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Different approaches to assessment of design and management of sustainable urban water systems

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Abstract

The implications of sustainability on a construction level are quite well known, for example, with respect to the use of resources and emissions. On a higher level, sustainable development is not univocal. There are various sustainable solutions to a problem. Sustainable development is a complex problem, and in urban infrastructure a specific solution usually is the result of a planning process in which people from various backgrounds are involved. Different people have different perceptions of urban infrastructure and its management. A system of four basic approaches is presented, distinguishing so-called eco, ratio, socio, and carrying capacity approaches. This system, based on an extensive literature review, can facilitate the process leading to a workable consensus on sustainable development. The approach and planning process has to meet a certain set of requirements. Requirements are given, partly based on experience with planning for urban water infrastructure dealing with "natural" water flows in three cities.

Keywords: Design and management; Sustainable urban water systems

1. Introduction

In this paper, the focus is on projects dealing with planning for and assessment of urban water infrastructure. A very wide range of literature

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is available on projects that are claimed to be sustainable. In many cases the sustainability of supposedly sustainable projects is demonstrated by mentioning the application of certain "sustainable" measures, usually alternative, more "ecological" ways of dealing with, for example, urban drainage and wastewater. Apparently these alternative ways are viewed as inherently sustainable, and application of these techniques as a reason for a project to be sustainable. To test whether this belief is justified, an appropriate assessment method for sustainability is necessary. Globally, different methods for assessment of sustainability have been developed with varying degrees of success. Most successful are methods for assessing the (relative) sustainability of products and constructions [e.g., the widely accepted life-cycle analysis (LCA) method]. On a larger (spatial) scale, development of methods is less successful. This paper will show that different people use different approaches to sustainable development, and that these differences cannot be neglected. Hence, it is necessary for a widely applicable assessment system to take these differences into account. Because of the divers and intensive use of urban areas, a number of different organizations will always be involved in designing or planning for urban water resources. These organizations (or stakeholders) will usually take different approaches to sustainable development, resulting from their different interests. To reach mutual understanding and facilitate the planning and assessment process, it is important to have insight in the differences between the approaches.

In this paper different approaches found in sustainable urban (water) management are discussed. The following paragraph explores the concepts of sustainability and sustainable development by some generally accepted definitions. Subsequently, a distinction will be made between different approaches to sustainable development.

2. Definitions of sustainable development

What is sustainable development? There are two quite different definitions.

2.1. The Brundtland Commission

The Brundtland Commission defines sustainable development as *a development that fulfils the needs of the present generation, without compromising the ability of the future generations to fulfil their needs* [18]. The Brundtland definition is commonly accepted, and is used in Dutch national environmental policy.

2.2. "Water 21" project

Sustainability implies that the supply of "natural capital" is maintained. The use of renewable sources—such as water—should not exceed the rate

of renewal, the use of nonrenewable resource—like fossil fuel—should be such that they will not be exhausted before alternative sources are available, and fundamental ecological processes and structures should be maintained [19]. This definition is based on the "Water 21" project, a European research project on sustainable water policy. Pearce and colleagues [9] use a similar definition: "maintenance of the natural resource base of future generations."

Please note that the first definition focuses on needs of generations (people), where the second focuses on factors external to society (the environment). As presented, the definitions may be quoted slightly out of context. In the original publications both definitions are accompanied by remarks providing some nuance. Here, these remarks are neglected to point out the differences.

3. Key elements of the definitions of sustainability

In the definitions of sustainable development at least four key elements can be distinguished. These elements comprise the core of the concept of sustainable development.

Every definition is based on some or all of these elements: (a) needs of the present generation; (b) needs of future generations; (c) carrying capacity of supporting systems (or quantity and quality of supporting systems); (d) maintaining system integrity (the coherence between supporting systems).

3.1. Needs of the present generation

Although the fulfilment of present needs will be different in most cases, the present needs can be expected to be known or at least possible to distinguish. With respect to urban water management, these needs can be described in terms of the desires for and demands to the water system, for example, with respect to flooding, sanitation, the ecological system, recreation, and aesthetic value.

3.2. Needs of future generations

Sustainability means evaluating not only the consequences of choices for the present situation but also taking into account the consequences for the (far) future. De Groot [3] even defines the concept of sustainability exclusively as the long-term aspect. Consciousness of time is at the base of sustainability. Being conscious of time, however, does not bring about knowledge of the needs of future generations. Publications on sustainability differ widely in the way uncertainty in the needs of the future is taken into account (see, for instance, [3,5,16,18]).

3.3. Carrying capacity of supporting systems

It is assumed that the (eco) systems that support development have a certain carrying capacity, and this capacity has to be maintained to obtain a sustainable situation. Here, for example, ecosystems are seen as parts of the environment. A solution for the question of sustainable development seems to be available: by assessing the carrying capacity of the supporting (eco) systems, the boundaries are found within which a development is sustainable. Examples of attempts at finding these boundaries are plenty, for example, in Van de Worp and Don [13] and in the Dutch Interdepartmental Research Program "Sustainable Technological Development," where, among other subjects, a sustainable urban water cycle is discussed [17].

3.4. Maintaining the ecological, environmental, and hydrological integrity

Maintaining the ecological, environmental, and hydrological integrity is closely related to the carrying capacity of supporting ecosystems. This key element stresses that not only the physical features (supporting ecosystems) as parts of the environment are important. The relations and structures within the environment and the water system are at least of the same importance to sustainable development. The importance of relations and a meaningful structure can be demonstrated by using a device analogy. A device can consist of high quality parts, but without a meaningful structure and coherence the "device" will not function.

4. Sustainable development: A complex problem

The challenge of sustainable development is a complex problem. The natural, social, and economic processes involved are not only highly complex from a conceptual or scientific point of view, they are also complex from a management point of view. These complex problems or unstructured issues have a number of characteristics (based on De Bruin [1]). A very important characteristic is that multiple solutions exist to a complex problem. The different solutions "score" differently for various aspects, which typically are very hard to compare, like biodiversity, air pollution, and resource use. How do we evaluate a tradeoff between these aspects? Further characteristics include that the problem and its solution influence a large number of stakeholders, like people, companies, NGOs, and government agencies. Each stakeholder has specific objectives and interests, and hence, will evaluate a given solution according to these objectives and interests. And the stakeholders and their interests are dynamic; they change over time. For example, the present views of stakeholders are different from their views on the environment 20 years ago and will most probably continue to change. As a result their interest in a specific solution to the sustainability problem has changed, and will continue to change. Another characteristic

is that no common understanding exists on the procedure to reach a solution of the problem and perhaps of greater relevance to the subject at hand, no common understanding exists on the assessment of solution of the problem.

These characteristics lead to the conclusion that in a specific case no commonly acceptable solution can be determined by knowledge, science, and experts alone. Vermeulen [15] pose that in the evaluation of complex phenomena (like sustainable development) objective scientific knowledge cannot be used solely, because uncertainties cannot be eliminated when dealing with complex phenomena. An interactive planning process involving all stakeholders is necessary. The tradeoffs between different aspects and various interests are unavoidably based on a system of norms and values according to the approach of those who made the tradeoffs. Chances are that the proposed solution to the problem of sustainability is accepted by a certain group of stakeholders, but that it is not acceptable to stakeholders whose different interests and system of norms and values would have lead to different tradeoffs. These stakeholders would assess the "sustainable" solution differently, because they would weigh separate and related issues differently. Whether a solution is *acceptable* to a given stakeholder in itself seems of no direct relevance to the question of whether something is sustainable or not. It is relevant, however, when this stakeholder has influence on the execution or success of the solution. Some stakeholders can actively block or hinder execution or withhold their cooperation. Some stakeholders can sabotage or undermine the success of a solution once it is in place; for this reason, the solution will not be sustainable. An example: separated collection of solid waste or the domestic use of reclaimed effluents need the cooperation of the people living in the city. Building "sustainable" systems that remain unused can only impact the environment negatively. However, an important pitfall of interactive planning is "negotiated nonsense." People can agree on $1 + 1 = 3$ and regard it as true for the remainder of the planning process. The result of negotiation should be able to "stand the test of scientific knowledge." After going into different approaches to sustainable development and their aspects, I will describe some requirements for the planning process.

5. Different approaches and their aspects

A major factor influencing the acceptability of a solution and, for that matter, of the assessment of its sustainability is the approach to sustainability used in finding the solution and the assessment of the solution. In literature, the elements of sustainable development described above are elaborated in a large number of concepts, principles, and guide models. Here, various basic approaches are distinguished, on the basis of analysis of a literature review in the area of sustainable (urban water) management, for example, in proceedings like Joliffe and Ball [7], Sieker and Verworn [11], and the

research of Tjallingii [13], Pearce and colleagues [9] and the European Expert Group on the Urban Environment [4]. The reviewed proceedings contain some 750 papers, of which some 1/3 specifically mentions sustainability. When dealing with stakeholders following different approaches, it is necessary to know the differences between the various approaches. The focus of this paper is not the methodological difference between the specific approaches. The differences described here are of a more philosophical or conceptual nature, and are influencing the choice for and the acceptability of an approach. These differences influence the setting of objectives and of "sustainable levels," and hence, influence the assessment of sustainability. Research shows that the most important differences in the approaches can be reduced to: (a) differences in perspective of the relationship between people and the environment, and (b) the attitude with respect to (quantitative) norms and (qualitative) values.

5.1. The relationship between people and environment

In this context, not only humans but also society and economic systems are seen as part of the domain of "man" or "people" as well, together with built parts of our physical living environment, like buildings, roads, drainage, and sewerage. The *environment* is considered to consist of all natural phenomena, features, and processes, for example, the water cycle, (geo) chemical, biota, and abiota. Two contrasting attitudes towards the relationship of people–environment can be distinguished. Either humanity or the environment is the driving force behind the approach to sustainable development and the choices made in the elaboration of sustainable development.

In a *people-driven* approach, people and their desires, needs, and objectives are the driving forces behind the perception of sustainable development. Any value of the environment is derived from its use in service of human objectives, which can be either rational or emotional. Although the environment is limiting in ways, the environment can be adapted to suit the objectives of society. Problems are defined as the difference between the present situation and the objectives, in contrast to environment driven approaches. *Environment-driven* approaches, like the carrying capacity approach, state that the seriousness and extent of environmental problems should be established objectively from nature. In an environment-driven approach, the environment, with its possibilities and limitations, is the driving force behind the perception of sustainability and the elaboration of sustainable development. The possibilities and features of the environment (i.e., of nature) have an intrinsic value that cannot be ignored. The approach in "The limits to growth" [8] fits this approach.

5.2. Norms and values

Besides the attitude of people towards their environment, the way in which people evaluate this relationship or interaction is important to the

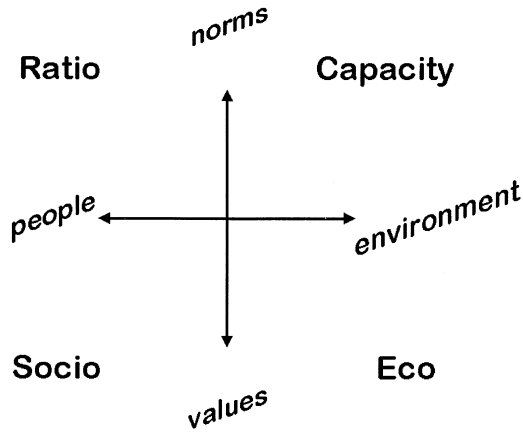

Fig. 1. Four basic approaches to sustainability, related to the aspects "people and environment" and "norms and values."

approach to sustainable development. Again, two contrasting approaches can be distinguished: (1) a quantitative approach based on norms, and (2) a qualitative approach based on values. The norms approach assumes that it is possible to determine norms or boundary values that are indicative of the sustainability of a development. In a normative approach solutions are optimized or the optimum solution is selected. Van Rooij [14], following a normative and people-driven approach, poses that society should choose only *measurable* objectives or targets. A target value in Van Rooij's view can be considered a project or area specific norm. An expression typical for the values approach is that "good is the enemy of better." In a values approach, values are maximized.

6. Four basic approaches to sustainability

In every project at least one approach has to be followed. In Fig. 1, four different combinations of the two aspects are used to form four different basic approaches. The approaches can be attributed to different quadrants of Fig. 1. Given the combination of aspects, these names have been chosen for the basic approaches: (1) norms and environment: capacity approach; (2) norms and people: ratiocentric approach; (3) values and people: sociocentric approach; (4) values and environment: ecocentric approach.

In a project usually a hybrid approach is (implicitly) used or can be recognized. The aspect of time can be considered as a third axis in Fig. 1. The approach followed in a certain case can be visualized as a blot or cloud somewhere in the plane of Fig. 1. As stakeholders and their interests change, the approach will change over time.

6.1. Carrying capacity approach

The (carrying) capacity approach is a normative approach focusing on the "carrying capacity of supporting ecosystems" or the environment. This basic approach typically assumes two states of the environment: (1) a sustainable state, and (2) a state of gradual (usually irreversible) degradation of the environment. Dutch national environmental policy is largely based on this approach; for example, for soil quality a system of norms is used, of which is assumed that when the soil meets these norms a sustainable situation is reached. The target values of these norms are related to the concentration at which no or negligible effect is measured, for example, on micro-organisms. Several researchers try to establish "sustainable levels of environmental stress," like the loading of surface waters with certain substances in effluent or CSOs. It is very hard to find univocal values in literature; usually only a number of parameters or sustainability criteria are summed up [13].

6.2. Ratiocentric approach

In the ratiocentric approach, choices are made based on an evaluation of the present situation and considering the objectives, which are set in an evaluation of all interests involved. Solutions to problems (technical or otherwise) are weighed using an objective method, making it possible to find an optimum solution. Ratiocentric is not equal to rational, however, as all basic approaches can be viewed rationally. Multicriteria evaluation methods are an example of a ratiocentric approach. In this approach maximum effectiveness can be described as the target variables coming as close as possible to the target values.

6.3. Sociocentric approach

In this approach, a central role is played by the interests and opinions of stakeholders, like the residents of a community, fishing clubs, and the waterboard. This means that priorities are set in an interactive process. A plan's maximum effectiveness can be described as when ". . . stakeholders are mobilized and make their contribution to the objectives. The various public and private stakeholders have to feel involved with the pursued processes" [5]. The sociocentric approach is a qualitative approach.

6.4. Ecocentric approach

In the ecocentric approach, "sustainable" is viewed as equal to "ecological." Nature is sustainable by definition, and a situation that approaches the natural situation as closely as possible is most likely to be sustainable. Environment has intrinsic value; natural properties of water systems are valued highly, and the importance of artificial features is to be reduced as

much as possible. For example, the Ecological Conditions approach [12] mentioned earlier is ecocentric. An important feature is that objectives are not met by trying to meet stringent norms, but by creating positive conditions for desired development. This is typical for a "values" approach.

7. Requirements

The planning process leading to a solution of a sustainability problem should meet certain (testable) requirements. Below a number of requirements is mentioned, largely based on De Bruin et al. [1] and De Bruin and Ten Heuvelhof [2]. These two deal with planning for complex problems in general, and so these requirements are more generally applicable and not just to urban water management. This specific set of requirements, however, is also based on experience with planning for sustainable urban water resource use in Almere, Amersfoort, and Leidsche Rijn, Dutch cities of 100,000 to 140,000 people. In the selection, a guideline for interactive planning by Hendriks et al. [6] was used. After the requirements below and in the discussion, this experience will be described concisely.

7.1. Before and at the start of the decision making or planning process

7.1.1. Content of the process

Before starting the process leading to a solution to a sustainability problem, an objective system analysis of, for example, the urban water system should be made, with respect to all key elements of sustainable development, for which many sustainability criteria are available.

7.1.2. Process

All parties should accept the system analysis; if not, the system borders should be altered accordingly; test the system analysis for negotiated nonsense, the system analysis should hold up to a scientific test.

All parties with interest in solution of the problem should be represented (stakeholder analysis).

Define a "marching route" before hand: define subjects and moments of choice.

Content follows from the process. Do not use a fixed problem definition; leave space in the agenda for new, related aspects; do not fix results before hand.

Consensus is not a necessity; acceptability is.

Use a process manager who is an expert regarding the subject at hand, and who is accepted by all parties involved as impartial to the outcome. The only interest of the process manager should be the process and not a specific solution. Think of a process manager as an impartial football referee.

7.2. During and after the decision-making or planning process

7.2.1. Content

Expert knowledge is used to facilitate the process; expert knowledge is invited into the process. Knowledge does not necessarily provide only one solution and can contain gaps. Knowledge used in the process needs to be negotiated and accepted by all parties.

Use expert knowledge, but keep a clear separation between (a) experts—knowledge—objectivity (not to be negotiated in the process); (b) stakeholders—opinions—subjectivity (to be negotiated; subject to opinion).

Test solutions with respect to consistency with system analysis, key elements and principles of sustainability.

Test intermediate results for negotiated nonsense; use negotiated knowledge.

No solution exists without history and context; these should be provided along the solution. Make subjectivity in results visible when presenting these results.

7.2.2. Process

Preferably do not discuss and choose concrete solutions directly but via discussion of selection criteria with relevance to central interests of the stakeholders.

Report negotiated nonsense back to the group of stakeholders and "rediscuss."

Assess according to negotiated criteria, test results for negotiated nonsense.

Analyse list of participants and solution; are all affected parties involved?

7.3. Experience in three Dutch cities

Planning sustainable urban water management in the Dutch cities of Almere, Amersfoort, and Leidsche Rijn is a part of the research described in this paper. Planning and research is still ongoing. Results are unpublished at this point in time (except for a progress report for Almere by Rijsberman and Van Marle [10]), and the limited space in this paper prevents thorough discussion of the planning process in these cities. The set of requirements mentioned above is based on preliminary results of the planning processes. Following the system of four basic approaches and the recommendations mentioned above, the planning process in Almere and Leidsche Rijn is successful so far. In this case, successful means that all participants from different departments of the local authorities and different backgrounds are enthusiastic, giving their full participation and all support the preliminary results. This situation is very different from the past were different departments of the local authorities would make different and sometimes even conflicting plans, to some extent ignoring each other plans and projects. In

Amersfoort, the planning process is not showing much progress, mainly due to changes in personnel.

The Almere and Leidsche Rijn experience show that a process-oriented approach using the four basic approaches can lead to progress and support not possible with a more strongly technical or "content-oriented" project approach. The Amersfoort experiences, however, show that an interactive, process-oriented approach is more dependent on the individual people involved and, thus, on changes in the group of people active in the planning process. The people involved have in a way a history together. When a new person substitutes a participant, this new person lacks the "common history," and is therefore, not able to participate in the way his or her predecessor did, until after some time a history in the planning process is built up.

8. Discussion

A commonly heard critique is that a process as is intended above does not lead to the best result, but only to the compromise of consensus. As I have tried to point out in this paper, an objective "best" does not exist, when considering solutions to complex problems, for instance, in planning for urban water resources. "Best" is always according to someone's system of norms and values. A "good quality process" leads to the *best achievable solution.* The solution, which results from a good process, is the best solution that is still acceptable and has the most support. An objective best according to the opinion of only one or a few of the stakeholders may, in theory, be better to the environment, but may never be effectuated, because of lack of support for its realization. However, negotiated nonsense is a pitfall, which has to be circumvented very carefully by (primarily) the process manager, by facilitating the process with appropriate knowledge and data.

9. Conclusions

Basic attitudes lead to choices that make people's approaches to sustainable development different. In this paper, some of these basic attitudes are elaborated, leading to basic approaches to sustainable development. The basic approaches differ in (a) perspective of the relationship between people and the environment and (b) the attitude with respect to (quantitative) norms and (qualitative) values. Differences in approaches to sustainable development can lead to differences in problem analysis and subsequently to different solutions. Hence, a system for assessment of sustainability in urban water management (and for other urban infrastructure, for that matter) can not be based on only one approach. This means that a generally applicable assessment system should incorporate all four basic approaches and the process of reaching a case-specific, hybrid approach.

There are no objective solutions to complex problems. Acceptance of the solution by all stakeholders is highly important to the successful realization of a sustainable solution.

The planning process leading to the choice of a solution is very important. Assessment of the solution without taking into account the "history" and context of a solution can be of only limited value. When the sustainability of a project is evaluated by an organization not involved in the design or planning process, chances are that they will not entirely agree with the approach to sustainable development followed, and therefore, reject the results of the project as "not sustainable (enough)." Hence, it can be concluded that it is important to make the considerations leading to an approach to sustainable development explicit, so people can at least agree to disagree.

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