**Sustainability, Environmental and Social Considerations**

INTRODUCTION

Prior to the 1970s, engineering projects were often human-centric. Engineers focused primarily on the technical and economic aspects of projects, without giving much concern to the social and environmental impacts of their work. To a large extent this was a reflection of the priorities of society at the time, and to a lesser extent, due to an insufficient understanding of the interconnectedness

between engineering works and natural and social systems. Engineers now recognise that they play a critical role in the wise use, conservation and management of resources. They also recognise that they have an obligation to ensure that the needs of future generations are considered. This is reflected by

professional bodies through accreditation requirements for engineering programs, and through codes of ethics for practising engineers.

In 1828 Thomas Tredgold of the Institute of Civil Engineers described engineering as the art of directing the great forces of nature for the use and convenience of man. As we have seen already in Chapter 1, nature tended to be regarded as a powerful adversary to be tamed. Today such views are tempered by

the realisation that the world has finite resources and the emphasis now is on the wise use of resources, not only to protect and conserve the environment, but also to achieve a sustainable way of life into the foreseeable future.

The concept of sustainable development has been discussed extensively in past decades, with the mainstream definition being that of the Brundtland Commission of 1987 (WCED, 1987):

*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*

This concept has developed further, and engineering systems, policies, designs and plans can be considered and evaluated today within sustainability frameworks.

SUSTAINABILITY

The systems approach provides a simple and consistent basis for investigating sustainability at all levels of society, from the global scale down to the individual. Gilman (1992) used systems concepts to provide the following definition of sustainability:

*The ability of a society, ecosystem, or any such ongoing system to continue functioning into the indefinite future without being forced into decline through exhaustion or overloading of key resources on which the system depends.*

Based on this definition, Foley et al. (2003) have shown that to achieve sustainability it is necessary to manage appropriately all the resources that a system relies on. These include the natural, the financial, the social and the man-made infrastructure resources that are important to the functioning of the system.

Roberts (1990) has shown that self-sustaining systems in nature are generally closed-loop systems that evolved gradually over time. In the past when humans developed production systems, they have relied on an open loop, once-through use of resources, which results in much waste. To be sustainable, it is necessary to use closed-loop systems. This emphasis on a closed loop for sustainable outcomes can also be seen in discussions related to a circular economy. The objective of a circular economy is to maximise value at each point of a product’s life (Stahel, 2016). Another closed-loop system concept is the cradle to cradle approach. This approach is in contrast to the linear cradle to grave approach. The cradle to cradle approach recognises that the perceived end of life for a given product can, and should, become the start of another product life and therefore an interconnection is introduced between product life cycles. A cradle to grave approach also recognises the product life cycles, but often includes waste at the end of the product life. Figure 9.1 shows a conceptual model of the initial extraction or use of resources,

followed by the processing, transportation and consumption of the modified resources as a closed-loop system that can evolve over time. More complex models include interconnected systems and cradle to cradle connections between product life cycles.

Diagram

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A key element of the model is the stewardship of the natural environment that is needed in order to provide a balance to the processes of extraction, modification and transportation. The main element of this closed-loop system is the recycling of waste from manufacture and consumption within a continuous loop. Energy inputs are a crucial element in the closed-loop system. For many natural systems the sun is the natural source of energy, but this is not so for man-made systems.

A conceptual model that can be used to assess the sustainability of a system or of sustainable system development (Foley et al., 2003) is shown in Figure 9.2. It outlines the flow of resources within the system. The model identifies infrastructure and other human-made resources (I) as a key element of sustainability. Infrastructure for urban development includes buildings, and the water supply system, as well as systems for waste, transport and energy. Such a systems approach provides a good platform for assessing development and sustainability, where infrastructure and resource flow are principal considerations.

Each subsystem within the larger development system can be modelled (e.g. a single house within a city development). The flow of resources such as water, energy and finance to and from the system can also be included in a more holistic way than in many other currently available tools.

A systems approach to the assessment of sustainability is not new. It was applied in early computer modelling studies in the 1970s (e.g. Meadows, et al., 1972) and in more quantitative studies which have continued up to the present. A major conclusion from such systems modelling, suggested by Suter (1999), is “that humankind needs to re-evaluate its exploitative attitude towards humans and the earth itself”.

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Another application of the term sustainability relates to corporate social responsibility. This can impact engineers and their work through both the strategic direction and the investment decisions of the organisations within which they are employed or interact. Sustainability has been adopted in the business world to connote the principles of social and environmental responsibility. Increasingly

business organisations have recognized that profits alone do not guarantee continuity of existence for their companies and that sustainability adds to their long-term business viability. Investors also see sustainability issues, such as controlling greenhouse gases, as priority concerns to be addressed by management. Since the late 1990s, the Global Reporting Initiative (www.globalreporting.org) has set the

benchmark for sustainability reporting at the corporate level and the Dow Jones Sustainability Index (www.sustainability-indices.com) has become a mainstream investment consideration.

The final application of the term sustainability, as discussed here, relates to considerations of natural capital. Schmidheiny (1992) of the World Business Council on Sustainable Development suggested that population growth and economic development will eventually be constrained by environmental and social pressures. The question of what level of population is sustainable for the world is the focus of much debate amongst many scientific researchers and has been since the time of Thomas Malthus in the late 1700s. The key to the answer is in maintenance of natural capital and the level of resource use which is required for a standard of living that can be perpetuated for future generations. Sustainability has thus been explained as being the state for which all social well-being and development are within the Earth’s biological capacity (Wackernagel and Rees, 1997).

Club of Rome

The Club of Rome was founded in 1968 and has been described as "a think tank and a centre of research and action, of innovation and initiative". It is composed of a group of scientists, economists, business people, senior public servants, heads of state and former heads of state from around the globe and addresses questions confronting the global society. The term "problematique" was developed by club members for the inter-related issues that were to be examined. The Club of Rome commissioned the book "Limits to Growth" which was published in 1972. Twelve million copies of the book were sold worldwide, in 37 languages. The book challenged a basic assumption of economic theory that the

resources of planet Earth could be infinite. The book was based on computer modelling of the consequences of the growth of global population. Various scenarios researched pointed to a major economic crisis occurring in the early 1990s. This did not happen. Subsequent updates on the book have been undertaken and in retrospect, one needs to ask, was "Limits to Growth" a fair or a false warning?

Adapted from Suter (1999)

PLANNING AND DESIGN FOR SUSTAINABILITY

Time is a key consideration for sustainability as systems evolve and communities develop. This was highlighted by Fleming (1999) who has suggested that sustainability needs to be considered within cycles of continuous improvement. In evaluating the sustainability of engineering systems, projects, processes and operations, a key aspect to consider is the stream of resource usage. Various tools can assist in such evaluations, and are dependent on the level of society to which they are being applied. Examples of readily available tools available on the Internet are listed in Table 9.1. Some are produced by non-government organisations, some represent formal government reporting and others are project specific or proprietary tools.

The continuous improvement methods employed by industry, such as cleaner production and total quality management, evaluate the level of goal achievement over time. Many of these approaches use a systems approach to examine resources so that there is minimal waste with the conversion of linear, once-through systems, to closed-loop systems that reduce waste. These are mainly improvement processes used by industry to become more sustainable at a particular industry level, as well as processes used by governments to align with agreed global initiatives and principles. In 1992, the first set of guiding principles emphasizing sustainable development, Agenda 21, were agreed to at the Earth Summit in Rio de Janeiro. In 2000, eight Millennium Development Goals were declared, and in 2015 countries adopted 17 Sustainable Development Goals. These principles and goals are not an assessment of sustainability in their own right. They inform assessments and provide direction.

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In many governments and organizations, a set of sustainability criteria are used to assess the relative merits of projects, processes and products. Included within these assessments is often interaction with the stakeholders and community groups through participatory and consultation programmes.

A major push for reduction of the use of resources comes in programmes such as Factor 10, which has the goal to lower the use of natural resources for generating material wealth, using new technology, by an average factor of ten within 30 to 50 years for the purpose of approaching sustainability. This is equivalent to increasing resource productivity tenfold over the same time period (Schmidt-Bleek, 1993).

Sustainability assessment requires the development of a clear set of criteria against which the assessment can be conducted. This includes considerations of environmental, economic and social factors. The Triple Bottom Line (TBL) approach establishes individual indicators to show how well a company satisfies goals in each of these three areas. Usually for TBL reporting indicators are chosen

for a number of criteria for each factor and then presented using a set of bars of different colours or stars to indicate how well a company is doing against particular criteria. The establishment of principles-based criteria for assessment of sustainability can improve the standard TBL approach.

A framework for assessing the natural capital within a region or within an organization can be developed with the use of systems such as the “Compass index of sustainability” to stress the inter-connected nature of the elements of environment, economics, and social well-being (AtKisson and Hatcher, 2001;

Hargroves and Smith, 2005). Over time, the results of the planning and engineering of cities are measured by such indicators. Predictions of changes to the development of the city infrastructure and the resource input and output for a city’s existence can also be made against these criteria. The design of individual buildings involves choices of materials to be used, lighting, air conditioning and water use.

Each of these choices for achieving sustainability goals will involve assessment of embodied energy within materials used, energy use over the life of products, the ability of the product to be recycled and satisfaction of performance criteria.

Sustainability assessment does not replace Environmental Impact Assessments or functional decision making based on Life Cycle Analysis or Social Impact Analyses or combinations thereof. A sustainable assessment tool needs to be incorporated within the decision-making framework to ensure that decisions in planning are, in fact, sustainable (Pope et al., 2004). Sustainability assessment can and should be applied to evaluating proposed and existing processes and projects at all levels of governmental and project decision making. Incorporating sustainability through the design and implementation phases of a development could involve the integration of social and environmental effects of a longer time horizon into analyses by the proponents of projects. Sustainability assessment requires defining clear societal goals (e.g. the Sustainable Development Goals) which can be translated into criteria, against which assessment is conducted. It is essential that the assessment method is able to discern sustainable outcomes from unsustainable ones.

Ecological Footprint

Ecological Footprint (EF) is a measure of humanity’s dependence on natural resources. For a certain population or activity, the EF measures the amount of productive land and water required to sustain the current level of resource usage for the production of goods and services and the assimilation of waste required by that population or activity.

In 2001, the world average EF was 2.55 global hectares per person, >30% above the current global capacity (Venetoulis and Talberth, 2005). The lifestyle of the average global citizen can therefore be considered as unsustainable. Natural resources are being used faster than they can be regenerated.

The size of an EF can change over time, depending on population, consumption levels, technology and resource use. EFs are measured in global area (hectares or acres). Wackernagel et al. (1997) defined biologically productive areas as (a) arable land; (b) pasture; (c) forest; (d) sea space (used by marine life); (e) built-up land; and (f) fossil energy land (land reserved for carbon dioxide absorption). The current global biologically productive area is 10.8 billion hectares, of which 21% is productive ocean and 79% is productive land. This represents less than one-quarter of the Earth's surface.

An individual's resource consumption is not restricted to local resources. The resources used by an individual are from around the world, clothes from China, cars from Korea and food from many different places. From a comparison of the Ecological Footprint to the existing biologically productive area, the

sustainability of an activity, lifestyle or population can be determined.

An ecological footprint of Greater London, prepared by Best Foot Forward Ltd. (http://www.citylimitslondon.com/) found that London's EF was 42 times the current capacity, or 293 times the size of London. This equated to 49 million global hectares, twice the size of the UK, and roughly the same size as Spain. Is this sustainable?

Australia has a usage of 7.0 global hectares per person, making it the 5th highest in the world. There are many websites that enable calculation of your individual footprint on the earth (http://www.footprintnetwork.org/), and to compare it with different countries.

The Matrix Evaluation of Sustainability Achievement is one such method (Fleming and Daniell, 1995; UNEP, 2002) which uses a weighting technique against a set of sustainability criteria and combines them with fuzzy set analysis. The important step is the definition of specific criteria which can be obtained to

achieve the overall project goal. In the case of a building, this might be to achieve a reduction of 50% of projected CO2 emissions over an existing conventional design. Therefore, the inclusion of sustainability as a project goal could totally change the final solution from that resulting from a short-term economic goal.

Global Reporting Initiative

The Global Reporting Initiative (GRI) provides a reporting framework for companies and organisations to guide the preparation of consistent and comparable sustainability reports. First released in 1997, the GRI has been progressively developing resources as awareness of, and expectations associated with, corporate sustainability reporting have increased. GRI gained legitimacy in 2002 when it became a collaborating centre with the United Nations Environment Program (UNEP). It is aligned with the International Standard ISO 26000:2010, Guidance on social responsibility and also now with the United

Nations Sustainable Development Goals. The GRI G4 guidelines will be phased out in 2018 and replaced by a series of standards. These standards are modular and define disclosure requirements using the following structure:

* General Disclosures
* Management Approach
* Economic Standards
* Environmental Standards
* Social Standards

In addition, there is a Foundation Standard and Glossary as supporting material.

Global Reporting Initiative, (2016)

ENVIRONMENTAL CONSIDERATIONS

History of Environmental Concerns

While it is true that the environment and sustainability have become much more of a focus for concern among people since the 1970s, it would be quite wrong to think that prior to that time there were no problems and concerns. In ancient Greece some 2500 years ago, Plato lamented the consequences of excessive logging and grazing in the mountainous region of Attica, near Athens. Similar concerns were raised around 1000 years ago in Japan where excessive eroded granite built up in Lake Biwa, due to logging for the construction of a temple (Parker, 1999).

Environmental legislation also dates from ancient times. In Rome all wheeled vehicles were prohibited between sunrise and two hours before sunset to improve the situation for pedestrians. This law fell into disuse, and in the 3rd Century AD, writers complained about the level of noise pollution generated by traffic in the streets. The city of Florence had laws governing the polluting of the rivers Arno, Sieve, and Serchio as early as 1477 (Higgins and Venning, 2001) and in 1810 Napoleon was issuing decrees aimed at eliminating polluting industries from the centres of cities.

In Australia, some of the earliest laws dealt with environmental issues. There were laws to protect the quality of the stream which supplied water for the original settlement in Sydney and it was prohibited to fell trees within 50 feet (15 metres) of the stream. People were not allowed to throw rubbish into the stream or have pigsties within a prescribed distance. In 1839, just three years after the city of Adelaide was settled, the state of the Torrens River was so bad that laws were passed to prevent, among other things, people driving cattle through it. This was the city’s only water supply and yet it was treated with scant regard by many. There are many countries today where this still happens but, as the world becomes more urbanised, there is a need to be aware of the impact of human activity on the state of

the planet Earth.

The Tragedy of the Commons

The tragedy of the commons has played itself out worldwide at various times and to varying degrees. It can be explained as follows: when a group of herdsmen have access to a common pasture, it is in each individual’s best interests to increase the size of their herd without reference to the overall carrying capacity of the land. However, this leads to the destruction of the common pasture, so that everyone

loses. This type of situation occurs in many ways, such as when an increasing population results in increased waste disposal into the commons: rivers, lakes, oceans, and atmosphere.

A major issue in city development involves the concept of the commons in regard to the decreasing quality of air and water due to emissions from transport systems and runoff from road systems. Another issue linked to the commons on a global scale is the consumption of energy by the developed nations which has resulted in producing CO2 emissions which have contributed to global warming. Those activities that are considered to be necessary for a high quality of life: food; energy and transport systems; communication systems; the supply of infrastructure; supply and maintenance of water and waste water systems; health systems; and the management of waste all need energy and hence generate CO2 emissions. There is much discussion on the linkages between CO2 production, climate change and quality of life. The linkage between the use of energy and the quality of life can be

examined by inspection of emissions of CO2 and energy use in industrialised countries in the world. The United Nations Human Development Index (HDI) is a measure of poverty, literacy, education, life expectancy, childbirth, and other factors for countries worldwide. It is a means of measuring well-being and has been used since 1993 by the United Nations Development Programme (UNDP, 2013). To compare the impacts of development across nations with respect to emissions, the Human Development Index (HDI) has been used in conjunction with CO2 emissions per capita as given in Table 9.2.

Table

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Energy Use

Energy use in developing nations is based on traditional systems of wood and coal, and not electricity. As these nations convert to electricity and develop industries that use more energy, there will be a major increase in CO2 production across the globe. The growth in energy use of the developing nations is only just beginning and can be expected to increase twenty fold in the next 20–30 years. The need to develop better technologies for the sustainability of cities and lower CO2 emissions are two goals which engineers need to address if there is to be equity among nations.

Of course the future cannot be predicted with certainty, but engineers will help create it. The goals that are now chosen for all development will dictate the future. In the past, individual goals were pursued independently of each other, leading to the present crises for social well-being, the environment and the economies of some countries. The need is to develop a balance between the use of resources, the environment, and social well-being to achieve sustainability into the future.

SOCIAL IMPACT

The environmental impact statement usually includes social impacts as well as effects on the physical and biological components of the environment. On the other hand, the USA Principles and Standards for Planning Water and Related Land Resources (USWRC, 1973) considered social well-being as a separate category of objectives. The social objective was defined as follows:

*To enhance social well-being by the equitable distribution of real income,*

*employment and population, with special concern for the incidence of the*

*consequences of a plan on affected persons or groups; by contributing to the*

*security of life, health and property; by providing educational, cultural and*

*recreational opportunities; and by contributing to national security. (USWRC, 1973)*

If a full economic, environmental and social evaluation of a project is carried out, it is most important to avoid the double-counting of benefits or costs under more than one account. If, for example, an economic value is placed on lives saved through accident reduction and this is included in the economic evaluation of the project, it would not be appropriate to also highlight the number of lives saved in the social evaluation. Other examples of double-counting are discussed later in this section. The following types of social effects may need to be considered for a particular project:

* distribution of income;
* population distribution;
* employment;
* life, health, and safety;
* educational, cultural, and recreational opportunities;
* national security and emergency preparedness;
* displacement and relocation; and
* neighbourhood disruption and intrusion.

As with environmental effects, each social parameter can have its own ordinal or cardinal scale of measurement. The above effects are considered in turn.

Distribution of Income

In theory it is possible for a government to redistribute the benefits and costs of any public sector project among the various individuals or groups in society. This being the case, it can be argued that the role of the engineer or planner is to devise projects which maximise the total net benefits to the community and let the government decide how these benefits (and costs) will be distributed. However, this redistribution of benefits and costs is often not practicable because of the difficulties in identifying all affected groups and because of the administrative cost of carrying out the transfers. Redistribution of the benefits of engineering projects rarely occurs in practice.

It is therefore important that the distributional consequences of any major project be explicitly considered. Of particular relevance is the effect of the project on the income levels of certain target groups. These target groups may be distinguished on the basis of income (e.g. those living below the poverty level), race, sex, or geographic region.

It has been suggested by Weisbrod (1972) that the distributional question can be approached by placing explicit weights on the benefits and costs received by each group in the community. Traditional benefit-cost analysis gives the same weight to a dollar of benefits received by a pauper and by a millionaire. It is conceptually possible to give a higher weight to benefits or costs incurred by low-income earners and thus develop a single index of social welfare, using the following formula:



where **SW** is the index of social welfare; **Bi** is the present value of benefits received by group **i**; **Ci** is the present value of costs incurred by group **i**; **wi** is the “social” weight of benefits or costs to group **i**; and **m** is total number of community groups. The difficulties of deciding on a set of weights and implementing this approach should be apparent.

Population Distribution

It has been argued that the redistribution of population throughout a region or the nation may be a major objective of government policy. This is particularly true in sparsely populated nations such as Australia. Major engineering projects in remote areas may contribute positively to the decentralization of population. The benefits of decentralization are related to enhanced national security and the benefits of rural versus urban living. High concentrations of population and industry are particularly

vulnerable to attack by conventional or nuclear weapons. On the other hand, the settlement of remote areas leads to additional infrastructure costs for electricity supply, roads, railways, water supply, ports, and airfields.

Projects such as major irrigation developments which contribute to maintaining the size of the rural community may be supported on the grounds of the “healthier” lifestyle of country living. Continued growth of large cities at the expense of the surrounding country areas may also involve considerable increases in infrastructure costs in the city, as well as increases in the crime rate and other social problems. The negative aspects of population redistribution on individual families also need to be considered. These include the weakening of friendships and family ties and the stress associated with moving, setting up a new home, and adjusting to a changed lifestyle. The benefits of urbanization versus decentralization can vary from family to family depending on the independence of the family members.

Employment

One of the benefits cited by governments when new public works are announced is the effect that it will have on unemployment. A large engineering project may involve considerable employment in the implementation phase and also in the operations phase. Some people consider this an achievement in itself. In an economy with little or no unemployment, workers employed on a specific project will be taken from productive activities elsewhere in the economy. Therefore, the opportunity cost of their labour will be assessed as a cost to the project in the economic evaluation. In such a case, the number of people employed on the project is not a social benefit.

In an economy with high unemployment, some of the workers employed on the project may have been previously unemployed. As discussed in Section 8.8, previously unemployed labour has an opportunity cost to the project considerably less than the wage rate. If this effect is correctly taken into account in the economic evaluation of all projects, there is no need to further describe the employment implications of the projects, as this would be a double-counting of the same benefit.

The foregoing applies to public sector projects only. In the economic evaluation of private sector developments, all labour is costed at the actual wage rate paid. Thus, at times when there is less than full employment in the economy, the true net benefits of the project to society will be understated. In such cases it is valid to include the additional employment opportunities created by the project as part of the social evaluation.

The distributional consequences of employment opportunities may also be important; for example, in the creation of employment opportunities in depressed regions of the country or among disadvantaged groups such as ethnic, or low-income groups.

Life, Health, and Safety

Many engineering works contribute to saving lives, improving health, or increasing safety in the community. Typical examples are flood mitigation works, water treatment plants, sewage treatment, improved road alignments, grade separation, and coastal protection works. Attempts have been made to include the benefits of lives saved into the economic evaluation of public sector projects by placing an

economic value on human life. Various methods have been suggested for estimating the economic benefits of saving human life. These include:

* the present value of the person's expected future earnings;
* a value imputed from political decisions which involve public expenditure aimed at reducing the number of deaths. For example, the government spends $50 m in equivalent annual worth to upgrade railway crossings which will save an estimated 100 lives per year from fatal accidents. The implied value of saving one life is greater than or equal to $50 m/100 (i.e. $0.5 m per live saved); and
* a dollar amount which people are prepared to accept as compensation in order to put up with the additional risk of death involved in the project. For example, a proposed new chemical plant will increase the probability of death per year to each person in an adjoining town by 1 in 10,000. The economic cost of this increased risk is the sum over all people in the town of the minimum level of compensation which each person is prepared to accept in order to tolerate the increased risk. The same basis can be used for projects which reduce the probability of death for part of the community.

Practical and theoretical difficulties exist with all of these economic approaches. An alternative approach is to estimate the number of lives saved per year and treat this as a social benefit. Similar arguments apply to projects which increase or reduce the risk to public health or the chance of accidents occurring. Either a dollar value may be used in the economic evaluation or an estimated reduction in the risk may be included in the social evaluation.

Educational, Cultural, and Recreational Opportunities

It has already been stated that the distribution of income, and in particular to certain disadvantaged groups, is an important social effect. Similarly the distribution of educational, cultural, and recreational opportunities among regions and socio-economic groups may be an important consideration in evaluating a major project. For example, a major dam may provide a new recreational resource for fishing, boating, picnicking, and swimming (depending on the final end use of the water). The social benefits of these recreational uses may be as important as the economic benefits of the water provided by the dam. In some cases it may be advantageous to choose a dam site close to a population centre in order to increase the recreational opportunities for a particular group of people.

Educational and cultural values may be enhanced by engineering projects providing improved access to sites of historical, archaeological, or scientific interest. For example, a new road along the coast may provide improved access to some unique geological formations which are of considerable interest to the public, but controls need to be enforced; otherwise, the project could lead to the ruin of the formation.

National Security and Emergency Preparedness

A new road or railway could have important consequences for national security. Such benefits are difficult to quantify in economic terms and, in fact, only become apparent in times of armed conflict. However, they may be an important social consideration in the evaluation of a project.

Emergency preparedness requires, for example, the provision of a flexible water supply, electricity grid, and road and rail network. The provision of a single dam to supply water to a city or a single power station to supply electricity may be economically efficient under normal circumstances but could be disastrous in the event of a catastrophe such as major technical failure, earthquake, hurricane,

nuclear explosion, or act of sabotage. The provision of some redundancy in all engineering systems is a good rule to follow.

Displacement and Relocation

Engineering projects in urban areas may involve the displacement and relocation of some houses, and commercial or industrial buildings. A typical example arises from the land acquisition associated with an improved transport link, such as a freeway, arterial road, tramway, or railway. It is common practice for the households or firms displaced to be suitably compensated for the loss of their land, home, shop, or factory.

It is often argued that the loss of physical assets is suitably compensated for by the payment of fair market value. However, such an argument ignores the fundamental distinction between value in exchange and value in use. Consider the market for houses of a particular age and quality. If the current market price for such houses is **Po**, this may be called the “value in exchange of the property”. Clearly all

homeowners who are prepared to sell at this price or less will put their houses on the market. However, there are many homeowners who are not willing to sell at the price **Po**. To these people, the value in use of the house exceeds its value in exchange. If a road authority were to compulsorily acquire such a house and pay compensation equal to **Po**, the homeowner would clearly suffer a loss of utility. Full compensation should cover the value in use of the asset and would usually exceed **Po** by a significant margin. A similar argument applies to commercial and industrial properties.

The difference between value in use and value in exchange of a house includes an allowance for the stress of moving, disruption of social ties, the cost of finding a new house, and changes in accessibility and travel costs at the new location. In practice such costs are difficult to assess and considerable negotiation may be required with the property owners.

The compensation costs for displaced households and firms are a true opportunity cost to a project and should be included in the economic evaluation, rather than the social evaluation.

Neighbourhood Disruption and Intrusion

An engineering project may involve significant disruption and/or intrusion into a community. This is particularly true of transportation corridors which can sever a cohesive community or produce intrusive impacts in the form of noise, vibration, air pollution, or aesthetic degradation. A sense of community is often very strong and may be centred on facilities such as schools, shopping centres, the town hall, or

parks. Proposals which isolate one part of the community from another may receive considerable opposition from local community groups. Transport corridors should be planned to provide the minimum disruption to communities and ensure that adequate safe crossings such as overpasses or underpasses are provided for pedestrians and cyclists.

The principle of compensation described in the previous section can be applied to neighbourhood disruption and intrusion, but it is very difficult to define the loss of utility for an entire community. Attempts have been made to assess the economic effects of noise due to airports, highways, or railways by assessing the lower property values adjacent to these facilities. If such an approach is taken, these social effects can be included as a cost in the economic evaluation.

SOCIAL ASSESSMENT TOOLS AND METHODS

An extremely important facet of undertaking any project analysis involves the participation of interested stakeholders. This is an area where many engineers will be called on to manage and participate with specialists who work in the social assessment area. A basic knowledge of the methods available for undertaking such project analyses is given in the UNEP EIA Training Manual (UNEP, 2002). A number of methods are described below which allow social concerns to be discovered and to determine local knowledge concerning a proposed project.

Analytical tools

*Stakeholder analysis* is an entry point to Social Impact Assessment (SIA) and participatory work. It addresses strategic questions, e.g. Who are the key stakeholders? What are their interests in the project or policy? What are the power differentials between them? What relative influence do they have on the operation? This information helps to identify institutions and relationships which, if ignored, can have negative influence on proposals or, if considered, can be built upon to strengthen them.

*Gender analysis* focuses on understanding and documenting the differences in gender roles, activities, needs and opportunities in a given context. It highlights the different roles and behaviour of men and women. These attributes vary across cultures, class, ethnicity, income, education, and time; and so gender analysis does not treat men or women as a homogeneous group.

*Data Review* of information from previous work is an inexpensive, easy way to narrow the focus of a social assessment, to identify experts and institutions that are familiar with the development and context, and to establish a relevant framework and key social variables in advance for the project.

Community-based methods

*The participatory approach* aims to ascertain local knowledge and actions. It uses group exercises to enable stakeholders to share information and to develop plans. These techniques have been employed successfully in a variety of settings to enable local people to work together to plan community-appropriate developments. Attributes of self-esteem, associative strength, resourcefulness, action planning and responsibility for follow-through are important to achieve a participatory approach to development. Generally there is a philosophy of empowerment of the stakeholders to enable people to adopt responsibility for outcomes. It can best be described as development of teambuilding skills and learning from local experience rather than from external experts. Other participatory consultation methods include selecting a sample of stakeholders to ensure that their concerns are incorporated

into the assessment. This selection is for the purposes of giving voice to the poor and other disadvantaged stakeholders.

Other Participatory Methods

*Role playing* helps people to be creative, open their perspectives, understand the choices that another person might face, and make choices free from their usual responsibilities. This exercise can stimulate discussion, improve communication, and promote collaboration at both community and agency levels.

*Wealth ranking* (also known as “well-being ranking” or “vulnerability analysis”) is a visual technique to engage local people in the rapid data collection and analysis of social stratification in a community (regardless of language and literacy barriers). It focuses on the factors which constitute wealth, such as

ownership of or right to use productive assets/resources, their relationship to locally powerful people, labour and indebtedness.

*Mapping* is an inexpensive tool for gathering both descriptive and diagnostic information. Mapping exercises are useful for collecting baseline data on a number of indicators as part of a beneficiary assessment or rapid appraisal, and can lay the foundation for community ownership of development planning by including different groups and making them aware of the implications of the project.

*Needs Assessment* draws out information about people's needs and requirements in their daily lives. It raises participants' awareness of development issues and provides a framework for prioritising actions and interventions. All sectors can benefit from participating in a needs assessment, as can trainers, project staff and field workers.

*Tree Diagrams* are multi-purpose, visual tools for narrowing and prioritizing problems, objectives or decisions. Information is organized into a tree-like diagram. The main issue is represented by the trunk, and the relevant factors, influences and outcomes are shown as roots and branches of the tree. Other techniques such as mind mapping can also be used for this purpose.

Observation and interview tools

*Focus group meetings* are a rapid way to collect comparative data from a variety of stakeholders. They are brief meetings - usually one to two hours - with many potential uses, e.g. to address a particular concern; to build community consensus about implementation plans; to cross-check information with a large number of people; or to obtain reactions to hypothetical or intended actions.

*Workshop-based methods* encourage participatory planning and analysis throughout the project life cycle. A series of stakeholder workshops tend to be held to set priorities, and integrate them into planning, implementation and monitoring. Building commitment and capacity is an integral part of this process (UNEP, 2002). These stakeholder workshops are in common use for many infrastructure and

resource projects throughout the world.