Desalination and Water Treatment
www.deswater.com

1 (2009) 1–6

1944-3994 / 1944-3986

Water engineering for the promotion of peace

W. Richard Bowen

i-NewtonWales, 54 Llwyn y mor, Caswell, Swansea, SA3 4RD, UK
email: wrichardbowen@i-newtonwales.org.uk

Received 26 August 2008; accepted 25 November 2008

ABSTRACT

In a world of limited resources, limited sympathy and limited rationality, competition leading to tensions and conflict can arise. In such circumstances, a key responsibility of any society is to ensure the security of its citizens. The role of engineering in contributing to such security is most usually considered to be the development, manufacture and use of military equipment so as to ensure dominance if tensions result in violence. To make a contribution to international security is a worthy goal for individual engineers and engineering enterprises. However, contributing by preparation for war is an inadequate response, especially considering recent analyses of the origins of conflict, government strategy and international initiatives. These emphasise the importance of cooperatively resolving the underlying roots of conflict so as to promote sustainable peace. Competition for water is already a root source of violent conflict in some parts of the developing world, and a source of tension in many others. Even for affluent Western countries, water stress is a significant factor in security strategy. Hence, water engineers have the expertise to make a substantial contribution to the promotion of peace by working to ensure the availability and equitable distribution of clean water and sanitation on a world-wise basis. This will require the incorporation of increased degrees of compassion and generosity in the fulfilment of our professional activities. The concept of *Peace Engineering* can provide an effective focus for these goals. A further task for engineers is to take greater responsibility for informing security analysts, politicians, and other decision makers about the specific capabilities of engineering to contribute to sustainable peace. The fulfilment of this task may be greatly enhanced if the promotion of a culture of peace *within* engineering is aligned with major international initiatives such as the UN's programme of action on a *Culture of Peace*.

Keywords: Conflict; Culture of peace; Development; Economics; Peace; Peace engineering; Strategy; Sustainable security; War; Water

1. Introduction

The goal of engineering may be described as the promotion of human flourishing through contribution to material wellbeing. The UK Royal Academy of Engineering has provided a cogent and challenging description of the activities of engineers:

"Professional engineers work to enhance the welfare, health and safety of all whilst paying due regard to the environment and the sustainability of resources. They have made personal and professional commitments to enhance the wellbeing of society through the exploitation of knowledge and the management of creative teams." [1]

Presented at the 2nd Oxford Water and Membranes Research Event, June 2008.

There is strong historical evidence that one of the most effective ways in which engineering can contribute to human wellbeing is through the provision of safe drinking water and adequate sanitation. For example, in the 1840s infant mortality in the UK was about 160 deaths for every thousand live births, roughly the same as in the poorest countries today. Children died especially from diarrhoea and dysentery. Public investment in the provision of affordable safe drinking water and adequate sanitation in the second half of the nineteenth century led to a steep decline in the infant mortality*. Similar health benefits were achieved in the US at about the same time For example, typhoid mortality in Cincinnati fell from 60 per 100,000 people to 5 per 100,000 people in about two years following the introduction of drinking water filtration to remove bacteria, with chlorination giving further reduction [2]. Remarkably, a recent poll conducted by the *British Medical Journal* even led to sanitation (water supply systems and sewage disposal) being voted the most important *medical* advance since 1840, from a short-list which included anaesthesia, antibiotics, discovery of DNA structure, germ theory and vaccines [3].

However, not all engineering activities have such universally beneficial outcomes. We live in a world of limited resources, limited sympathy and limited rationality, with the result that competition leading to tensions and conflict can arise. In such circumstances, a key responsibility of any society is to ensure the security of its citizens. The role of engineering in contributing to such security is most usually considered to be the development, manufacture and use of military equipment so as to ensure dominance if tensions result in violence. Resources deployed in this way are enormous: world annual military expenditure in 2007 is estimated at $1339 billion [4], almost a third of US engineers are employed in military activities and the largest single employer of engineers in the UK is a military company. War devastates individuals, families, societies and the structures that support them. The greatest suffering is inflicted on the most vulnerable in society. For example, the United Nations Foundation estimates that ninety percent of those killed, wounded, abused or displaced in violent conflict are (civilian) women and children [5]. Such a use of engineering skills is directly counter to the aspiration of engineers to enhance the welfare, health and safety of *all*. Indeed, such an extensive activity may be considered a form of contempt for life.

Water engineering and military engagement appear quite distinct activities. However, they are becoming entangled with the increasing realisation that water is a scarce resource and hence a potential source of conflict. In this context, the present article begins with a summary of recent analyses of the origins of conflict and approaches to peace. Secondly, examples of the relationship between water and conflict in the developing world will be considered. Thirdly, the role of water resources in UK military strategy will be outlined. Fourthly, the relative magnitude of world military expenditure and the costs of water provision will be reviewed. The analysis to this point will have indicated that water engineers have a special opportunity, indeed a responsibility, to use their skills to promote peace. The article will then suggest two approaches to the fulfilment of this responsibility: water engineering as a vital part of *Peace Engineering* and water engineering as a key component in the promotion of a *Culture of Peace*.

2. The origins of conflict and approaches to peace

Independent organisations such as the Oxford Research Group have provided perceptive analyses of current threats to peace and of the most effective responses. The Group identifies four factors as the root causes of conflict and insecurity at present and the likely determinants of future conflict: (i) climate change, (ii) competition over resources, (iii) marginalisation of the majority world, and (iv) global militarisation. The Group characterises the predominant current responses as a *control paradigm* - an attempt to maintain the existing state of affairs through military means. They argue that current security policies are "self-defeating in the long-term", and so a new approach is needed. They propose that a more effective approach is a *sustainable security paradigm* - to cooperatively resolve the root causes of these threats using the most effective means available [6]*.

The second identified root cause, competition over resources, is the most relevant in the present context. Such competition is a major factor in many current military conflicts. For example, the ongoing conflict in the Persian Gulf region is to a large extent about control of the location and exploitation of oil, as are the tensions and conflicts in the Caucasus. Tensions related to water are also already apparent between a number of states, including: Israel, Jordan and Palestine; Syria and Turkey; China and India; Egypt, Sudan and Ethiopia; Angola and Namibia. The Oxford Research Group notes:
"Water is a source of security and prosperity, and with water shortages likely to increase, with the potential to severely affect food production in some areas, some of these tensions could develop into full-scale armed conflict unless there is strict observance of water laws and a multi-lateral approach to developing water management agreements." [6]

* Infant mortality is death of infants in the first year of life. It is now 5.0 in the EU for every thousand live births.

* Ideological differences are not included in this list of factors. However, the Group's document later introduces political dialogue as an important feature of the proposed sustainable security paradigm.

However, water is already a factor in armed conflicts in some parts of the world.

3. Water and conflict in the developing world: Darfur

The conflict in Darfur has caused extensive loss of life and much suffering. The origins of this conflict are complex, but access to water was an important issue. Darfur was severely affected by a long-term drought in North Africa. The World Council of Churches has reported that the conflict was triggered by the resulting clashes over access to water and pasture between small groups of black African farmers and Arab pastoralist communities. The conflict escalated as the groups grew bigger. Eventually a government-backed militia, the Janjaweed, became involved. This militia would terrorise local villagers, displacing them from their homes and hence taking control of water sources [7].

The traditional source of water for many villages in Darfur was surface lakes that filled during the rainy season. The drought interrupted this supply. Water can also be provided from hand-dug wells. However, these need to be 20 m deep, so their construction and use is hazardous. Water is drawn up from such wells using cans attached to ropes. Due to their open nature, such wells can easily become unhygienic. A better engineering solution is to drill boreholes accessing deeper water and equip them with submersible pumps. Such wells can be sealed with concrete to prevent contamination. A number of NGOs are involved in such work. The current extent of this conflict is a stark reminder of how a timely application of relatively simple engineering for the provision of water might have prevented much suffering. However, water engineering may still have a role in resolving the conflict.

The case of Darfur points to three salient aspects of the use of water engineering for the prevention or resolution of conflict in developing countries. Firstly, it is important to intervene early. The World Council of Churches has also reported an increase of "small clashes" concerning resources such as water around Africa, such as a clash in the Mt Eldoret region of Kenya in which 60,000 people were displaced and about 200 people killed [7]. Early intervention can prevent such clashes escalating. Secondly, the displacement of people in such conflicts gives rise to a need to provide water and sanitation wherever they subsequently gather. Thirdly, such conflicts may be in part or wholly about the control of other resources, such as exportable oil in the case of Darfur.

4. Water and conflict in the developed world: UK security strategy

Despite the modest size of its population and its peaceful geographical location, the UK has the second highest military budget in the world in cash terms, and the fifth highest in purchasing power (after the US, China, India and Russia) [8]. UK government strategy on security therefore has global significance.

In 2006 the UK government decided to develop a new nuclear weapons system at an estimated initial cost of $40 billion. The UK government's case for this new system emphasised the need to insure against an uncertain future. Four main uncertainties were identified : (i) the continued and unpredictable proliferation of nuclear weapons, (ii) weak and failing states offering safe havens for international terrorists and creating wider instability, (iii) increasing pressure on key resources such as energy and water which may increase interstate tension, (iv) the rapid and uncontrollable development of military–relevant technology by the civil sector making potential adversaries increasingly capable [9]. This is a very different list to that given by the Oxford Research Group. However, the one common feature is the competition for resources, especially energy and water.

Within the UK Ministry of Defence is a Directorate General known as the Development, Concepts and Doctrine Centre. This Centre has published a detailed analysis of the future strategic context for defence for the next thirty years. Water resources feature at a number of points in this document, for example:

"Water stress will increase, with the risk that disputes over water will contribute significantly to tensions in already volatile regions, possibly triggering military action and population movements. Experience indicates that countries generally seek equitable solutions to water disputes, but that severe shortages may provoke more virulent responses. Areas most at risk are in North Africa, the Middle East and Central Asia, including China, whose growing problems of water scarcity and contamination may lead it to attempt to reroute the waters of rivers flowing into neighbouring India, such as the Brahmaputra [10].

By the end of the period, nearly two-thirds of the world's population will live in areas of water stress...Food and water insecurity will drive mass migration from some worst affected areas and the effects may be felt in some affluent regions through distribution problems, specialized agriculture and aggressive food-pricing." [10]

This is a source document for the development of UK defence policy. Due to the long timescale considered it is necessarily somewhat speculative. However, it is clear that water is expected to be a significant long-term issue in the development of that policy.

Current overall UK government strategy on security has recently been clarified in a single document for the first time. This publication makes clear that, "The broad scope of this strategy also reflects our commitment to focus on the underlying drivers of security and insecu-

rity, rather than just immediate threats and risks" [8]. It further recognises that competition for energy, climate change and water stress are "the biggest potential drivers of the breakdown of the rules-based international system and the re-emergence of major inter-state conflict, as well as increasing regional tensions and instability" [8].

The consonance of these aspects of the strategy with the Oxford Research Group's analysis is striking. However, there is at present a substantial tentativeness about their implementation. For example, the total UK budget for conflict prevention and peacekeeping is only about 2% of that for direct military expenditure, and of the same order as subsidies to arms exporters [11].

5. Military and water costs: some overall com-parisons

A range of processes, both simple and advanced, is available for the production of safe drinking water and for sanitation. Developed countries can afford the costs of installation of advanced and expensive processes. However, even simple processes are often not available in developing countries. As a result, 2 billion people are affected by water shortages in over forty countries, 1.1 billion people do not have safe drinking water and 2.4 billion have no provision for sanitation. The consequences are enormous. It is estimated that 25,000 people die *every day* from water-related hunger (some specifically from thirst) and that 6,000 people, mostly children under the age of five, die *every day* from water-related diseases [12]. It is also in such developing countries that water stress is presently most likely to lead to violent conflict. If there is a commitment to seek to prevent such conflicts, it is therefore pertinent to compare military and water costs.

The costs and benefits of water and sanitation improvements at a global level have been quantitatively evaluated [13]. Five levels of intervention were considered, two of the most significant of which are:

(a) Halving the proportion of people who do not have access to improved water resources and improved sanitation facilities by 2015, a Millennium Development Goal target. ("Improved water" includes basic technology such as stand post, borehole, protected spring or well, or collected rainwater. "Improved sanitation" includes septic tank, pour-flush, simple pit latrine, small bore sewer or ventilated improved pit latrine.)
(b) Access for all to a regulated piped water supply and sewage connection into their houses.

All interventions were compared to the situation in 2000 and costed to include full investment and annual running costs. The total annual costs of the two outlined here were estimated to be: (a) $11.3 billion; (b) $136.5 billion.

It is easy to lose an awareness of individuals in global calculations of this type, so it is helpful to consider the annual cost per person receiving interventions: (a) $5.4; (b) $20.6.

These are very modest sums in the context of the benefits to the individuals.

There are, of course, many uncertainties in such calculations and detailed country case studies are required. However, it should be noted that the annual cost of the least expensive intervention is a tiny 0.8% of world annual military expenditure. Even the annual cost of the most expensive intervention is only 10% of world annual military expenditure.

6. Interim overview

The analysis so far has indicated how competition for water is already a source of violent conflict in some parts of the world, and a source of tension in many others. Even for affluent Western countries, water stress is a significant factor in security strategy. Western security strategy is at present mostly based on a military control paradigm, though with some recent reference to a sustainable security paradigm.

Whilst proposing such a sustainable security paradigm — cooperative resolution of the root causes of threats using the most effective means available — the Oxford Research Group noted that "Governments will be unwilling to embrace these ideas without pressure from below" [6]. This prediction is confirmed by the very tentative implementation of such ideas by the UK, even though they form part of published government strategy.

Astonishingly, none of the documents on security strategy so far cited makes explicit reference to non-military engineering, such as water engineering, even though such engineering can provide specific solutions for the implementation of a sustainable security paradigm. This indicates that security analysts, politicians, and other decision makers have a very inadequate appreciation of the capabilities of engineering. It is, therefore, especially important that professional engineers are among those exerting "pressure from below" to ensure the implementation of a security strategy that can offer a more enduring possibility of peace. The following sections suggest two approaches for engineers, and in the present context especially those knowledgeable about water engineering, to contribute to such a strategy: *Peace Engineering* and engineering for the promotion of a *Culture of Peace*.

7. Peace Engineering

Engineering may be used to *dominate* in violent conflicts. Such an approach inevitably leads to death and great suffering for many civilians, especially the most

vulnerable in society. Engineering may be better used for the *resolution* of conflict through peaceful means, such as the present contribution of NGOs in Darfur. Even better still, engineering may be used for the *prevention* of conflict by removal of the root causes. This has led to the emergence of the concept of *Peace Engineering*, seen as a vital complement to the dichotomy of military engineering and civil engineering (broadly understood). This approach is especially associated with P. Aarne Vesilind, a specialist in environmental and water engineering. In collaboration with a colleague, he has provided the following definition:

"Peace engineering is the proactive use of engineering skills to promote a peaceful and just existence for all people. Examples of how engineers have been and will continue to use their skills for this purpose include the Peace Corps, the World Bank, Pan-American Health Organization, and perhaps hundreds of nongovernmental organisations such as Engineers Without Borders. One way of promoting peace in engineering is to teach ethical skills alongside technical skills within our universities. Thousands of engineers have devoted themselves to this concept, but few have ever thought to call themselves by this title: *peace engineer."* [14]

Particularly important to this approach is the commitment of engineers to use their skills in developing countries and especially in those countries that are most susceptible to conflict. A recent collection of essays [15] on this topic gives examples of how individual engineers have used their skills for this purpose. The essays give some remarkable accounts of the diversity of uses of engineering skills, such as the career of Dennis Warner, a water and sanitation expert, who in a 30-year career has worked in Ethiopia, Iraq, Rwanda, Kosovo, Gujarat and Israel/Palestine [16].

Such peace engineering is not glamorous and does not use the latest technology, but it is a highly effective means of preventing conflict through the priority it gives to helping people in extremely vulnerable situations. It recognises that the sources of conflicts are many, that they are frequently related to poverty, and seeks to address them at the local level. Such work requires intense personal commitment from the individual engineer working in the (most usually) developing country.

Engineers working in developed countries can also make a major contribution to the prevention of conflict in both the developed and developing world if they choose career paths that respond to recent analyses of the determinants of conflicts. The four groups of factors identified as the most likely root causes of future conflict are climate change, competition over resources, marginalisation of the majority world and global militarisation. All of these have a major engineering component. For example, engineers can choose to prioritise: renewable energy as a means of controlling climate change; innovative water treatment processes and energy efficiency as a response to resource competition; processes especially suitable for use in developing countries as a response to marginalisation; and the halting of weapons development as a key component in checking global militarisation.

8. Engineering for the promotion of a *Culture of Peace*

The prevention and resolution of conflict requires more than engineering, it is also depends on a multitude of cultural, societal and political factors. Further, the absence of conflict is a necessary but not sufficient condition for peace. Peace is additionally characterised by relationships between individuals, and social groupings of all sizes, based on honesty, fairness, openness and goodwill. Hence, if engineering is to contribute fully to the prevention and resolution of conflict, and to the establishment of genuine peace, it needs to align its activities with those of other like-minded individuals and institutions.

Alignment of engineering aspirations with the UN activity for the promotion of a *Culture of Peace* [17] may be an especially effective way forward. Such a culture is considered to consist of values, attitudes and actions that promote cooperation and mutuality among individuals, groups and nations. The United Nations has identified eight action areas: fostering a culture of peace through education; promoting sustainable economic and social development; promoting respect for human rights; ensuring equality between men and women; fostering democratic participation; advancing understanding, tolerance and solidarity; supporting participatory communication and the free flow of information and knowledge; promoting international peace and security [18].

Engineering can make an important contribution to all of these areas. A number of such contributions have already been described in this article. The UN recognises that a key challenge in the action area to promote sustainable economic and social development is the availability of clean water and sanitation world-wide, including in the less developed and densely populated regions, as well as providing the infrastructure for its equitable distribution. It is further pertinent to note that even those actions that appear societal or political can benefit from appropriate engineering. For example, drilling convenient wells can promote gender equality as women are freed from the often onerous task of collecting water from a remote source.

A real benefit of considering these action areas is to use the context of an authoritative set of priorities to provide a specific focus for the future tasks of individual engineers, engineering institutions and engineering enterprises. Further, alignment with this international action can help the task of ensuring that politicians and other decision-makers appreciate the role of engineer-

ing in the non-military prevention and resolution of conflict and the promotion of peace and security considered in the most fundamental way.

9. Conclusions

Engineers, and in the present context particularly those with expertise in water engineering, have the skills to make a great contribution to security and sustainable peace through helping to resolve the root causes of conflict. Indeed, if we accept the challenge to work to enhance the welfare, health and safety of *all*, we have a responsibility to undertake this task*. This will require the incorporation of increased degrees of compassion and generosity in the fulfilment of our professional activities. The concept of *Peace Engineering* can provide an effective focus for these goals.

A further task for engineers is to take greater responsibility for informing security analysts, politicians, and other decision makers about the specific capabilities of engineering to contribute to sustainable peace. The fulfilment of this task may be greatly enhanced if the promotion of a culture of peace *within* engineering is aligned with major international initiatives such as the UN's programme of action on a *Culture of Peace*.

Acknowledgement

I thank Espen Eie Bowen for helpful comments during the writing of this article.

References

[1] Royal Academy of Engineering, Statement of Ethical Principles, London, RAE, 2007.
[2] United Nations Educational, Science and Cultural Organization. Water: a Shared Responsibility: World Water Development Report 2, Paris, UNESCO, 2006.
[3] British Medical Association, Medical Milestones: Celebrating Key Advances Since 1840, British Medical Journal 334. Poll results are given at http://www.bma.org.uk/ap.nsf/Content/BMJPollresults
[4] Stockholm International Peace Research Institute, SIPRI Yearbook 2008. Armaments, Disarmament and International Security, Oxford, OUP, 2008.
[5] United Nations Foundation, http://www.unfoundation.org/media_center/publications/pdf/Conflict_Prev_Peace0.pdf, 2008.
[6] Oxford Research Group, Global Responses to Global Threats, Oxford, ORG., 2006.
[7] World Council of Churches, http://www2.wcc-coe.org/pressreleasesen.nsf/index/Feat-07-06.html, 2006.
[8] Cabinet Office, The National Security Strategy of the United Kingdom, London, TSO, 2008.
[9] Cabinet Office, The Future of the United Kingdom's Nuclear Deterrent, London, HMSO, 2006.
[10] Development, Concepts and Doctrine Centre, The DCDC Global Strategic Trends Programme 2007–2036, London, DCDC, 2007.
[11] S. Elworthy, Cutting the Costs of War, Oxford, ORG., 2004.
[12] United Nations Educational, Science and Cultural Organization, Water for People, Water for Life: World Water Development Report, Paris, UNESCO, 2003.
[13] G.. Hutton and L..Haller, Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level, Geneva, World Health Organisation, 2004.
[14] D.A. Vallero and P.A. Vesilind, Socially Responsible Engineering, New Jersey, John Wiley, 2007.
[15] P.A. Vesilind, ed., Peace Engineering, Woodsville, Lakeshore Press, 2005.
[16] D.B. Warner, Working for peace in international emergencies: the varied roles of engineers and engineering, in Peace Engineering, P.A. Vesilind, ed., Woodsville, Lakeshore Press, 2005, pp.75–92.
[17] United Nations, Declaration and Programme of Action on a Culture of Peace, General Assembly, A/RES/53/243, New York, UN, 1999.
[18] United Nations, Culture of Peace, General Assembly, A/61/175, New York, UN, 2006.
[19] W.R. Bowen, Engineering Ethics: outline of an aspirational approach, London, Springer-Verlag, 2009.
[20] W.R. Bowen, Strategies for engineering development: Advancing technology, prioritising people, Desalination, 227 (2008) 3–13.

* A detailed analysis of such challenges and responsibilities has been provided [19,20].