 21 | 521 | (18) 20 | 541 |
| Grand Total | 920 | 575 | 115 | 101 | 1751 | 751 | 2502 |

**Methods of estmating the figures of this table are explained in page ( ) Point No. 33*

(1) Dr. Moran, D. and Dr. Pearce, David, "The Economies of Biological Diversity Conservation", Expert Group Meeting on the Arab Cooperation in the Area of Protection of Biodiversity, Tunis 9-12 Nov. 1998, P.

2- Four economic entities which are subject to be influenced by the chosen natural resources are valuated. These economic entities are: GDP (Gross Domestic Product), consumption share for each resources, value of export for the year 1997, and compensation of employees (wages).

3- Benefits in EVAMOB are of two kinds: the first is tangible benefits which have true values recorded in the statistics or calculated from relevant data. The second is, non-tangible, or the hidden gains that the national economy could obtain from the resources. Such benefits have not been estimated. The economic values attached to them in EVAMOB are value judgement based on relatively accepted economic explanation.

4- Tangible and non-tangible benefits form the actual economic value of a resource, this implies that neither its share in the GDP nor its value of output alone correctly represents the overall yield or return of a resource.

Therefore EVAMOB provides the policy makers with strong evidences when they establish their new development philosophy. It also provides planners, NGOs, environmentalists and the public with powerful thinking approach when advocating the positive return on conservation investments. Table No. 6 reveals the total GDP shares of all chosen resources for the year 1998 that is RO. 920,000*. Nevertheless this is just the face value while the real economic value is double this face value, and reaches RO. 1,751 million. But when considering the non-tangible benefits the overall benefits increase about three times the face value. The figure 2502 million which is the final outcome of EVAMOB is in effect a bio-economic asset although it sounds illusive entity, yet it truly reflects the reality. One may think that EVAMOB calculation is complex and elusive. This is partly because such calculations have not yet developed as a public policy tool, and partly because economists and policy makers normally make frequent use of the national income measure of (Gross National Product GDP) according to National Accounts System (NAS) which completely ignores the true economic value of biological resources and view the sales of non-renewable resources entirely as income.

However, EVAMOB requires further development to include other species/ecosystems. Besides, the basis of calculation should be refined to allow relatively precise economic valuation.

### *3.3 Methods of Calculations and Estimation of the Model's Variables*

**Shares of Resources in GDP**

1- GDP of agriculture is the average of the period 1988-1998 as shown in the Statistical Year Book (27th issue, 1998)
2- Fisheries share GDP, same method as above.
3- Livestock share GDP calculated from JIACA, Agriculture Masterplan, tables of food production/ in the National Conservation Strategy of Oman, vol. II, Appendices.
4- Watershare GDP: derived from cost of water to various uses as follows:

| Use | Quantity $mm^3/y$ | Cost/$m^3$/baisa | Total cost R.O. mill. |
|---|---|---|---|
| Agriculture | 1487 | 10 | $\frac{1487000000X10}{1000}$ (14) |
| Industry + Household | 200 | $\frac{440 + 660}{2}$ = (550) = | $\frac{200000000X550}{1000}$ = (110) |

- quantities taken from table No.2 of this paper (commercial uses is added to industry and household raising the quantity from 158 to 200 $mm^3/y$)

5- Land share GDP: Estimated as intermediate consumption for agriculture and industrial production: value added for agriculture for the period 1988-1998 (annual average) less average annual wages = 80 million represent contribution of both land and water, assuming each has equal importance, thus land share in GDP is estimated 40 million for other uses excluding agriculture.

6- Wildlife share: Tourism revenue used as a proxy to GDP share since most tourism is nature-based (terrestrial and marine). Tourism share in GDP in 1998 was 1%, so a moderate estimation in absolute figure could be RO. 500 million.

**VALUES ASSOCIATED TO CONSERVATION:**

7- The coverage of agricultural (crops) production to local consumption needs is estimated as R.O. 35 million.

8- Fish local consumption estimated as 400,000 tons in year 2000. Average price per ton is about RO. 500.0, so total value of consumption is estimated as RO. 50 million.

9- Livestock consumption value estimated as RO.20 million based on beef production of 3000 tons with an annual growth rate of 4% plus mutton production in the same year expected to be 6000 tons. Beef and mutton production will be about 10,000 tons. Average price per 1kg equals RO. 2 that brings total value of meat production to RO. 40 million assuming all production is consumed locally, while erting only for live animals (camels).

10- Water consumption value for household, industry and commercial uses is estimated to be RO. 110 million as explained in point 4.

11- Value of land allocated as input for all activities (excluding agriculture) estimated to be RO. 400 million. It is assumed that land value generally represents 15-20% of the total cost of a physical structure. According to National Accounts Bulletin, Second Issue, January 2000, total intermediate consumption for GDP of all sectors was about RO. 2151 million less agricultural intermediate which is RO. 47 million (as land value in agriculture is already estimated) the remaining is RO. 2368, if multiplied by $\frac{15+20}{2}$=17% the result will be the representing land consumption value (RO. 400 million).

12- Exports are calculated from Foreign Trade Statistics for the year 1997.

**Non-Tangible Benefits**

13- For agriculture: RO. 800 representing the following unaccounted values.

- agricultural animal feed, herbs and medicines, honey bees feed, support other species to exist .. etc.

14- Fish resource non-tangible benefits: RO. 50 based on pelagic – used as fodder. Fish loss is estimated over 10% of total landing if only 5% is kept as feed and sold at a low price of RO.100 per ton the earning will be $\frac{118000 \text{ X } 5 \text{ X } 100}{100}$ = RO. 600,000 plus other

disguised benefits such as transportation, storage activities, boats, nets making and maintaining, the value of all these activities is roughly estimated at RO.400,000 so total non-tangible benefits will not be less than one million.

15- Livestock non-tangible benefits are estimated to be RO.30 million coming (in addition to slaughtering) from animal oil, diary product and from livestock remaining parts like – skins, horns, …etc.

16,17: Land and water hidden values are considered to be RO. 200 million for each resource. This is based on value judgement estimation considering that land and water form the foundation on which plants, animals, and micro-organisms interact with one another and with the physical environment . Isn't that a non-tangible benefit for both land and water? It is worth to weigh this vital role a percentage of 50% of all accumulated hidden benefits.

18- Wildlife non-tangible value is estimated to be RO 20 million based on the expected job opportunities created by protection and monitoring requirements, entry fees to nature reserves, herbs and medical plants from wild flora …etc.

### 3.3 ECONOMIC VALUATION BY SUSTAINABILITY AND UTILITY CRITERIO

This is another, but more analytical approach to measure the economic significance of biodiversity. This approach utilizes the concept of sustainable income generated by rational use of environment ( natural ) resources, as pre- requisite for any welfare objective , and utility concept to reflect the value of biodiversity.

**SUSTAINABILITY CRITERIO**

The essence of this analysis is to incorporate the conservation of natural capital when considering national production, systematically, let;

$NNP_{(EN\ .\ AD)} = NNP – (DE – NCD)$

Where,

NNP = Net national Product ( Environmentally Adjusted).
DE = Defensive Expenditure ( intermediate inputs).
NCD = Natural Capital Depreciation (depletion of natural resources).

This equation implies that (NNP) is the overall product, as calculated according to Social National Accounts, irrespective how much of it might be depleted through the

production process. It follows that the national Income will decline f not certain amount of expenditure is devoted to conservation. Therefore, if welfare is defined by some criterion of sustainability as the maximum level of consumption which will not affect the prospect of consumption. Then this welfare could only be achieved if "appreciation " replaces " depreciation" by " defending " the Natural capital from depletion. In other words, $NNP_{ED}$ is the sustainable national income which secures social welfare by keeping consumption from dropping, Grammatically, as shown in the figures, there are three consumption trends against time: Decreasing, increasing and stable. Only figure (2) reflects a case of sustainable income since consumption curve rises with income increase because: C = f(y), whereas figure (1) indicates a case of unsustainable income in which natural capital depreciated or resources degraded. The stable consumption level in figure (3) reflects a critical welfare level.

**FIGURE 1**

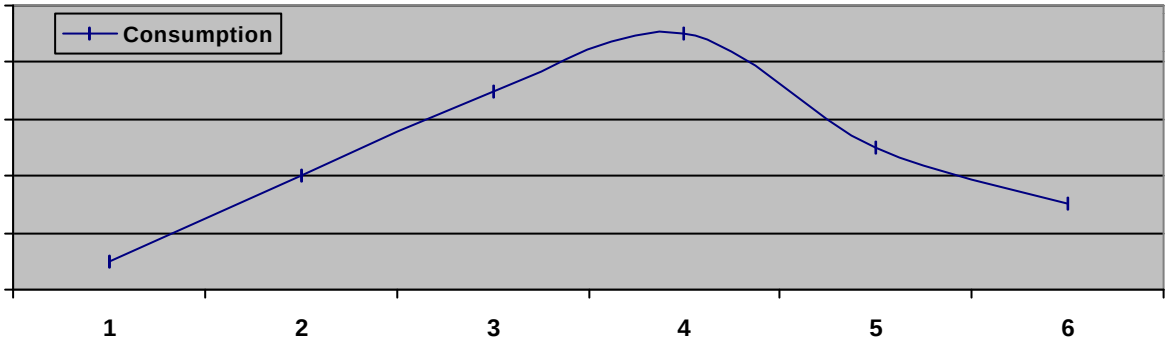



**FIGURE 2**

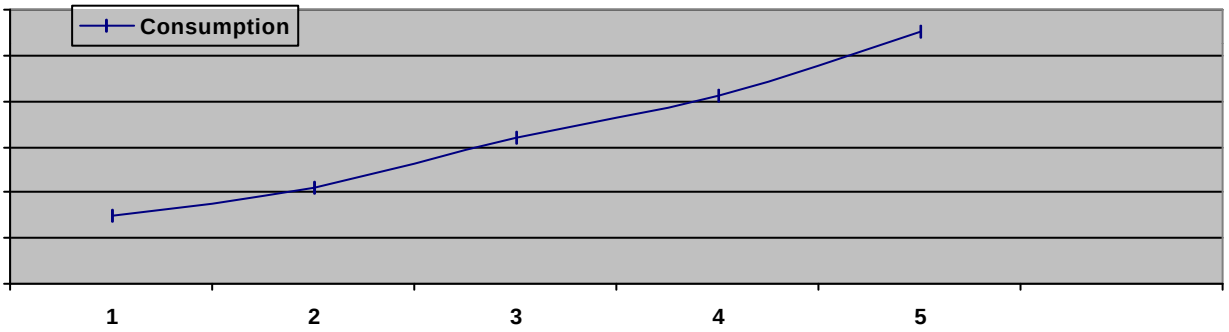
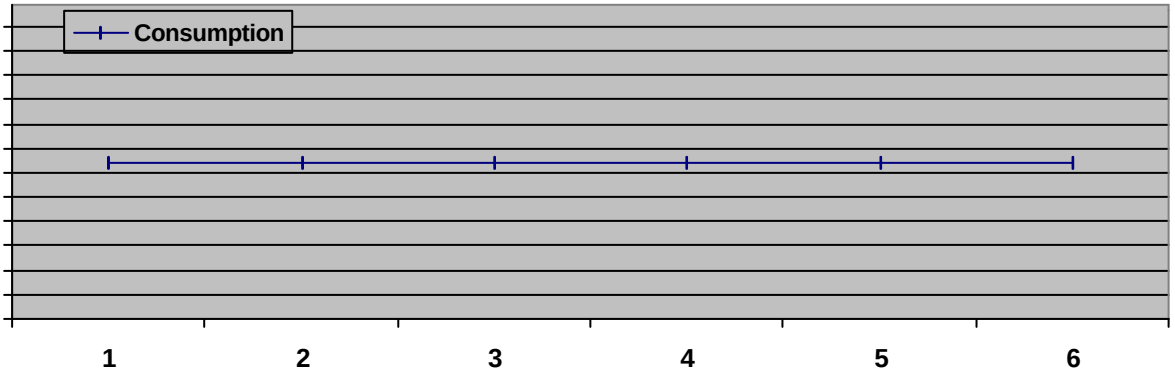



**FIGURE 3**



**UTILITY CRITERION**

Biodiversity of any society represents the asset " wealth " of that society. Each society places value differs from what other society does. If a society place zero value to a resource or specific species, then this means no market utility could be derived from it, that is; Utility = f (Bio).
Since utility stems from expected value, and this value could be calculated, then the Biodiversity value could be estimated.

This may be perceived as:
The value of Utility equals the rate of return of the asset, so it is (flow) which we can apply to evaluate the stock which reflect the value of Biodiversity.

Suppose the coral reef in Galabadous coast in Ecuador, or Musandam in Sultanate of Oman, or Ras Mohamed in Egypt, adds U.S $ 1000.000.
Per annum as truism returns, and the rate of return of this asset (reef) equal, the market interest rate, say 5%, then the value of this asset = 1000.000 = 5/100 x Asset (reef).
Asset (reef) = 100/5 x 1000.000 = 20 millions U.S $.

Let us revise once again the previous analysis of the environmentally adjusted net, National production ($NNP_{ED}$), and the driven sustainable income (welfare objective function).
When considering the (right) of the coming generations to produce, consume, and live happily, one may think of maximizing the objective function (welfare).
Here, the application of an optimization technique seems possible to maximize not a "specific point " but a " flow " or maximizing the value of the asset over time in an increasing pattern of the rate of return to natural capital, or the biodiversity.

However, sophisticated linear programming if applied, would require so much empirical work and numerical data to properly define the objective function and the constraints. Non-the-less it worth more discussion.