ANNEXURE 3: Details on Discounting in an Economic Analysis

The discount rate used for the economic analysis of projects with environmental impacts is the same as without these impacts but both are different from the rate used in the financial analysis in which only the opportunity cost of capital is considered. The approach recommended here for its practicability is to calculate a discount rate embodying both the opportunity cost of capital and the social time preference, i.e. the weights society places on consumption at different points in the future. The economic net present worth (NPW) of a project is:

$$NPW = \sum_{t=0}^{\infty} \frac{Bt - Ct}{(1 + r)^t} - \alpha K_0$$

where:

Bt and Ct	are the social benefits and costs in year t
r	is the rate of social time preference (also called social discount rate, SDR)
K_0	is the capital invested in terms of year zero
α	is the opportunity cost per dollar of public investment usually in terms of private investment forgone

The term α in the above formula is sometimes called the shadow price of investment. It replaces the nominal price of funds of one dollar per dollar. If α=2, the investment must show a present value of 2 dollars per dollar. It depends on the percentage of funds diverted from the private sector, if any, and on the opportunity cost of capital from the private sector. In its simplest form α could be derived as

$$\alpha = \frac{\rho}{r}$$

if we assume that reinvestments in perpetuity in the private sector are included in the private sector opportunity cost of capital ρ. To the extent that capital markets are not perfect and that externalities exist ρ and r are different. The social rate of time preference is usually lower than the opportunity cost of private capital and so $\alpha > 1$.

The rate of social time preference still needs to be determined and cannot be derived from an aggregation of individuals' market-revealed time preference since private and collective time preference are two different things. People may be ready to sacrifice for future generation knowing that others would be prepared to do the same. Given the imperfections of our markets and policies, for example with respect to the environment, the derived rates of capital productivity or opportunity cost of capital cannot be used as a measure of r. One is then left with the political process to establish the social time preference. It is assumed that the policy maker's goal is to transfer to the next generation a resource base equivalent to what the generation has. One way to do so, is to set r as an unknown to find the IRR of the investment. Repeated decisions for some kind of projects with specific environmental impacts would imply a range of social discount rates which eventually could serve as a guide for future decisions concerning similar projects.

ANNEXURE 4: Environmental Impacts and Multi-Attribute Analysis

1. Impact Matrix

The following steps are necessary for constructing an impact matrix: (a) identify the impact, (b) measure of impacts, (c) identify relationships between project's impacts and environmental quality, and (d) determine environmental quality index of each single environmental resource. To identify impacts different guidelines exist for sector. As far as environmental impacts are concerned, several guides and software have been developed which have proved useful in the identification of the potential environmental impacts of development projects. Among these are the Environmental Assessment Sourcebook of the World Bank and Ecozone, software developed by the FAO for the identification of environmental impacts of agricultural development projects.

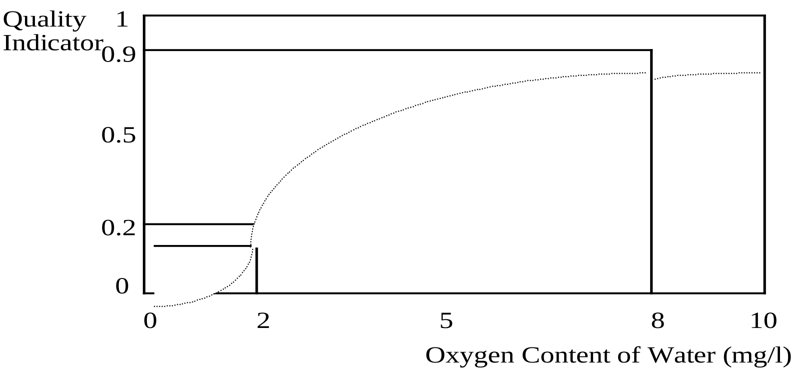
A variety of methods exist for *measuring* in quantitative (physical) terms the development projects' impacts on the environment. Sometimes this is done by summing up all the impacts affecting the same environmental resource during the project life (for example, all impacts on soil quality of an agricultural project are summed up for obtaining the aggregate impact of the particular project during its economic life). Another method could be to consider only the maximum value of an impact. This is the case, for example, of a situation where thresholds or standards are imposed. Only the impacts affecting the environmental resource beyond the thresholds and standards are considered. Other methods used depending on the circumstances are the minimum impact, the average impact, etc.

Once the above measures have been obtained, the *functional relationships* between impacts and environmental quality must be assessed. This step deserves particular attention in that it allows assessing how the environmental quality changes at a marginal change of the environmental impact. In other words the following question is answered: how does the environmental quality change at a change of pollutant emissions?

Physical relationships are measured by *environmental quality indicators,* usually comprised between 0 and 1. This step sometimes also named *normalisation* allows obtaining comparable scales among the criteria and may facilitate the computational problems inherent to the presence of different dimensions in the impact matrix. For example, environmental criteria can be measured in numbers of endangered species, hectares of new forests, grams of pollutants in water or air, and so forth. Normalisation would translate these dimensions into dimensionless units. There are various ways of normalising the project impacts. The method referred to here assumes that all environmental impacts can be assessed on the basis of environmental quality indicators that range from 0 (very bad quality) to 10 (very good quality). The next step is the construction of the matrix in which the rows indicate the environmental resources and the columns the alternative projects (Table A-5)[12]. An illustration of the above concept is provided in Box A-1.

Box A-1: Environmental quality indicators

The following graph illustrates the functional relationship between water quality (environmental resource) and quantity of oxygen dissolved. If a development project increases the quantity of oxygen from let say 2 mg/l to 8 mg/l, then the quality indicator of water will increase from 0.2 to 0.9 and vice versa, if the development project impact reduces the oxygen content of water from 8 mg/l to 2 mg/l, the quality of water will decrease from 0.9 to 0.2.



[12] The environmental quality indicator is always attributed even when the project will have no impact n a particular environmental resource. In this case, the indicator will be the same as in the without project situation.

Table A-5: Valuation matrix

Environmental Criteria	a	b	c	d
1. Water quality	0.8	0.9	0.6	0.6
2. Soil erosion	0.5	0.7	0.6	0.7
3. Air pollution	0.6	0.9	1	1
4. Flora species	0.8	0.8	1	1
5. Fauna species	1	1	0.7	0.6

In this example only criteria related to environmental impacts have been considered. The addition of social or economic related criteria would not affect the procedure.

2. Dominated Alternatives

The comparison between environmental quality indicators displayed in the valuation matrix will allow identifying if there is an alternative that shows better or at least no worse results than the others for each single indicator. In this case we say that this alternative dominates or is superior to the others and represents the best solution for decision-makers. If all quality indicators but one of an alternative are superior, it will not be possible to take a decision since the entity of the inferior indicator may outweigh the other positive impacts. Other techniques are therefore necessary to proceed with the analysis, such as the ones described in the following sections.

ANNEXURE 5: Advanced Decision-Making with MCA/MAA

1. Identification and Verification of Ranking Parameters

Other ranking approaches often used (aside from simple aggregation) are: worst score, weighted worst score, and weak dominance of absolute indicators of concordance and discordance.

The *worst score* parameter is employed when one of the main objectives is to minimise the risk that adverse and irreversible impacts occur. The ranking procedure is to: i) identify the worst quality indicator for each project; ii) select the project that shows the best performance among the worst quality indicator.

This technique does not require weights to be defined and is therefore particularly simple and suitable for situations in which it is assumed that all environmental resources affected have the same importance. An example of project ranking with this technique is provided in Box A-2.

Box A-2: Project ranking using the worst score technique

The valuation matrix of Table A-5 displays the environmental quality indicators of 5 environmental resources and 4 alternative projects. The worst scores of that table are the following:

Alternative Projects	Indicators	Ranking
a	0.5	3rd
b	0.7	1st
c	0.6	2nd
d	0.6	2nd

Project b will be chosen

The ***worst weighted score*** technique is similar to the previous one except that environmental resources are weighted on the basis of their perceived importance in the total quality of environment. The procedure is to: i) attribute a weight to the affected environmental resources;

ii) identify the worst weighted quality indicators for each project; iii) choose the project with the highest score among the worst indicators (Box A-3).

The *weak dominance and absolute indicators of concordance and discordance* technique is based on the Pareto improvement concept according to which dominated alternatives (i.e., projects that show all inferior indicators) should be eliminated. However, when a high number of impacts or environmental resources are taken into account this approach is not appropriate since it is plausible that at least one indicator of one particular project will be better than the competing projects.

Box A-3: Project ranking using the weighted worst score technique

Environmental Resources	Weights
1	0.271
2	0.302
3	0.215
4	0.107
5	0.105

All the indicators of the valuation matrix (Table A-5) will be multiplied by their weights in order to obtain the following weighted valuation matrix:

Table A-6 Weighted valuation matrix

Environmental Criteria	Alternative Projects			
	a	b	c	d
1	0.2168	0.2439	0.1626	0.1626
2	0.151	0.2114	0.1812	0.2114
3	0.129	0.1935	0.215	0.215
4	0.0856	0.0856	0.107	0.107
5	0.105	0.105	0.0735	0.063

Alternative Projects	Scores	Ranking
a	0.0856	1st
b	0.0856	1st
c	0.0735	2nd
d	0.0630	3rd

Projects a and b will be chosen

Moreover, with this approach the analysts are not able to rank non-dominated alternatives. In order to overcome these constraints methods based on the "weak dominance" concept have been developed. Among the many existing methods ELECTRE (Elimination Et Choix TRaduisant la rEalité) has been widely used in the developed countries. It consists in the computation of two matrices named "Matrix of Concordance" and "Matrix of Discordance". These matrices can be used directly for ranking the alternative projects or be compared with some predefined "threshold values" (weak dominance) of concordance (TC) or discordance (TD). They also can be used for computing absolute indicators of concordance (IC) and discordance (ID).

Matrices of concordance and discordance are constructed with the technique of paired comparisons among alternative projects. Let start with the concordance matrix, two alternative projects *a* and *b*. The concordance value of *a* with respect to *b* will be the sum of the environmental resources' weights for each environmental quality indicator of *a* > *b*. The same value is taken in the case environmental quality indicator of *a* = *b*.

The formal mathematical expression is: $C_{ab} = \{ j \mid z_{ja} \succ z_{jb} \}$

where: C_{ab} = concordance value of project a with respect to b

j = all criteria j

Z_{ja} = all criteria j of project a

Z_{jb} = all criteria j of project b

Box A-4 provides an example.

Box A-4: Construction of the concordance matrix

We know from the valuation matrix of Table A-5 the environmental quality indicators of our projects' impacts. We also know from Box A-3 the weight of each environmental resource. The calculation of concordance values will be as follows:

Concordance Value (*a*,*b*) (i.e., concordance value of project *a* with respect to project *b*) =
0.107 + 0.105 = 0.212
where 0.107 and 0.105 are the weights of environmental resources for which environmental quality indicators of *a* are higher or equal to *b.*

Concordance Value *(b,a*) (i.e., concordance value of project *b* with respect to project *a*) =

0.271 + 0.302 + 0.215 + 0.107 + 0.105 = 1.000

Proceeding with the paired comparisons the following Concordance Matrix will be obtained.

Table A-7. Concordance matrix

Alternative Projects	a	b	c	d
a	-	0.212	0.376	0.376
b	1.000	-	0.678	0.678
c	0.624	0.322	-	0.698
d	0.624	0.624	0.895	-

Similarly to the concordance matrix, the *discordance matrix* is constructed by comparing single pairs of alternative projects. The discordance value of project *a* with respect to project *b* is calculated as the highest difference between the environmental quality indicators of project *b* and those of project *a*. Contrarily to the concordance matrix, weights are not required here. Box A-5 illustrates how to construct the Discordance Matrix.

The mathematical expression will be complementary to the previous one:

$$D_{ab} = \{ j | z_{ja} \text{ p } z_{jb} \}$$

Box A-5: Discordance matrix construction

We know from the valuation matrix of Table A-5 the environmental quality indicators of our projects' impacts. The comparison between the project *a* and the project *b* tells us that the highest difference between the environmental quality indicators of project *b* with respect to project *a* is 0.3, corresponding to the environmental resource 3. The discordance value of project *b* with respect to project *a* will be the highest value of the difference between environmental quality indicators of project *a* with respect to project *b*. That is 0 because all the indictors of *a* are lower or equal to those of *b*. The other values will be computed in the same way and will be entered in the Discordance Matrix below.

Table A-8. Discordance matrix

Alternative Projects	a	b	c	d
a	-	0.3	0.4	0.4
b	0.0	-	0.2	0.2
c	0.3	0.3	-	0.1
d	0.4	04	0.1	-

Once the two matrices have been constructed it is possible to proceed with the ranking of projects on the basis of the "weak dominance" approach or by computing for each single alternative the "absolute indicators of concordance and discordance".

The *weak dominance* approach requires that two thresholds be defined: the concordance threshold (CT) and the discordance threshold (DT). The alternative *a* will dominate the alternative *b* if its concordance value is higher than the CT and its discordance value is lower than the DT. If more than one alternative respect the above rule thresholds will be changed (CT will be decreased and DT increased) up to the point were only one alternative dominates the others. Box A-6 illustrates how to apply the above approach.

The *absolute index of concordance and discordance*: these indexes are computed as the difference between the sum of concordance or discordance values displayed in the rows of the matrices and the values displayed in the columns. The first index measures by how much the alternative *a* dominates the others. Therefore the higher the value the better the alternative chosen. The second index measures by how much the worst alternative is dominated. Therefore the smaller its value the lower the adverse effects if this alternative is chosen. Box A-6 illustrates how to compute these indicators in our example.

Box A-6: Ranking of projects using the weak dominance approach

Once the concordance and discordance values have been computed, two thresholds must be defined: CT and DT. Assume these thresholds to be 0.8 and 0.4 respectively. From the concordance and discordance matrice we observe that project *b* has the highest concordance value , followed by project *d*. The ranking will therefore be as follows:

Alternative Projects	Dominant	Dominated
a		4th
b	1st	
c		3rd
d	2nd	

Which will the dominant and the dominated alternatives be if CT = 0.65 and DT = 0.4 ?
Which will the dominant and the dominated alternatives be if CT = 0.6 and DT = 0.4?

1st Answer

Dominant	Dominated
b	a, c, d
d	c
c	d

2nd Answer

Dominant	Dominated
b	a, c, d
d	c, a, b
c	d, a

Box A-7: Ranking of Projects Using the Absolute Indexes Approach

Once we have the concordance and discordance matrices, the indexes for project *a* are calculated by summing up the concordance or discordance values displayed in the row corresponding to project *a* and subtracting the sum of the values displayed in the column corresponding to project *a*. For project *b* the index will be obtained by summing up the values in the row corresponding to project *b* and by subtracting the sum of values of column corresponding to project *b*. Once all indices have been computed, the following summary table will be constructed.

Alternative Projects	Concordance Index	Discordance Index	Concordance Ranking	Discordance Ranking
a	- 1.284	0.4000	4th	4th
b	1.198	- 0.6000	1st	1st
c	- 0.305	0.0000	3rd	2nd
d	0.391	0.2000	2nd	3rd

REFRENCES

Convery, Frank (1995), 'Applying Environmental Economic in Africa', Technical Paper No. 277, Washington: World Bank.

Krutilla, John V. and Anthony Fischer (1975), The Economics of Natural Environments, Baltimore: Johns Hopkins Press.

Little, I.M.D., and J.A. Mirlees (1974), Project Appraisal and Planning for Developing Countries, New York: Basic Books.

Munasinghe, M. (1993), Environmental Economics and Sustainable Development, Washington: The World Bank.

Pearce, D.W. and C.A. Nash (1991), The Social Appraisal of Projects – A Text in Cost-Benefit Analysis, London: MacMillan Books.

Ward, W.A. and B. Deren (1995), The Economics of Project Analysis – A Practitioners Guide, Washington: Economic Development Institute of the World Bank.

Weisbrod, B. (1968), 'Income redistribution effects and benefit-cost analysis', in S.B.Chase, ed, Problems in Public Expenditure Analysis, Washington: Brookings Institute.

Winpenny, J.T. (1993) Values for the Environment – A Guide to Economic Appraisal, London: HMSO.

READINGS

a) Project Appraisal

Baum, Warren (1982), The Project Cycle. Washington, D.C.: The World Bank.

Gittinger, J.P. (1982), 'Economic Analysis of Agricultural Projects', Baltimore: Johns Hopkins University Press.

Harou, Patrice (1983), 'On the real rate of discount', Forest Science 29 (2): 249 - 252.

Harou, Patrice (1984)a, 'Possibilities for shadow pricing forestry investments', International Journal of Forest Ecology and Management (8) : 59 - 73.

Harou, Patrice (1984)b, 'On a social discount rate for forestry', Canadian Journal of Forest Research 15 : 927 - 934.

Savvides, S. (1994), 'Risk analysis in investment appraisal', Project Appraisal, Vol. 9, No. 1.

UNIDO, 1970. Guidelines for Project Evaluation, New York: United Nations.

a) Multi-Criteria Analysis

Hokey, M. and Storbeck J. (1991), 'On the origin and persistence of misconceptions in goal programming', Journal of Operational Research Society, Vol.42, n.4 pp. 301-312, 1991.

Ignizio P. (1984), Introduction to Linear Goal Programming, Beverly Hills: Sage Publications.

Martel J.M. and Belaid Aouni (1990), 'Incorporating the DM's preferences in the goal programming model', Journal of Operational Research Society 1990, Vol.41, n. 12.

OECD (1994), Project and Policy Appraisal - Integrating Economics and Environment, Paris: OECD.

Paelinck , J.H.P., and P. Nijkamp (1976), Operational Theory and Method in Regional Economics, Farnborough: Saxon House, (jointly with D.C. Heath, Lenxington)

Pearce, D. and K. Turner (1992), Benefits Estimates and Environmental Decision Making, Paris: OECD.

Romero C., (1991), Handbook of Critical Issues in Goal Programming, Oxford: Pergamon Press.

b) Participation

World Bank (1994), 'The World Bank and participation', Mimeo, Washington.

World Bank (1994), 'A review of techniques for systematic client consultation', Mimeo, Washington.

Romero C., (1991), Handbook of Critical Issues in Goal Programming, Oxford: Pergamon Press.

c) Participation

World Bank (1994), 'The World Bank and participation', Mimeo, Washington.

World Bank (1994), 'A review of techniques for systematic client consultation', Mimeo, Washington.