Sustainability in Large-Scale Water Resources Project Planning

Saleh A. Wasimi

School of Computing Sciences, CQ University, Rockhampton, Queensland 4702, Australia

s.wasimi@cqu.edu.au

Abstract— **Large-scale water resources projects are essentially irreversible human interventions of nature usually requiring huge amount of public investment and affecting large segment of population. It is therefore imperative rather ethical that any such project proposal is thoroughly scrutinised before implementation.**

The universally accepted criteria for judging the suitability of a large-scale water resources project are economic development, social equity and environmental sustainability. Economic development focuses on monetized gains that the project would deliver, social equity ensures a fair share of water resources to each member of communities in project area, and environmental sustainability aims at preserving the vital components of the resources of the current generation for making these resources available for use by the future generation.

I. INTRODUCTION

A large-scale water resources project such as the Snowy River Project or the Fairbairn Dam Project can transform the socioeconomic landscape of a region. Indeed, the benefits that a large dam project can bring are multifaceted, for example, flood control, irrigation, municipal water supply, hydroelectricity, recreation, and pisciculture. Conversely, a large dam project can create adverse environmental effects such as decline of migratory species population [1], increased outbreaks of parasites/diseases [2], and extirpation of endangered species [3]. Large-scale water resources projects are essentially irreversible – once a large dam is constructed, it is not practical to go back even if serious environmental adverse effects are discovered later. The rectifying measures of the adverse effects of a dam can be enormously expensive or even beyond the reach of modern science. Moreover, a large-scale water resources project usually requires huge amount of public investment. It is therefore essential rather ethical to engage all communities involved as well as scientists and planners in consultation and decision-making before embarking on a large-scale water resources project.

There is international consensus that a large-scale water resources project should satisfy the three criteria of economic development, social equity, and environmental sustainability [4]. Bell and Morse [5] state that these three criteria can be brought under one umbrella of sustainability. They call economic development and social equity criteria as weak sustainability because these involve trade-offs between environment, social and economic benefits [6]; and environmental sustainability criteria as strong sustainability because it involves preserving the environment without any trade-offs. Planning a viable water resources project can be a balancing act between weak sustainability and strong sustainability criteria.

The concept of sustainability has existed in the scientific community for quite some time and the debate on what it really means persists. US National Research Council has defined sustainable practice as "a management system for the preservation of natural resources that provide food, income and livelihood for present and future generations and concomitantly maintains or improves the economic productivity and ecosystem of these resources" [7]. WCED [8] defined sustainable development as "development that meets the needs of current generations without compromising the ability of the future generations to meet their needs and aspirations." Bell and Morse [5] argue that we may never have an exhaustive definition of sustainability nor it is desirable to have a universal consensus of its ramifications. It is like finding an exhaustive definition of truth and justice. We all want truth and justice, but justice to one may be exploitation to another. People differ in the environmental, social and economic conditions within which they have to live, and having a single definition that one attempts to apply across this diversity could be both impractical and dangerous. Kidd [9] state: "there is not, and should not be, any single definition of sustainability that is more logical and productive than other definitions."

Sustainability has both spatial and temporal dimensions. An urban water treatment plant may not be sustainable within the confines of the urban area, but it may be sustainable if the neighbouring stream system in the rural area is included in the analysis. Similarly, a project may or may not be sustainable for a short planning horizon but the opposite may be true for a long planning horizon. Fig. 1 shows a situation where a project is not sustainable when the planning horizon extends up to a, but it is sustainable when the planning horizon is extended to b.

Governments throughout the world are now attempting to enshrine sustainability into their policies. In Queensland, the development assessment and approval processes of a large-scale water resources project occur through the

Integrated Development Assessment System (IDAS) established under the Integrated Planning Act 1997. IDAS requires consultation with relevant government agencies and public notification along with meeting the requirements of the Federal government's Environment Protection and Biodiversity Conservation Act 1999 (EPBC) and the State government's State Development and Public Works Organisation Act 1971 (SDPWO). SDPWO Regulation 1999 under a bilateral agreement between the Federal and State governments is accepted to include EPBC Act and exempt a 'significant project' from assessment by the relevant local governments. To meet the legal requirements a large-scale water resources project proposal needs to address inter alia the sustainability issues, specifically the following:

- Description of the need for the project, nature of the project, and its potential environmental, social and economic impacts both beneficial and adverse;
- Comparison with alternative projects including the option of no action;
- Assessment of the significance of potential environmental, social and economic impacts along with proposal of acceptable standards and levels of impacts;
- Suggestion of measures to mitigate or avoid any significant adverse impacts;
- Description of the outcomes of consultation with the stakeholders about the project; and
- Reporting of submissions from the public and referral agencies obtained after public display of the proposal for a reasonable length of time, and proper consideration of all submissions.

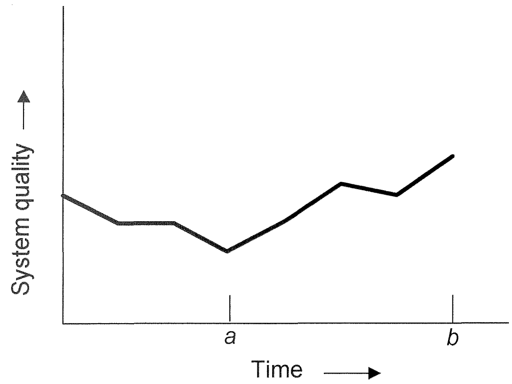

Fig. 1 Sustainability with time.

Notwithstanding the epistemological and philosophical underpinnings of sustainability and the unending debate, scientists have to devise practical ways to interpret sustainability so that it can effectively be used for decision-making in large-scale water resources projects. Regulations such as IDAS provide the imperative legal framework. For evaluation, there is the need for the development of appropriate metrics which are meaningful across disciplines. In that vein, this paper elaborates the applicable conceptual elements, and is organized such that in the next section the concept of economic development is presented. The section after that is on social equity. Following that the perspective of environmental sustainability is presented. The paper ends with a concluding section.

II. Economic Development

A common belief is that economic prosperity is well linked to water availability and that water scarcity problems are water supply problems best remedied by supply developments [10]. Large-scale water resources projects such as large dams are the obvious choice because of the economy of scale and their inherent multipurpose nature. It is to be expected that there would be many alternative water supply development opportunities available including the option of no action. No action does not necessarily entail that the current situation would not improve in future. In fact, economic conditions such as income, opportunities, output, et cetera are never static – they evolve with time. This makes the comparison of the benefits of a large-scale water resources project with the without project scenario difficult because we have to extrapolate the current economic state into the future in the absence of the project.

Cost-benefit analysis is a methodology designed to provide an economic evaluation procedure for public projects. It is analogous to the profitability criteria used in the private sector for decision-making for an investment. The primary difference of cost-benefit analysis from profitability is the need to assign monetary attributes to all benefits and costs irrespective of their marketability. There are however, government policies such as the Principles and Guidelines (P&G) adopted by the US Water Resource Council in 1983 or international agreements such as the World Commission on Dams (WCD), to assist in the process. The theoretical underpinning of cost-benefit analysis comprise assigning price to all benefits and costs based on willingness of people to pay given a perfectly competitive economy, discounting all future values to present value using a discount rate, and selecting only those projects which have positive net present values. The basic rationale for selecting a project with positive net present value is that those who receive the benefits can at least potentially compensate those who incur the costs. This is known as Kaldor-Hicks compensation test [11]. If full compensation were paid this would result in net gain to the society and everyone would be better off.

Philosophically, economic sustainability implies improving or at least maintaining productive capacity per head over time. On a national scale it tests if the national economy is setting aside sufficient savings to replace or add to their reproducible assets. To achieve a sustainable living standard, an economy's productive capacity must prove capable of delivering a stream of consumption over time which allows future generations to fare at least as well as the current generation [12]. Since the economic inputs and outputs occur at different times, it is necessary to choose a discount rate for proper comparison and whether an investment to be made by the current generation is worth it. A disputed issue amongst the economists is what should be the discounting rate. From neoclassical economic theory, the discounting rate should equal the marginal rate of return on private investment [11]. But those who oppose this view argue that this marginal rate is distorted by taxes, and public funded projects have significant externalities which would influence the rate. Lind [11] opines that the discounting rate should be 5%-7% in real terms in the US. In Queensland, the discounting rate used for large-scale water resources projects is 4 percent.

Cost-benefit analysis is a rough tool for the assessment of economic development because of market distortions and non-market valuations, nevertheless it remains a popular tool because it can identify big winners and losers and going through the process itself provides a learning curve of the complexities that exist in reality.

III. Social Equity

In simple words, social equity can be described as providing fair access to nature's water resources to each individual in a society. It is the responsibility of a government in a civil society to provide water supply and sanitation needs to each individual to fulfil the requirements of maintaining at least the basic living standards irrespective of one's ability to pay for the services. In Great Britain, for example, it has been found that such costs account for about 3 percent of living expenses [13]. There have been suggestions that these costs be paid out through social security payments to those who cannot afford, but critics of such an approach argue that actual costs vary greatly from region to region whereas social security payments tend to be uniform across regions and cannot account for the real need of an individual.

In a broad sense, social equity implies providing equitable share of water resources and ancillary amenities to different sectors of economic activity such as agriculture, fishery, industry, et cetera so that no segment of the population is disadvantaged more than others both for the current generation and future generations. There are goals and priorities in societies, which should no doubt be reflected in the allocation of the water resources, but if a segment of the population is disadvantaged it should be adequately compensated or alternative strategies should be devised such that the disadvantaged community can continue its sustenance in undiminished ways. A top-down approach is not the right way to achieve this as has been proven time and again, rather community consultation is a necessary step to find the right ways [14].

In practice, social security implies involving all communities including the weak and the vulnerable in decision-making process [15]. History has shown that this has not been the case especially in developing countries. The weak and vulnerable have been ignored, they suffered the most, and were not adequately compensated. Examples include the Kaptai Dam project in Bangladesh where more than 100 000 tribal people were dislocated and the Ataturk Dam in Turkey where more than 60 000 Kurdish people were displaced [16]. The fallout from these disengagement of ethnic minorities were unfortunate guerrilla warfare in Bangladesh that lasted for 22 years and Kurdish people are still fighting the Turkish army. Lessons learned from past experiences demonstrate that it is not easy to get support from all communities for any large-scale water resources project as has been the case for instance with the Traveston Crossing Dam project in Queensland [17], and Petts [18] states that there is no 'holy grail' to gain public trust, but deliberate engagement of the public has emerged as the right thing to do. Grassroots participation helps to create and fortify a general feeling of inclusion and belonging, and creates a 'virtuous circle' [14].

Social equity is difficult to measure. The Brundtland Report [8] brought social equity into international prominence by identifying the persistence of global poverty alongside material abundance and pointed that it is a moral imperative to share the fruits of development within and between economies, to ensure that those less well-endowed are offered more equitable access. Since then a measurable concept that has evolved is 'social capital'. Moldan et al. [19, p.256] define social capital as "the ability of people to work together for common purposes in groups and organisations", which includes "features of social organisation, such as networks, norms and social trust, that facilitate coordination and cooperation for mutual benefit".

IV. Environmental Sustainability

Environmental sustainability can be defined as the situation in which vital environmental functions are safeguarded for the future generations [20]. Many nations have articulated environmental sustainability expressed in laws and policies such as the United States Federal Water Pollution Control Act or 'Clean Water Act' (CWA), the European Union's Water Framework Directive (WFD), and Australia's Water Reform Framework. CWA provides the long-term national objective to "restore and maintain the chemical, physical and biological integrity of the Nation's waters" but does not define components, attributes or indicators [21]. Despite the United Nations' best efforts after the Earth Summit in Rio de Janeiro in 1992, there is no universal agreement as to what the environmental indicators should be – the matter remains a very complex issue. One of the key concepts in deciding on the environmental indicators is the 'reference condition' or benchmarking to which direction the indicators should show improved performance in the evaluation of a project proposal. Reference condition is important because it creates clearly defined goals and objectives by which the success of a project can be measured [22]. The WFD defines reference condition in terms of "no or minimal anthropogenic stress" and satisfying the requirements: (1) reflecting undisturbed conditions for hydromorphological elements, general physicochemical elements, and biological quality elements; (2) having concentrations of specific synthetic pollutants close to zero or below the limit of detection of advanced analytical techniques in general use; and (3) exhibiting concentrations of specific nonsynthetic pollutants within the range normally associated with background levels [23]. The oft cited and debated reference to target 'undisturbed' or 'pristine' condition warrants some explanation. Throughout history human beings have altered nature, and since the beginning of the industrial revolution anthropogenic forcing has contributed to climate change so that no part of the world with human presence is undisturbed [24]. The world is changing irreversibly, and to attempt to go back, which may not necessarily be a desirable outcome, would at best be a costly exercise if not impossible [22]. Realizing this reality, some experts choose as reference condition sampling sites which are considered "the best from what's left" and others use multiple definitions to delineate pre-intensive agriculture era, least disturbed condition, best attainable condition, etc. [23].

It is relatively easy to set physical and chemical environmental quality standards based on properties of water that can be measured, but preservation of biodiversity can be a much more challenging task to quantify. To illustrate the latter, let us consider a set of focal species (or bio-indicators of environmental quality) for a particular region, which need not be many because as Mangel et al. [25] point out that not many species are essential or of particular concern for conservation. There is a range of values of environmental parameters where the biological index score of the species would remain acceptable. At the fringes there would be domains where the ecosystem would be under stress but capable of springing back when conditions are favourable. Beyond that there would be permanent damage to the ecosystem. These facts are revealed in many studies [26], [27], [28], [21], and [29]. These suggest that the 'reference condition' should not be fixed points, but rather domains or range of values where we should not have any preferences. This view is supported in [23]. There should be considerable leeway based on prudent scientific judgement to alter the environment. Stance by some of the environmentalists such as in [30] wherein it is stated "protect free-flowing rivers from dams and major water resource development" forestalling any scientific analysis is counterproductive to overall prosperity and well-being of communities. The presence of EVR (Endangered, vulnerable and rare) species and legislation such as the U.S. Endangered Species Act would require separate considerations since few species benefit from efforts directed at rare species owing to their restricted distribution and idiosyncratic habitat needs [31].

V. Conclusions

Large-scale water resources projects can bring significant benefits to communities but they can also cause adverse environmental effects. Since such projects are essentially irreversible, it is imperative that all aspects including socioeconomic and environmental are considered meticulously. In the past, economic considerations dominated the decision making process; social equity issues remained in the domain of the groups with significant political clout; and people were not cognizant enough of the complexities of environmental impacts. Due to recent advances in social science and ecology, people are now better equipped to make more informed decisions about whether to go ahead or not in the implementation of a large-scale water resources project. It is essential though to strike a balance between economic development, social equity and environmental sustainability. Too much emphasis on environmental sustainability may deprive communities of the genuine opportunities that may come about regarding development of their water resources. By contrast, too little emphasis on environmental aspects can bring about a damage which the future generation will live to regret.

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