

Resource Allocation and Problem Prioritization for Sustainable Military Facilities, Infrastructure, and Installations

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This paper describes a process for systems-based sustainability analysis to support the allocation of resources for sustainable design and development of built facilities at military installations. Systems-based sustainability analysis can be applied to the planning and design of a capital project to systematically identify technologies and strategies that will make the project more sustainable. The systems-based approach can then be used to identify key attributes of candidate technologies and strategies that are associated with the likelihood of success of each strategy. This paper presents a framework for evaluating candidate technologies and strategies in terms of attributes and factors of both the solution and context of application that affect the likelihood of achieving sustainability goals.

Sustainability and Military Capital Projects

The Department of Defense (DoD) is interested in the concept of sustainable design and development in response to a variety of drivers, including Executive Order mandates, a desire to demonstrate environmental excellence, awareness of a trend toward reduction in budgets for operating and maintaining military installations, and recognition of the importance of environmental stewardship in achieving mission requirements. Having set sustainability goals for its installations and their facilities, one of the significant questions the DoD has is, “What makes a facility sustainable?” As a concept, sustainability has been touted as a means of “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987, quoted on the front cover of *Sustainable Design and Development: A Guide for Army Garrison Commanders* – ACSIM 2000). This definition brings out two primary considerations for DoD personnel seeking to implement the concept: the notion of meeting today’s needs, and making sure that the means and methods of meeting those needs do not have adverse impacts on the ability of future humans, including the armed forces of the future, to meet their needs.

Given this definition, it is clear that courses of action that do not meet DoD’s needs today are not sustainable. What is less clear is how DoD should go about meeting the requirements of its mission without negatively impacting the ability of future generations to meet their own needs. Specifically, how do decisions made at multiple levels (from doctrine to policy to operations) have the potential to impact future generations? In the case of built facilities, what actions *now* might reduce or eliminate options for meeting human needs in the future? How should courses of action be set to ensure that the outcome of those actions is sustainable?

In the context of this paper, a “sustainable facility” is one for which the current and probable future states of the facility cause no net negative impacts to resource bases or ecosystems (the two means by which humanity now and in the future will meet its needs), while satisfying the needs of its stakeholders. This paper presents two contributions toward a strategy for making military facilities more sustainable: a systems-based method for identifying sustainability improvement opportunities, and a likelihood of success rating framework that can help prioritize candidate solutions after they have been identified.

Overall Approach for Systems-Based Sustainability Assessment

To identify improvements to an existing facility (or a designed system that exists on paper but is not yet constructed), the ideal sustainability state can be defined from a performance standpoint, serving as a starting point for working backward to define gaps between the existing and the ideal states. In defining the ideal sustainability state, a facility is sustainable if it meets the following criteria AND falls within any feasibility constraints imposed on the project:

- Stakeholder Satisfaction = Basic needs met
- Resource Base Impact = No or neutral impacts
- Ecosystem Impact = No or neutral impacts

Figure 1 provides a graphical representation of these three criteria considered together. A facility would be sustainable if it falls anywhere within the octant of sustainability depicted in the diagram.

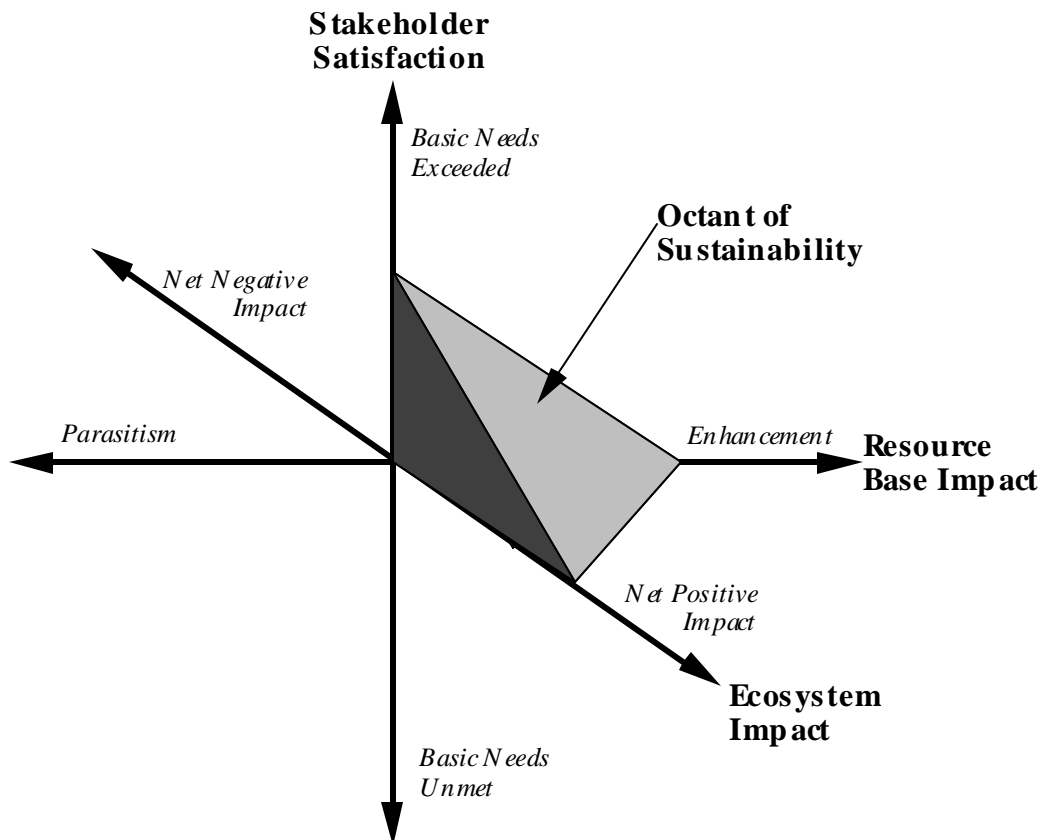


Figure 1: Systems-based Sustainability Criteria (Pearce 1999)

To determine the relative sustainability of an existing vs. “ideal” facility, i.e., one that meets the constraints depicted in Figure 1, we need to know how the facility performs with respect to the three criteria that define sustainability for a built facility, represented by the three axes of the diagram:

- Stakeholder Satisfaction – how well does the facility meet the needs and aspirations of its stakeholders? Does it meet their expectations well enough that stakeholders do not take compensating actions that would reduce sustainability?
- Resource Base Impacts – does the construction or operation of the facility contribute to the degradation or depletion of resource bases? If so, is that negative impact ameliorated either by natural regeneration of the resource base itself, or through some compensatory positive impact of the facility system?
- Ecosystem Impacts – does the construction or operation of the facility contribute to the destruction or degradation of natural ecosystems? If so, is that negative impact ameliorated either by natural recovery of the ecosystem itself, or through some compensatory positive impact of the facility system?

If the sustainability of a facility system can be estimated in terms of these three factors, then different design alternatives of the facility can be compared in terms of their relative sustainability, enabling designers to choose the most sustainable alternative among the set of options considered. The resultant outcomes of comparing the existing state of the facility to the “ideal” sustainability state of that facility represent sustainability improvement opportunities for the facility. These opportunities can then be addressed in terms of Best Available Technologies and Strategies (BATS) that change the facility in such a way as to improve its performance in terms of one or more of the performance criteria without reducing its performance with respect to the other criteria.

Search for BATS that Address Sustainability Improvement Opportunities

Having identified specific opportunities to improve sustainability by identifying gaps between the existing and ideal sustainability states of the facility, the next step is to seek out ways to reduce, eliminate, or offset negative impacts associated with that facility’s existing state. This process involves reviewing the knowledge base of existing Best Available Technologies and Strategies (BATS) for sustainable facilities to search for matches for each opportunity. For each opportunity, potential applicable BATS can be identified that might improve the sustainability performance of the resulting facility, i.e., reduce some negative impact caused by the facility as identified in the gap analysis. Figure 2 illustrates eight different categories of strategies for minimizing, eliminating, or offsetting negative impacts associated with different components of the facility system. These strategies are divided into four categories:

- **First-order Strategies** – these strategies are ones that should be examined first in seeking to increase the sustainability of the system. Since they involve actions that can be taken directly *inside* the boundary of the system, they offer maximum control of outcomes by stakeholders and, correspondingly, the least amount of risk.
- **Second-order Strategies** – these strategies involve changing the sources or sinks of flows or the kinds of flows themselves in order to reduce negative impacts. These are the second course of action since they offer some control over outcomes by stakeholders (who get to choose for the most part what products they want to use and from whom, i.e., purchasing power for goods and services). However, since the behavior of the sources and sinks is out of direct control of stakeholders, there is some measure of risk involved.
- **Third-order Strategies** – these strategies involve working directly with affiliate systems (which serve as sources or sinks to the facility itself) to help them improve their own sustainability. Compared to second-order strategies, stakeholders have even less control over outcomes and therefore have higher risk of unpredicted outcomes. However, source and sink systems have a vested interest in maintaining their market, so there is some motive on the part of affiliate systems to improve their sustainability if doing so will solidify relationships with their customers.
- **Fourth-order Strategies** – the final class of strategies consists of finding ways to offset negative impacts of the facility system by improving the impacts of other, unrelated systems. In many instances (e.g., for all new materials and equipment that must be imported during the construction of a facility), this is the only way to reduce net impacts to zero. However, it is a measure of last resort in that it offers the least amount of control to stakeholders and therefore the greatest amount of risk in terms of outcome predictability.

For each negative impact identified in the systems-based analysis, the search for strategies should start by seeking first-order strategies that would reduce the associated negative impacts to zero. If no BATS can be found that are first-order strategies, then the search proceeds on through second-, third-, and fourth-order strategies until a solution can be found that could reduce the associated negative impacts to zero. For cases in which no higher-order strategies are available to reduce impacts to zero, the lack of higher-order strategies represent missing or yet-to-be-developed BATS that should be developed in future research.

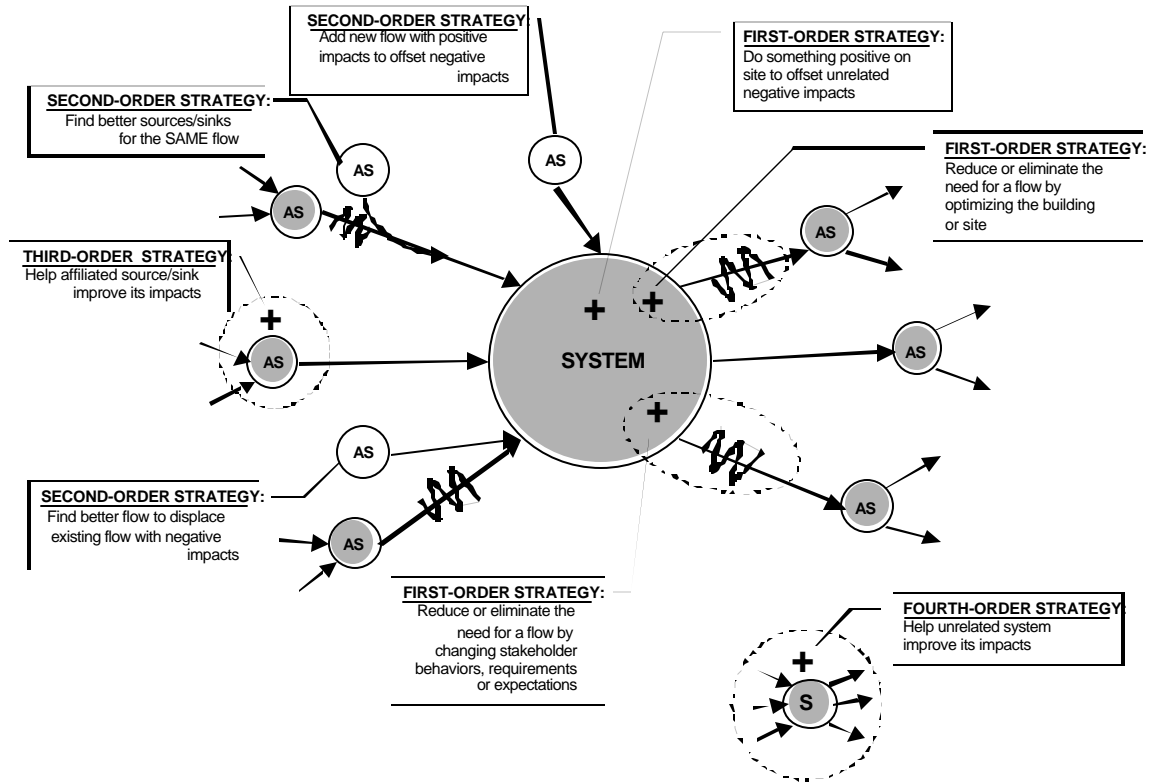


Figure 2: The Spectrum of Strategies for Improving Facility Sustainability (Pearce & Fischer 2001)

Prioritization of Potential BATS for Resource Allocation Based on Likelihood of Success

After systems-based analysis is used to identify BATS that could be used to improve the sustainability of a facility being analyzed, the next step is to further assess the feasibility, costs, and benefits of all potential BATS to select those that maximize sustainability benefit while reducing associated costs and/or negative impacts. For these BATS, a conceptual feasibility check should first be performed to determine if they can be applied without compromising stakeholder satisfaction requirements or other project constraints. If a BATS does not meet feasibility constraints, it should be eliminated from further consideration. If a BATS *does* fall within feasibility constraints, it should be considered in light of the likely cost and effort required to achieve the sustainability improvement provided by that BATS. BATS can also be evaluated based on associated risk, reliability, value, and difficulty associated with the kind of strategy being used. Together, these attributes comprise a framework for identifying BATS that warrant the allocation of resources for implementation (Table 1).

Risk is used as an evaluation criterion in terms of the likelihood that implementing the BATS would actually result in the desired effect. In general, greater control is associated with strategies taking place *inside* the system (first order strategies) than *outside* (all other strategies). Likewise, being a customer of affiliate systems (third order strategies) means greater control over the success of efforts to improve those systems than if there is no market relationship between systems (fourth order strategies). By definition, control is inversely proportional to risk. Therefore, risk can be estimated for each BATS based on the level of control exerted over its lifecycle by decision makers, corresponding to the classification of strategies identified in the previous section and illustrated in Figure 2.

Reliability is also an important complementary consideration for determining how effective the BATS would be over time in achieving its desired impact without additional special efforts on the part of facility decision makers. In general, transparent solutions (where users are unaware that a better product has been

substituted for another, for instance) are more reliable than other solutions. Transparent technology-based solutions are more reliable than solutions dependent on consistent *behavior* of stakeholders. For example, installing a technology that separates waste has a greater reliability than if stakeholders are expected to remember over the long term to separate their own wastes. Provided adequate expertise exists to operate and maintain the technologies, technology-based solutions avoid the foibles of reliance on human behavior for their success.

Table 1: Likelihood of Success Criteria for Rating BATS (Pearce & Fischer 2001)

RATING	CRITERIA
RISK	
A	Classification as a First-order Strategy
B	Classification as a Second-order Strategy
C	Classification as a Third-order Strategy
D	Classification as a Fourth-order Strategy
RELIABILITY	
A	Excellent – completely transparent technologies requiring no behavioral changes on the part of stakeholders and resulting in no perceptible changes in performance
B	Good – transparent technologies that require no behavioral changes on the part of building users, but may require behavioral changes on the part of building professionals (e.g., designers, contractors, operators, maintainers, etc.)
C	Fair – non-transparent technologies that produce noticeable changes in performance and require some adaptation or “getting used to” by users
D	Poor – strategies relying mostly or completely on behavioral modification of users
VALUE	
A	Excellent – will completely eliminate undesirable impact without creating any significant new undesirable impacts that can’t be easily addressed
B	Good – will partially eliminate undesirable impact without creating any significant new undesirable impacts that can’t be easily addressed
C	Fair – will completely eliminate undesirable impact, but at the same time will create new undesirable impacts that cannot be easily addressed
D	Poor – will partially eliminate undesirable impact, but at the same time will create new undesirable impacts that cannot be easily addressed
DIFFICULTY	
A	Easy – requires no additional resources AND no significant behavior changes.
B	Doable – requires some additional resources OR some change in behavior or expectations on the part of stakeholders
C	Difficult – requires many additional resources OR significant change in behavior or expectations of stakeholders
D	Impossible – some policy or constraint prohibits implementation, or BATS is unavailable in this situation. Change in policy would be required for implementation.

The third evaluation criterion is value, in this case referring to the ability of each BATS to achieve the goal of ameliorating negative impacts without causing other negative impacts as a result. BATS can be rated

based on how much of the undesirable impact they would eliminate if implemented correctly, and how many new undesirable impacts their implementation would generate. For instance, installing a more efficient lighting system might reduce negative impacts associated with electricity consumption over the life cycle of a facility, but it would also generate a solid waste stream during retrofit as well as set in motion a chain of events necessary to manufacture and transport the elements of the new system.

The last criterion, difficulty, is included as a measure of how able project stakeholders are to implement the solution, given the available resources, current objectives and expectations, and constraints associated with the specific project situation and context. Solutions can be rated as more difficult to implement if they required additional resources (including time, cost, expertise, etc.), or changes in current behavior for affected stakeholders.

Together, the four criteria return a qualitative comparison of the relative costs and benefits of each option, and can be used to prioritize potential BATS for allocation of resources. While the criteria shown in Table 1 could be considered subjective based on the attributes of the evaluator, together they represent a step toward a consistent metric of how successful a given BATS is likely to be within the context of its application. As such, the criteria can be used as a basis for allocating scarce resources toward those solutions that are most likely to achieve the objective of increasing the sustainability of the facility under consideration.

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