Handbook of Water Economics

Principles and Practice

Colin Green

University of Middlesex

WILEY

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1
Introduction

The relationship of the economy to the environment is as the leaf to the tree. Therefore, the decisions we take concerning the environment, and the effectiveness of the implementation of those decisions, will determine whether or not we achieve sustainable development. Economics, the application to choice, offers a means of understanding the nature of the choices we must make and, through this understanding, of making better choices.

Nowhere is this dependence of society and the economy upon the environment seen more clearly than in relation to water. Traditionally, the start of civilisation is ascribed to the settlements in the valleys of the Euphrates/Tigris, where the combination of fertile river-deposited sediment and readily available water enabled secure food supplies. The same pattern of settlement can be seen in other parts of the world from the Americas (Williams 1997) to Asia (Mendis 1999). That each society depends on water meant that we began very early on to try to modify the water environment for our purposes; the Shaopi reservoir was built around 590 BC, a navigation canal in Guangxi in 219 BC, and Dujiangyan dam in around 200 BC (Xhang 1999). In turn, the inability to manage water successfully, particularly under prolonged drought conditions, has resulted in the death of cultures in the Americas (Williams 1997) and Asia (Postel 1992).

One result of the dependence of society on successful water management is that until very recently water engineers saw their purpose as being to determine what the public need, to determine the best means of satisfying that need, and then to construct the required works. By defining the issue as one of necessity rather than desirability, the question of whether or not the project was desirable was finessed; it was instead inevitable. In turn, the task in water resource planning became one of predicting by how much demand for water would inevitably increase in the future and then providing for this increase. The assumption was that all growth is good as well as inevitable, and that economic and social development will necessarily require a proportionate growth in all inputs, including water.

That the identification of the possible options and the decision as to which is the best option were defined as being part of the engineer's job, led inevitably to both a focus on engineering approaches and to the identification of the best in terms of engineering issues. After all, engineers became engineers in order to build

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things and after all the socially construed role of engineers is to build things. That something could be done became to imply that something should be done. Whilst the result was a number of major engineering triumphs, there were a number of significant failures as well (Adams 1992); a number of expensive projects that had been built to match a predicted growth in demand that did not occur (USACE 1995); a growing recognition of the environmental and human consequences of some projects (Acreman *et al*. 1999); and an increasing questioning of whether some projects were really necessary (Bowers 1983; Reisner 1993). A significant number of projects have also never delivered successfully; in India, only some 70% of hand pumps are estimated to be working at any one time (South East Region 1999) and some 30% of the public latrines in Bombay are out of service (Operations Evaluation Department 1996).

Today, this dependence of development upon water management is even more pronounced. The availability and management of water is increasingly seen as perhaps the defining constraint upon development (World Water Council 2000), with an increasing number of countries reaching conditions of water scarcity. By 2025, IWMI (2000) estimates that 78% of the world's population will live in areas facing some degree of water scarcity. To release this constraint on development will involve major investments: the World Water Council (2000) estimates that annual investment in water management will have to rise to US$180 billion from the current US$70–80 billion in order to reduce the number of people lacking basic water or sanitation and to increase average calorific intake to a minimum of 2750 calories per day. Increasing food production to meet this target and to accommodate population growth is a critical problem. An oft-quoted figure is that it takes 1000 tonnes of water to produce 1 tonne of wheat, although the actual requirement depends upon amongst other things the potential evapotranspiration rate in the region (Rockstrom *et al*. 1999). In turn, whilst each person uses 7 to 100 tonnes of water in their home for drinking, cooking, washing and other purposes, another 1000 to 2000 tonnes of water is required to grow the food that they eat. It does not matter whether this water is delivered directly as rainfall, indirectly by concentrating the runoff from a wider area through rainfall harvesting, or through irrigation. Thus, whilst the average European uses twice their body weight of water in their home each day, the food that they eat has consumed roughly three tonnes of water. Growth in population and a shift toward higher meat consumption translate directly into a demand for more water.

However, it is not just water that is scarce; so, too, over much of the world is arable land, and most of the rest of the land is already in use as forests, wetlands and grasslands. In China, there is approximately 0.10 hectares of arable land per person so that roughly 2.5 square metres of land must supply enough food to feed one person for a day. A major benefit of irrigation is that more than one crop can be harvested in a year; consequently, irrigation in conjunction with high yield varieties and high inputs can yield 8000 kg/ha (Seckler 2000). Thus, 40% of the world's food is currently produced from the 17% of land that is irrigated.

About 50% of the world's population live partly or wholly in arid or semi-arid lands where not only is average rainfall less than 30 cm but there is wide variability in the amounts from year to year. Consequently, the IWMI (2000) estimates that meeting projected food requirements will require an expansion of 29% in the irrigated area together with an increase in irrigated crop yields from a global average of 3.3 to 4.7 tonnes per hectare. Or, alternatively, irrigated cereal yields will need to increase to 5.8 tonnes per hectare if the irrigated area is not to be expanded. Achieving either will require substantial investment. On a more parochial basis, of the £197 billion modern asset equivalent value of the water and wastewater system in England and Wales, £109 billion is the network of sewers (OFWAT 2002a). This is roughly equivalent to £7000 per household. If climate change results in an increase in the intensity of rainfall from the frequent events, as it is reported to have done in the USA (Hurd *et al*. 1996), then the costs of upgrading the network to cope with increased runoff will amount to a significant fraction of the current asset value.

At the same time, almost any intervention in managing water affects the environment either intentionally or incidentally. Globally, an estimated 20% of freshwater fish species became extinct, threatened or endangered in recent decades (Wood *et al*. 2000). We have, however, only recently realised the dependence of the economy on the environment; notably the functional value of the environment (de Groot 1987), and particularly the importance of wetlands (Pearce and Turner 1990). Constanza *et al*. (1997) sought to estimate the global value of the services provided by the environment on the basis of previously published studies. Whilst not too much attention should be given to the resulting values, since the leaf cannot value the tree, their paper further emphasises the dependency of the economy on the environment. Rivers conveniently transport runoff from those usually inhospitable places where there is high precipitation to those areas where it is most useful for human purposes. In addition, for centuries, rivers provided the best transport routes. Similarly, lakes and groundwater store water until we need it.

In the developed world, much of the current investment is going into undoing the damage caused by past intentional or accidental damage to the environment. The modification of the river Rhine for navigation and other reasons (the Upper Rhine has been shortened by 82 km and the Lower Rhine by 23 km) and the reclamation of the natural flood plains for agricultural purposes have created a number of flood problems. The results of the various works on the Rhine have cut the time taken for the flood peak to travel from Basle to Karlsruhe from 2 days to 1 day and from Basle to Maxau from 64 hours to 23 hours. This has tended to increase the risk that the flood peak on the main stem will coincide with that on the downstream tributaries. The discharge for the 200-year return period flood has also increased from 5000 m^3/sec in 1955 to 5700 m^3/sec in 1977 (Bosenius and Rechenberg 1996).

Much of flood management in Germany today is consequently concerned with removing some of these past modifications to the catchments, the river corridors

and the river channel itself and to reducing runoff, recreating storage in the flood plain and in restoring the natural form of the river (Bismuth *et al*. 1998). The Flood Action Plan (International Rhine Commission n.d.) is the archetype of this approach. The same principles are being applied to other rivers in Germany: for example, the planned recreation of some 28 wetlands on the Elbe (BMBF 1995). Similarly, in the Netherlands, both the plans for the river Meuse (de Bruin *et al*. 1987) and for the Rhine (Ministry of Transport, Public Works and Water Management 1996) involve the recreation of wetlands and a degree of river restoration. On smaller scales, river restoration, or 'daylighting' (Pinkham *et al*. 1999), is increasingly common in other countries (Brouwer *et al*. 2001; Riley 1998). In the USA, a number of dams have now been demolished (Pritchard 2001) and the discharge regimes of others are being modified to provide a more natural variation in the flow regime of the river downstream (Acreman *et al*. 1999).

Already in the UK, the costs of collecting and treating wastewater exceed the costs of providing potable water, and the Water Framework Directive (European Parliament 1999) will further increase these costs in Europe. The salts leached from irrigated soils have caused severe problems (Postel 1993), whilst pesticide and fertiliser residues, along with animal manure, are a widespread problem (Nixon 2000; USEPA 2000). Over-abstraction of groundwater has caused major problems in cities as diverse as Mexico City and Bangkok (Briscoe 1993), and some rivers, of which the Yellow River is simply the best known, also run dry because of over-abstraction (English Nature and the Environment Agency 1999).

In short:

- water is critical to social and economic development,
- over much of the world, both arable land and water are scarce,
- managing water is highly capital-intensive, and capital is also scarce; and
- there are environmental consequences to almost any intervention in the water cycle whilst the economy depends upon the environment.

In turn, water management is about seeking to change risks, to alter either the probability of some event or the consequence of that event whether that event be a drought, a flood, or a pulse of pollution. The individual risks may be vanishing close to zero or to one, but in principle the decisions are always about choosing risks. However, since choices are always about the future, we are seeking to choose the future but the one thing that the rational person can be absolutely certain about is that the future is inherently uncertain. So, we are seeking to make choices about risks under conditions of uncertainty. Indeed, I shall argue later that uncertainty is a precondition for a choice to exist.

Achieving sustainable development therefore requires us to make 'better' decisions: to be more successful at avoiding mistakes; to make more efficient use of available resources including water; and to maintain the environment as the necessary support for the economy. But, 'better' decisions are not simply technically better; they have to be socially better as well. We need to be more successful

in resolving the multiple and frequently conflicting objectives that we bring to decisions; in particular in regard to equity considerations. These objectives explicitly include a regard to gender equality, not least because women are often the principal sufferers from existing water problems (Mehta n.d.). Moreover their position has often been made worse by past projects (Rathgeber 1996) because they were seen as not having separate interests of their own but simply as part of a household production unit (Haddad *et al.* 1997). The adequate resettlement of those who, given the population density across much of the world, will be displaced by a project is now recognised as a question of justice and as necessarily involving that they will have a voice in the decision process (WCD 2000).

From the Dublin Declaration (ACC/ISGWR 1992) onwards, it has been accepted that public involvement in all levels of decision making is both an objective in itself and also essential if management plans are to be successful. Thus, the Government of New South Wales's (n.d.) guidelines on preparing River, Groundwater and Water Management Plans state that 'Community involvement is critical in identifying potential issues, differing values, opportunities and constraints, and available alternatives at a catchment level.' Similarly, in the UK, the DETR (2000) stated that: 'Public participation in making decisions is vital. It brings benefits in making an individual decision and also for democracy more generally. ... It is also a moral duty. Public authorities work for the public. To do so in a way that the public want and to ensure that they know what the public needs, they must involve the public when they make decisions.'

Adding new objectives and recognising the complexities has made decision making and identification of appropriate options more difficult where the options themselves are more complex. Twenty years ago, designing a flood alleviation scheme was easy: the engineer simply drew a straight line from A to B, built a concrete trapezoidal channel and called it a 'river improvement' scheme. Today, environmentally sensitive solutions can involve sewing together into one integrated system a myriad of small-scale local works.

However, we are of limited intellectual capacity and the decisions that face us threaten to be too complex for us to adequately understand the nature of the choice we must make. In his classic paper, G.A. Miller (1956) reported that experimental studies showed that we could handle no more than seven, plus or minus two, factors at a time. A raft of studies by Tversky and Kahneman (1973, 1981) and others (e.g. Slovic *et al.* 1976) have also shown that our cognitions are affected by all sorts of biases. The purposes of economic analysis are therefore three-fold:

- To simplify the nature of the choice to a level that we can comprehend;
- To enable us to understand the key elements of that choice; and
- To communicate that understanding to all of the stakeholders so as to form a framework in which they can debate, argue and negotiate their concerns.

At the same time, better decisions depend upon better options being created. In the past, there has been a tendency to propose that whatever approach had

been adopted in the Netherlands, or for the Mississippi, or for London, should immediately be adopted in Zambia, on the Yangtze and in Buenos Aires. The result has been that the latter countries have been supplied with expensive, inappropriate technologies that fail to work in the local conditions or, in some cases, have created a worse problem than that they were intended to solve. Akuoke-Asibey (1996) describes a rural water supply programme where the investment had effectively to be made three times before a sustainable system emerged; this experience has not been atypical. Many of those heroic projects also had significant, negative consequences, particularly in terms of the environment; the Aral Sea disaster is simply the best known of many failures. So, we have accumulated a history in which there were many projects that failed to deliver what was promised and, when they did, the other unintended or unanticipated impacts of the projects were significant.

However, this past can be painted too bleakly as if the whole history of water management was one of unmitigated failure which self-evidently it has not been. Moreover, we need to remind ourselves that development is not possible without failures; if we only repeat that which has worked in the past, there can be no improvements. If we seek to innovate, there will inevitably be some failures; indeed, we must legitimate failure as a way of learning if we want to innovate. The condition is that the failure should teach us something new and not simply repeat a past lesson. Clare Johnson (2001) paraphrased Al Capone by suggesting that once is a lesson, twice is a failure and thrice is incompetence.

One negative consequence of the history of only partial success has been that some people have sought to preclude some options, particularly dams, from ever being considered. At the same time, the myth of magic bullets has been updated with a new set of bullets, or several sets of bullets. Some of the more promising new options are in danger of being treated uncritically, as if they are always more appropriate than any of the options that have been used in the past. This is precisely the mistake we made in the past. As the World Commission on Dams (WCD 2000) emphasised, we need better ways of making decisions as well as better options.

Better options depend upon the creativity, imagination, experience and skills of designers; here economic analysis cannot help directly. But better options also depend upon the designers' understanding of the nature of the problem and here economics can help because it seeks to clarify what the decision all about, what is the problem and what are our objectives. Better answers often emerge as a result of better questions being asked.

The first and fundamental question that economics keeps asking is: why are we doing this? Again, experience suggests that after a project has been under design and construction for 10–15 years, the primary objective of all involved is to complete it. Again, once it is operational, the project is frequently operated in a particular way because that is what the manual says should be done. The second fundamental question economics asks is: what are the alternatives? There

is no point in being against some option unless there exists an option that is in some sense 'better'. Thirdly, it asks: what sacrifices do we have to make for this option? It is a presumption of economics that no choice is painless, that any choice involves a real sacrifice so that if a choice appears painless, it is only because the implications have not been examined. Fourthly, it asks: does it work? Many of the new options proposed as magic bullets turn out only to work in some conditions and to have significant problems. Thus, source control looked superficially to be an attractive way of resolving an urban flooding problem in one city; unfortunately, the city turned out to be so densely developed that implementing source control would involve massive resettlement.

2
What is Economics?

The popular definition of economics is that it is the study of the economy but few dictionaries of economics define the term 'economy' although definitions of subcategories such as market and planned economies usually are given. This absence of a definition shows both that economists do not define economics as the study of the economy and the apparent irrelevance of the economy to economics.

But, if economics is not the study of the economy, then it may be asked what it actually is. John Stuart Mill's (1844) definition of political economy actually came close to defining it in terms of the study of the economy: 'The science which traces the laws of such of the phenomena of society as arise from the combined operations of mankind for the production of wealth, in so far as those phenomena are not modified by the pursuit of any other object.' But later definitions of economics focus on the relationship between means and ends. Thus, Robbins (1935) defined economics as being: 'The science which studies human behaviour as a relationship between ends and scarce means which have alternative uses.' Similarly, Samuelson's (1970) definition is: 'Economics is the study of how men and society end up *choosing*, with or without the use of money, to employ *scarce* productive resources which could have alternative uses, to produce various commodities and distribute them for consumption, now or in the future, among various people and groups in society' (emphases in the original). On the basis of the definitions of Robbins and Samuelson, then the pithiest definition of economics and that which will be used here is: 'The application of reason to choice' (Green and Newsome 1992).

There is a further definition that ought to be mentioned and that is the one given by Hausman (1992): 'Economic phenomena are the consequences of rational choices that are governed by some variant of consumerism and profit maximization. In other words, *economics studies the consequences of rational greed*' (emphasis in the original). This is a somewhat aberrant definition in that the claim that economics is solely concerned with greed was explicitly rejected by Alfred Marshall, perhaps the key figure in the development of the dominant paradigm of economic analysis, neoclassical economics. Marshall (1920) wrote: '. . . the splendid teachings of Carlyle and Ruskin as to the right aims of human endeavour and wealth would not have been marred by bitter attacks on economics, based upon

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the mistaken belief that science (economics) had no concern with any motive except the selfish desire for wealth, or even that it inculcated a policy of sordid selfishness.'

2.1 Why Do We Have to Choose?

If economics is defined as the application of reason to choice, this simply shifts the burden to defining choice and reason. Conventionally, reason is essentially regarded as a rigorous, logical framework of argument, whether the argument is internal to the individual or made within a group of individuals seeking to determine what common course of action should be adopted. Conventionally, economics follows Russell (1954) in arguing that the application of reason leads to the choice of the best means of achieving some predetermined objectives: ' "Reason" has a perfectly clear and precise meaning. It signifies the choice of the right means to an end that you wish to achieve. It has nothing whatever to do with the choice of ends.' Thus, in neoclassical economics it is assumed that the objectives are givens and choices do not involve a choice of objectives. But, the difficulty of some choices lies precisely in that we have to choose between objectives. However, Kant (1785) argued that we should apply reason to determining what our objectives should be, and concluded that reason dictated that our objective should be duty. It seems reasonable therefore to assume that we may use reason to argue as to the objectives that we should seek to achieve. Furthermore although as Simon (1986) observed '... in economics, rationality is viewed in terms of the choices it produces: in the other social sciences, it is viewed in terms of the processes it employs', here I will refer to rationality purely in terms of a logical, rigorous process of argument. The outcomes of that process will only be consistent with each other if nothing changes in the interim: we neither gain new information nor learn anything.

The neoclassical economic model then asserts that choice is necessary because of the scarcity of resources: this is too narrow a definition of conditions that make choice necessary. For example, I have to make a choice to decide which part of a newspaper to read first and parents have to choose what name to give to a baby. Thus, a choice is necessary whenever the alternatives are mutually exclusive; a choice exists when there are two or more options and only one can be chosen. Conversely, if there is only one course of action, then there is no choice to be made. Equally, even if there are alternatives but one option is clearly to be preferred to all the others then effectively the choice has already been made. For a choice to still exist, the alternatives must compete in some way; it must be possible to argue that at least two options should be preferred to all the others but for a decision not yet to have been reached between the two options. For a choice to still exist, there need to be competing reasons that lead to different conclusions as to which option should be preferred. Once the logical argument leads to the conclusion that one option should be preferred to all others, then the choice is made.

The second condition for a choice to exist is that we cannot decide between the alternatives; we are uncertain as to which option should be preferred where we can define uncertainty as 'an inability to differentiate': in this case, in terms of the order of preference across the alternatives. Once we are reasonably confident that one option should be preferred to all others, then the choice is made.

Therefore, the simplest definition of the conditions under which we have to make a choice is:

$$\text{Choice} = \text{Conflict} + \text{Uncertainty}$$

Thus, we only have to make a choice when the available alternatives are mutually exclusive, the adoption of one precluding the adoption of the others, and it is not self-evident which is the best option to adopt. If all the stakeholders in the decisions are both certain and agreed as to which is the best option then only in the most trivial sense is there a choice to make. So choice is a process through which we seek to resolve the conflict and achieve a level of confidence that one option should be preferred to all other available alternatives. It is a rational process in that a rigorous, logical framework of argument is used to decide which option should be adopted.

If this definition of choice is adopted then a number of results follow:

- We may be falsely confident that one option should be preferred to all others;
- Conversely, we may be falsely uncertain as to which option should be preferred to all others; and
- Some choices may be truly marginal in that the reasons for choosing one option over another are exactly counterbalanced by reasons for making the opposite choice. It may, in short, be impossible to resolve the conflict even if we had perfect information.

However, the neoclassical economic model starts with the assumption of perfect information and then relaxes the conditions to allow choice under imperfect information. But, under the definition of choice just given, if there is perfect information there is no choice to make unless the options are all equally attractive. Consequently, to start with the assumption of perfect information is the least appropriate place to begin an analysis of choice. It is extremely unlikely that we will ever have perfect information and the logical starting point is one of uncertainty and how we may seek to reach a state where we can say with some confidence that one option is to be preferred to all others.

Finally, choices are necessarily always prospective: the choice and its consequences lie in the future. In short, we are always trying to choose a future and choices are between hypothetical futures or expectations of the future. We must make choices on the basis of what we expect will be the consequences of those choices and choices are always about what we 'ought' to do in one or both of the two senses of 'ought': that course of action that logically follows from the argument and that which morally should be done (Beyleveld and Brownsword 1994).

In turn, what I chose yesterday has no force in determining what I should choose today; 'is' does not determine 'ought' in either of the two senses of 'ought'. The choices we have made are no more than history and it cannot be argued that what we choose next should be consistent with what we have chosen before. Indeed, to the extent that we learn from the outcomes of the choices we have made in the past, our choices now and in the future will be different. In consequence, past purchasing decisions are ephemera of only historical significance. Whilst choices should logically be influenced by the lessons learnt from past choices, each choice is a new choice that, in principle, must be made anew rather than be dictated by the past. However, routine and habit, simple unthinking repetition of previous choices, are convenient ways of minimising the effort that must be put into making choices although they are treated with some contempt simply because they do not involve any thought, any rational process of choosing.

2.1.1 Conflict

The available alternatives can be mutually exclusive because of a number of reasons and often a combination of these different reasons (Figure 2.1).

2.1.1.1 Functional equivalence

If I am thirsty then I may choose between a cup of coffee or tea; I would be thought somewhat strange if I took a cup of each and even more so if I choose a cup of mixed tea and coffee. In this case, tea and coffee are functional substitutes although I may have a taste preference for one rather than the other

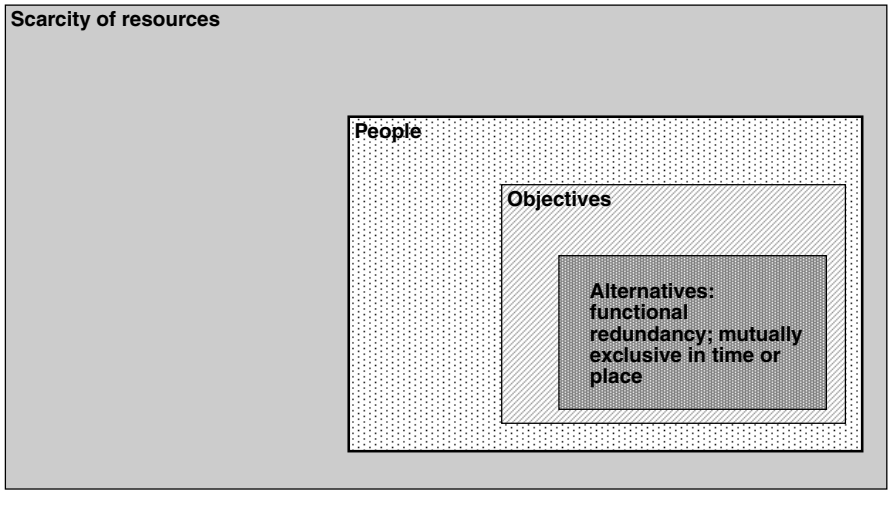

Figure 2.1 *The conflicts that make choice necessary*

at a particular point in time – and a preference that may also depend upon where I am. Similarly, faced with three possible sites from which to pump a given quantity of groundwater, it would be a waste of resources to develop all three.

If the extent to which two or more options are near perfect substitutes for each other is one reason why we can be forced to choose, it is easy then to become confused between different types of substitution. If I ask for a drink and am offered a pair of shoes, I would be surprised. We can distinguish between at least three different possible forms of substitution:

- functional substitutes;
- utility substitutes (the pleasure gained from one is equivalent to the pleasure gained from the other so that having one compensates for the other);
- exchange substitutes (one can be bought or sold for the other).

Thus, whilst I gain utility from both cups of coffee and pairs of shoes and I can sell a pair of shoes to buy a cup of coffee, a pair of shoes is of no use to me when I am thirsty. The danger is, as occurs in some economic analyses, that what starts as an assumption of one form of substitution then subtly glissades into another. In particular, collective choices are typically about functional equivalence, they are specific, e.g. the choice is about whether and how to provide a potable water supply rather than simply about increasing the sum of utility.

The concept of utility substitution is fundamental to neoclassical economic analysis but should not be confused with a lack of differentiation. One pair of shoes quite obviously can provide greater utility than another; Lancaster (1966) argues that a good, such as a pair of shoes, is a bundle of attributes each of which attributes is more or less desirable. In turn, there can be no constraints of the functional form of either the utility function with respect to an attribute, nor on the functional relationship of the utilities for the different attributes, nor as to the rate at which one good can be substituted for another. There is by now a very large literature covering utility theory and its measurement (e.g. Hull *et al*. 1987).

In fact, in making individual choices we can readily accommodate both a lack of functional equivalence for individual goods (e.g. someone will not regard someone else's wedding photographs as being in any way a substitute for photographs of their own wedding) and quite complex utility functions. It is only necessary to make the wider assumptions of universal utility substitution when economists seek to argue that individual choices and markets achieve the optimum.

2.1.1.2 Space

One fundamental reason why two options are mutually exclusive is that they cannot exist in the same space; a reservoir and climax forest cannot occupy the same space. Nor can two people sit on the same chair with any comfort. Similarly, I cannot go on holiday to two different places nor can a meadow be used for

pasture and planted with a crop of wheat. Again, it is not possible to have a 60 cm diameter and 90 cm diameter water main in the same trench since to place both pipes would be equivalent to having the capacity of a 108 cm diameter pipe.

2.1.1.3 Time

Similarly, the need to choose is often because of the constraints of time; we may be able to afford to rent two videos but cannot watch both of them tonight. Consumption is thus time constrained (Soule 1955) and the extent to which resources can be sacrificed to gain time is extremely limited. Indeed, in Western societies, we might argue that consumption is ultimately constrained more by the availability of time than by income. That there are more things we could do, and would like to do, than there is time to do them. The need to choose whether to visit the National Gallery or Hampstead Heath, for example, arises not because we cannot afford to do both but because we do not have the time to do both.

Most goods are time rivals: the time required for the consumption of one cannot simultaneously be used to consume another. Thus, it is not possible to watch television and weed the garden at the same time. Others are not time-rival goods and may be consumed simultaneously: most activities are apparently compatible with simultaneously listening to music. Equally, some goods are joint-time goods: drinking beer, reading a book and lying on the beach being one possible example.

Goods differ in their time availability. Some, like newspapers and many foods, are ephemeral: these only have a utility if they are consumed within a relatively short timespan. Others are only available for short periods of time; examples include television programmes and hot, sunny days. Yet others, such as landscapes are essentially permanently available although their utility will often vary over time depending upon other variables, notably the weather, the time of day and the mood of the children.

Moreover, only a few goods can be consumed in discontinuous time segments; most require a discrete segment of time. Thus, whilst a newspaper or book can be put down and picked up later, a meal or holiday requires one continuous period of time.

Consequently, one of the major problems faced by the consumer is the time scheduling of consumption. The availability of the good and the time to consume it must be matched: the individual must maximise utility by choosing that good which has the highest value from those available in that time period. Consequently, the opportunity cost of consumption is the utility that would have been gained from the next most desirable consumption within that time period.

Furthermore, the individual's time is already subject to a schedule which is relatively fixed before consumption can be considered. Patterns of sleep cannot be easily changed into amounts or timings in order to take advantage of consumption opportunities. Similarly, the timing of consumption must conventionally be arranged around the timing of work, or school, or in families. Thus, one possible reason for the popularity of video-recorders is that these enable goods which are

only available at a single point in time, television programmes and films, to be stored until either time, or the most appropriate time, is available for their consumption.

Few economists have paid any attention to this question although geographers (Carlstein 1982) have been concerned. But as Soule (1955) noted, it is arguable that increasing consumption is constrained primarily by the time available, and by the problems of time-scheduling consumption, rather than by resources. Local recreation is perhaps particularly constrained by time, the decision being which visits to undertake in the time available rather than by income since parks, coasts and rivers typically involve no entrance charge and the resource costs of travel on foot are negligible. Similarly, the resource costs of reading a book, watching the television or listening to the radio or hi-fi are also negligible once the book, television or radio has been bought. The decision of which of these activities to undertake is thus likely to be governed by consideration of what other activity could be undertaken in the same period of time rather than by comparing the resource costs. As Table 2.1 shows, a considerable proportion of a household's time is spent in such activities and on the input side of a household's life, one set of decisions that must be made is between committing the time to the activity (e.g. DIY, cooking) or buying in the service.

Table 2.1 *Household time and expenditure allocation*

Category of expenditure	Amount per week (£)			Time per week (hrs)	
				Full-time working	
	Total	Durables	Flows	Woman	Man
Work				32.50	36.95
Travel to work				4.83	8.23
Breaks				2.90	3.60
Total work				40.23	48.78
Sleep				56.33	56.48
Motoring and bicycles		23.80			
Motoring: spares and accessories		1.70			
Motoring: insurance and taxation, repairs		12.70			
Fuel etc.			17.60		
Fares and other travel costs			9.50		
Total travel		38.20	27.10		
Housing, gross rent		24.90	12.80		
Water			4.20		
Repairs, maintenance and decoration		8.90			
Professional fees		2.20			

(*continued overleaf*)

Table 2.1 *(continued)*

Category of expenditure	Amount per week (£)			Time per week (hrs)	
				Full-time working	
	Total	Durables	Flows	Woman	Man
Other services			3.70		
Fuel, light, power			11.90		
Telephone			8.40		
Total housing services		36.00	41.00		
Meal preparation				5.00	2.15
Food for home consumption			41.40		
Washing up				1.63	2.15
Laundry				2.88	0.13
Tidying				0.98	0.38
Laundry, shoe repairs and dry cleaning			0.70		
Cleaning				2.20	0.20
Total housework		0.00	42.10	12.69	5.01
Clothing			22.00		
Furniture and fittings		26.00			
Operating, maintenance, repairs		3.60			
Kitchen/garden equipment		5.00			
Leather and travel goods, jewellery, watches etc.		2.10			
Shopping				4.90	4.03
Other household/garden				0.83	2.10
Total household durables and consumables		36.70	22.00	5.73	6.13
Eating in the home				5.40	5.13
Personal care			9.40	7.25	5.08
General childcare			2.60	0.95	0.58
Playing/teaching				0.40	0.28
Total personal and childcare		0.00	12.00	14.00	11.07
Greetings cards, stationery, paper goods			2.30		
Leisure goods		19.70			
Watching TV				11.23	18.38
Reading				3.48	1.65
Relaxing				6.83	2.60
Alcohol			15.00		
Tobacco			6.10		
Crafts and knitting/sewing				1.60	1.65
Pets			3.00		
Total home leisure		19.70	26.40	23.14	24.28

Table 2.1 *(continued)*

Category of expenditure	Amount per week (£)			Time per week (hrs)	
				Full-time working	
	Total	Durables	Flows	Woman	Man
Subscriptions			1.10		
Seeing family/friends				9.00	8.00
Sports			0.60	0.48	1.65
Clubs/societies			2.70	3.23	3.58
Pubs				0.23	0.95
Meals out/cinema			20.50	0.58	0.53
Other leisure services including holidays			46.10		
Miscellaneous			7.60		
Other			2.00	2.53	1.95
Total outside leisure		0.00	80.60	16.05	16.66
EXPENDITURE TOTAL	385.70	130.60	251.20		
Savings and defensive expenditures	23.50				
Structural insurance	3.90				
Medicines, prescriptions etc.	4.70				
Total	32.10				
Council tax, domestic rates	11.30				
Income tax	70.40				
National Insurance	18.40				
Savings and investments	10.40				
Repayment of debts	3.10				
TOTAL TAX	113.60				
TOTAL	531.40				

Sources: Anderson *et al.* (1994); National Statistics (n.d.).

Time is equally crucial in production although it was left to operations research rather than economics to identify its importance. Thus, the origin of linear programming lies in time scheduling different tasks between machines so as to maximise profitability (Williams 1967). Time allocation is similarly a critical issue in irrigation management; for a given quantity of water in a reservoir, the varying needs of the crops for water as a function both of the time in their growing cycle and the predicted weather, how much water should be released at what point in time, given that once released it will no longer be available? A similar problem confronts managers of potable water reservoirs; at what time should restrictions on releases and hence cutbacks in supply be announced?

The time and space constraints are linked; the mutual exclusivity in space constraint can be relaxed if we allow the same space to be occupied at different

times or we can occupy different spaces at different times. Whilst famously we cannot be in two places at the same time, we can be in two places at different times: I can go on holiday to two different places at different times. This is, however, to assume that the two different times are perfect substitutes for each other. Frequently they are not: next year's labour is often no substitute for the same quantity of labour now unless, for example, it does not matter whether the scheme is constructed this year or next year. Equally obviously, time is not reversible.

Hence, an issue is the extent to which there is path dependency over time in the occupation of space; who occupies a chair at this moment in time has no necessary effect on who can occupy that chair in a subsequent moment in time. Similarly, the use of a field for pasture this year does not affect its potential use for growing wheat next year; conversely, the conversion of the meadow from pasture to wheat means that it will take longer to convert that field back to pasture and particularly to a meadow. Equally, maintaining an area as a climax forest does not prevent its conversion to a reservoir at some future date; conversely, once the area is converted to a reservoir, it will take between 100 and 1000 years before it can be re-established as a climax forest, depending upon the predominant species of trees.

If there can be a question as to the extent to which one future time is substitutable for another, the degree to which one point or area of space is substitutable by another can also be important. The extent to which they are substitutable depends in part on the activity concerned; a mountainside at 6000 metres is not realistically a substitute for a flood plain for growing arable crops. Soil, topography, microclimate and the availability of water are all characteristics that can determine the suitability of an area or point of land for a particular purpose. Moreover, location, the relationship of that area of land to other activities is also usually important; estate agents often claim that location is the primary determinant of house prices. These are self-evident points but it is not unknown for policies to be proposed that implicitly assume that there are near perfect substitutes for particular areas of land. For example, that habitats could be re-established elsewhere or that development should not be allowed on flood plain land but forced to take place elsewhere. Similarly, in the case of the climax forest and the reservoir, there may be nowhere else a climax forest could develop, even given sufficient time to elapse. Again, the assumption that in response to climate change, ecosystems can simply move or be moved uphill and towards the polar regions assumes that the soil and other conditions are similar there to those in the areas where the ecosystem is currently established.

A key characteristic of the precautionary principle (O'Riordan and Cameron 1994) is then to keep open as many futures as possible to avoid making choices that create path dependency.

2.1.1.4 Objectives

Russell's (1954) assertion that the use of reason is limited to the choice of means to some ends assumes that our objectives are givens, perhaps through religious authority, or have been determined before and outside of any choice as to ends. Thus, that there can be a complete separation of the discussions of means and of ends: that we can determine what we should do prior to and in the absence of any knowledge of what we can do. Moreover, either that there are no possible conflicts between the choice of action that each of our objectives should cause us to adopt, or that any such conflicts have already been resolved prior to any choice actually being confronted.

However, sometimes the objectives we bring to a choice are mutually exclusive; achievement of any one objective necessarily means that we have to sacrifice the achievement of another. Thus, Sen (1992) has argued that the problem with equality is that one form of equality can only be achieved by sacrificing another form of equality. Alternatively, there may simply be no available option that is superior to all others against all of our objectives although in principle there could be such an option. Choices that self-evidently involve a conflict of objectives are the most difficult which we face: the agony of the judges asked to decide in the case of conjoined twins was self-evident, given the choice between an operation to separate the twins that would necessarily result in the death of one and not operating and the strong probability that both would die.

2.1.1.5 People

Once more than one person is involved or affected by a decision then potentially there is a conflict between those people as to which option should be chosen. At the simplest level, the balance of gains and losses to each person is unlikely to be identical for each person; we differ in our preferences not least as a function of age, physical, cultural (Schwartz and Thompson 1990) and psychological differences (Seligman *et al*. 1994). Since choices are about the future then a key question is: how is the future created, how does the world work? The diagram adopted by cultural theorists (Schwartz and Thompson 1990) is insightful: differences in the views as to how to choose the future between groups are described as a reflection of their fundamental views as to whether the world is inherently stable, inherently unstable, or locally stable. At the one extreme lie the 'contrarians' who believe that it will always turn out all right in the end and hence there is no need to worry since if technology creates problems, technology will then solve those problems.

People may equally disagree as to the likelihoods of the potential outcomes of each option and differ in the degree to which they are risk averse or risk seeking; what is an acceptable risk to one person may be quite unacceptable to another. Hull *et al*. (1987), for example, observed that managers from the oil industry

found 50–50 gambles implausible because they never experienced as good odds as those. Conversely, managers from other industries considered that the odds that oil industry managers face every day were quite unacceptable.

Nor is there likely to be an option that is a Pareto optimum (Pearce and Turner 1990) in that it leaves all people at least as well off as they were before and nobody worse off. But more importantly, we may disagree as to the objectives that we ought to pursue in making the choice. Since choices are always about the future, we always have to decide what we ought to do, and the logical 'ought' and the moral 'ought' are frequently bound together. Collective choices are then seldom solely between different means to an agreed end but involve arguments about what ought to be the ends we seek to achieve. However, choices are usually between different means and it has been observed that what is important is to decide upon the means. Thus, it is possible for agreement to be reached on the means even when we continue to disagree on the ends to be pursued. Spending too much time debating the ends can be counter-productive, simply establishing that we disagree about these, when it may be possible to reach agreement as to what to do.

2.1.1.6 Resources

Mutual exclusivity in time or place and conflicting objectives are internal constraints to choices in project appraisal. They force the choice between the available options; even if infinite resources were available, it will not be possible for a reservoir and a climax forest to occupy the same space. Similarly, even if I had an infinite income, I still could not go to the theatre and the cinema at the same time. In collective decisions in particular, resource scarcity is an external constraint: it may be possible to determine the best option in each of a number of different choices but resource scarcities preclude us from adopting all of those best options. For example, if there were to be universal agreement both that education policy A is preferable to education policy B and also that health care policy M is preferable to health care policy N, resource constraints might still limit us to choosing between the combinations of A plus N or B plus M. However, the choice between A or B and M or N is almost certainly about conflicts between the objectives we want to achieve and disagreements between people as to what importance should be attached to achieving each objective. Thus, these choices would remain even if we had infinite resources.

In choices about project prioritisation, programmes or policies, it is this resource scarcity which forces the choice; nothing precludes the provision, for example, of potable water supplies to all villages in an area except the scarcity of some resource where that resource might be money or the availability of skilled technicians.

2.1.1.7 The nature of value

In everyday language, if we ask someone what are their values, there is usually a long pause and then they say something about justice, democracy or religion:

in common parlance, values refer to ends (Boulding and Lundstedt 1988). But economics uses value in different senses and it is possible to distinguish between two different bases for value:

1. Value in itself, and
2. Instrumental value.

Adam Smith, for example, adopted the first approach by using a cost of production theory of value and Ricardo, as did Marx, developed a labour theory of value: the value of a good is given by the cost of producing that good. On the other hand, neoclassical economics is associated with the instrumental theory of value: the value of something is its contribution to the achievement of some objective. In the case of neoclassical economics, this objective is the maximisation of the individual's utility so economic value is subjective and, importantly, a good can have a value without having a price. Indeed, in economic analysis money is simply used as a yardstick or numeraire by which to assess the relative values of different actions.

The neoclassical economics definition of value in instrumental terms has two major implications:

- It is actions rather than things that have value; and
- An action necessarily has as many values as objectives are brought to that choice of action.

First of all, it is implied that it is actions that have value rather than the thing involved in the action itself. Thus, wearing a hat has values relating to keeping off the rain, keeping my head warm, keeping my bald patch from being sunburnt, and so forth. Similarly, eating food assuages hunger and gives pleasure; and it is watching television that has a value: the value of a television is given by the expectations of the programmes it will then be possible to watch. The value of things, such as hats, food and a television, is then an imputed value based on the expectation of the actions that can be undertaken with it in the future. It is a function of the likelihood of different actions being undertaken and the contribution of each action to the achievement of each objective. The thing itself has no value outside of expectations of future actions in which it can be used.

These actions are all necessarily in the future although the relevant future may be very short-term; an ice cream is usually bought with the expectation of eating it immediately whereas a bottle of wine may be bought to lay down for many years. Thus, it is possible to talk about the value of a 'thing' only in terms of the potentiality for action associated with that thing, a form of expected value.

Secondly, since value is defined in instrumental terms, an action has as many instrumental values as are the objectives engaged by that choice of action. Hence it is not possible to argue that an action only has an economic value unless economic value is defined so widely as to cover all possible objectives. Even then, only once those objectives are completely ordered hierarchically can an

action be taken as having a single value. The neoclassical economics definition of economic value, as the contribution of some action to maximising the individual's utility, is then either one possible value, or utility must be expanded to include all of the individual's objectives. In addition, the neoclassical economic definition of value obviously means that value is subjective: value lies in the eye of the beholder. The neoclassical model also requires the assumption to be made that an individual has developed a utility function which defines how all possible acts of consumption will contribute to this overarching objective of utility and has done so in advance of making any actual choice.

Because the value of a thing is imputed by the individual's expectations of the actions that can be undertaken with it or for which it is necessary, quite clearly the imputed value of that thing can vary markedly between individuals and the market in turn may be highly segmented. Thus, to a vegetarian a beefburger will have no value at all except in so far, for example, in that it can be used to keep a fractious niece happy.

If an action has as many values as objectives are brought to a decision, then a critical question is: which objectives are engaged by the decision? In neoclassical economics, it is assumed that the individual and individuals define the objectives and, conveniently, each have predefined a completely ordered utility function. In turn, in neoclassical economic analysis, in collective choices, the only objective considered is some aggregate of individual utilities where the potential Pareto improvement, or Hicks–Kaldor compensation principle, is conventionally taken to be the appropriate aggregation function. It is usual to make some reference to equity (in the relatively trivial sense of income distribution) but equity is not considered to be an objective to be considered in making the collective choice. But the problem even with recognising equity is that it raises the question: where does this objective come from? In neoclassical economics it is assumed that value is given solely by the individual, it measures individual preference, the contribution of that action to the individual's utility function. For equity to be accepted as an objective in collective choices, it is then necessary to ask why the individual should bring equity to a choice outside of his or her utility function. By treating equity as a separate objective, it has been assumed that it does not form part of the individual's utility function, that the individual's utility function does not include some form of altruism, nor that the individual experiences a duty with respect to other people. If the individual's utility function does include altruism or normative components, then neoclassical economic theory dictates that such elements should be considered in collective choices except in so far as to do so would involve double-counting.

In practice, two different issues are involved. Firstly, the assumption that values are solely given by individual preference is itself a moral claim that can be disputed and which cannot be treated as axiomatic. In particular, Islam (Khalid and O'Brien 1992) is centred around duties to other people and other species and so the economic question is what ought we to do rather than what do we want to