Hiroshan Hettiarachchi
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Environmental Resource Management and the Nexus Approach

Managing Water, Soil, and Waste in the Context of Global Change

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Chapter 1
Managing Water, Soil, and Waste in the Context of Global Change

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Abstract This is an introductory chapter to the book. It provides the background and brief discussion on how and why resource management efficiency should be improved and how the proposed nexus approach may help. It provides a definition to the nexus approach applied to the water-soil-waste context. It also discusses how the negative impacts from some global change aspects can be overcome with nexus thinking.

1 Background

Despite all advances we have seen in the food and agriculture industries, one in seven people still goes to bed empty stomach (Lal 2014). Feeding seven billion mouths has already proven to be challenging, but the prediction is that this number will be increased by another two billion within the next 35 years (UN 2013). This situation certainly gives a warning on the way we currently address food security. The question in short is if we are using all potential solutions. Perhaps resource efficiency could play a larger role than what we think of it now.

Before getting into the discussion on solutions, it is worthwhile to understand why and how food has become an issue. The period between 1950 and 1970 marked a clear shift in the way we do "business" as mankind. Population doubled since then. Urban population exceeded rural population for the first time (Hoff 2011). New technologies flourished. New industries found their way into existence increasing the energy needs. The increase in global trade was sixfold (WTO 2008). The increase in water use and river damming was also sixfold (Xu et al. 2007). As a result, about 70 % of the world's freshwater resource is now used for agriculture (WBCSD 2005; USGS 2015). All these reasons have somehow contributed toward the food issue. It is not that we did not attempt to address food security. But whatever the change that has been happening since the 1950s is happening faster

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than we can react. With all these facts in place, now we understand one thing clear; the change, which we now know as global change, is not only real, it is also accelerating its pace.

What is global change? In general, the planetary-scale changes that can make significant impact on Earth system are referred to as global change. The land, ocean, atmosphere, life, the planet's natural cycles, and deep Earth processes are the major components of the Earth system (IGBP 2015). Each of these components exists in a dynamic equilibrium with one another, and any significant change in one can result in changes (often negative) in others. Global change is not new. It has been happening for millennia. As a species, mankind has been adapting to all changes happening around them for hundreds of thousands of years. What's new is that, this time, the changes are happening fast. This demands us to find ways to cope up with the accelerated pace of global change. We, as humans, as always, begin to pay attention to any issue only when we feel the impact. With some serious signs of change such as increasing sea levels, more droughts, and changing rain patterns, if there is any right time to pay more attention, it is now.

2 Global Change Adaptation

Thirty years ago acceleration of global change was only a theory; now we know it is real. Currently there is much debate on how we should adapt to global change. With the effects of global change accelerating, adaptation should be required virtually in all regions of the globe. Adaptation to global change may involve adjustments or responses to actual or expected events or their effects. While no clear measuring stick is found to understand if we, as a society, have done a good job with adaptation, the ongoing discussions have undoubtedly raised the awareness. Thanks to these discussions, "global change" is now in the common vocabulary of many and a phenomenon understood by many.

The fivefold increase we witnessed in fertilizer use since the 1960s and also manufactured reactive nitrogen from fertilizer exceeding the global terrestrial production of reactive nitrogen are all signs of how we have tried to cope up with some changes (Lal 2014; UNEP and WHRC 2007). Feeding a population of seven billion people would not be possible without artificial fertilizers. Can the scientific advances and the engineering innovations in agriculture alone provide solutions to the expected future demand for food? In addition to the sciences and engineering, there is a whole range of other factors we need to take into consideration. A diverse range of adjustments to management models, human behavior, and public policy are among the other major aspects that need to be considered for adaptation (JGCRI 2015). Thinking outside the box is essential to finding effective solutions to an issue which is challenging and complicated. One helpful starting point is to revisit the management models and tools used in optimizing resource efficiency.

3 Water, Soil, and Waste

What we recommend is taking a second, but serious, look at how we manage our water, soil, and waste resources. Essentially, these are three key environmental resources involved in crop-based food production. Water is a natural resource that is important to a variety of stakeholders representing many different uses. The role played by soil in our day-to-day activities, and especially in food production, is also readily understood. They are both natural resources, and until we realized otherwise lately, these two resources have been taken for granted for their abundance. On the other hand waste is completely different from the above two. As a society we often look at waste only as a nuisance and a "problem." But it is in fact a man-made resource. The value is not readily visible as material is mixed in different proportions such as in a low-grade deposit of iron ore. For example, municipal solid waste (MSW) is rich in organics, although the proportion varies from place to place. With appropriate technological solutions, the organic fraction of MSW can be completely diverted from waste stream to the soils as compost or a soil conditioner.

Thus far "integrated management" options have been the most favorable tools used to manage environmental resources such as water, soil, and waste. Integrated water resource management (IWRM) is one of such example. While a city government is interested in how potable water is distributed and wastewater is collected efficiently within its boundaries, industries outside of the city need to coordinate with another local government body to arrange their water needs. In the meantime, the federal government of the same country might be engaged in negotiations with neighboring countries on how they should share one river to obtain water for agriculture as well as energy production. The need for managing water resources collectively, by different stakeholders, paved the way to this management option that we call IWRM today. The idea is to coordinate development and management of water-related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability (GWP 2000).

IWRM has been a helpful management model. However, like many other integrated management tools, IWRM also has one major weakness that limits its applicability and acceptance among the policy makers. While managing the main resource in concern, it often disregards the interdependencies the main resource may have with other recourses. Actions taken in managing one resource can make a positive or negative impact on another. Wastewater management is one of the best examples to explain how the above three resources are linked to each other. Proper management of wastewater provides not only a secondary source of water for some specific use but also nutrients that can be fed back to the soils.

The question is if we have the management "tools" and "mind-set" ready to capitalize on these synergies. The answer as of today is no. Sludge is just a by-product the wastewater treatment plant needs to get rid of, and in some countries, they are disposed in landfills. On the other hand, water sector rarely looks at wastewater as a legitimate supply source, except for some rare examples such as the NEWater project in Singapore (PUB 2015). The solution we propose is a formal mechanism to utilize theses synergies, which may not be achieved until the management of these three resources is also integrated. Integrated management at such higher level that goes beyond resource boundaries is certainly a new idea. We define it as the nexus approach.

4 The Nexus Approach

As per the Oxford Dictionary, a complicated series of connections between different things is referred to as a nexus (Oxford Dictionary 2015). In the management sense, nexus approach would mean managing more than one, complicated, and interconnected things to achieve better results. In a nutshell the nexus approach should provide a platform to look at more than one resource at a time in one nexus. Although universal acceptance to the nexus approach is yet to be gained, the concept itself is not exactly new. In connection with environmental resource management, the term nexus was introduced for the first time during the 1980s, notably in a project by the United Nations University on Food-Energy Nexus Programme (Sachs and Silk 1990). Resource management circles throughout the world continued to use the nexus concept to explain the interdependencies between different recourses in 1980s and 1990s. Some examples of these nexuses included water-electricity, water-energy, groundwater-electricity, water-agriculture, and finally water-energy-food.

However, the nexus approach only gained momentum and became popular among the international academia and policy circles in the lead up to the Bonn 2011 conference on the "Water, Energy, and Food Security Nexus." The conference clearly argued that such an approach would result in improved water, energy, and food security by integrating "management and governance across sectors and scales" (UNU-FLORES 2015). It also pointed out that this approach would reduce trade-offs, build synergies, and promote sustainability and provide transition to a green economy (Hoff 2011).

The Bonn 2011 conference also discussed the need to have more integrated policy and decision making in all sectors involved and also the need for a coordinated and harmonized nexus knowledge base (Hoff 2011). This explains one characteristic feature of the nexus approach. Since nexus approach is about putting few disciplines into one action plan, the success depends on how the approach is supported by new and favorable policies. This has made governance and capacity development inclusive parts of nexus approach. Implementation to accommodate new changes would not be possible without them. Such new approaches certainly involve increased costs, but it is fair to say that expected future savings through nexus approach would be much higher.

In a previous section we briefly mentioned the challenges observed in the integrated management models and hesitation in the policy circles to accept some results produced by integrative management tools/models. It is also worthwhile to briefly discuss the reasons and how it does not become an issue in the nexus approach. Going back to the IWRM example, we know that the key variable is allocation of water. All other aspects of water users (energy, agriculture, industries, etc.) remain in the equations as fixed constraints, where they should also be treated variables in reality. Not being able to capture the reality, sometimes, leads to less favorable results. Decision makers are reluctant or sometimes completely unable to implement the recommendations made based on such integrated modeling tools.

As far as the modeling part is concerned, the major difference between integrated management and nexus approach is that in the nexus approach, the traditional input-output models are replaced by the concept of linked cycle management. Therefore, the model results should be much closer to reality compared to the models developed based on integrated approach. We do agree that this is easier said than done. The development of nexus approach-based modeling tools is yet another challenge to be addressed in the years to come.

5 Climate Change, Urbanization, and Population Growth

As briefly discussed in the first section of this chapter, there are many scientific aspects that lead to the discussion on global change. While some aspects are the results of global change, there are others that contribute to the acceleration of the same. We identify climate change, urbanization, and population growth as three of the most prominent aspects that can make significant impact on environmental resource management, especially water, soil, and waste.

Unusually long-lasting changes in weather patterns are referred to as climate change. The period of changes may vary from decades to as long as millions of years. When the World Climate Research Programme (WCRP) was established in 1980, there were so many "if" questions such as if the climate was really changing, if human activities are at least partly responsible for those changes, and also if the changes could be predicted. Few years later scientists discovered that the changes in the climate are in fact part of a big puzzle that we now call global change.

Climate change is believed to be caused by factors such as biotic processes, plate tectonics, volcanic eruptions, and variations in solar radiation received by Earth (USEPA 2015). Certain human activities are also considered as contributing factors toward some climate change components such as global warming. The Intergovernmental Panel on Climate Change (IPCC) recently revealed in a report that scientists are more than 95 % certain that most of global warming is caused by increasing concentrations of greenhouse gases and other anthropogenic activities (IPCC 2014). Global greenhouse gas emission from the food-related industries is only second to energy and heat production. Agriculture along contributes 14 % and other land use changes and forestry contribute 17 % (IPCC 2007). On the other hand, both soil and water are considered to be among the most climate-vulnerable sectors among environmental resources. Climate change causes further drying of already arid zones, and also extreme weather events result in less productive yield in crops. The whole world anticipates climate change adaptation to be the solution.

However, climate change adaptation is also proven to be costly. If irrigation is the solution for water scarcity, it should be noted that irrigation always cost more money compared to rain-fed agriculture. Desalination or tapping into deep groundwater is also much costlier than the use of conventional water supplies.

While climate change is more or less a result of global change, urbanization is a main driver of the cause. As mentioned before, city dwellers are now more than 50 % of the global population and this figure is expected to reach 70 % by year 2050 (Hoff 2011). This rapid increase in urbanization undoubtedly brings more challenges into the resource management equations which demand for new solutions to increase resource efficiency. Based on the monetary and technological capabilities, urban areas, if combined with nexus thinking, have the capacity to convert this threat to an opportunity. For example, the increased volume of waste and wastewater generated by the increased population can become a source of nutrients and a secondary source of water.

Similar to urbanization, population growth is also a driver of global change. The trend in the growth is clear; global population will reach nine billion by the middle of the century. What is not so clear is the impact it may make on environmental resources, especially the ones that are essential to food, water, and biomass production to sustain the increase in the population. In many developing countries, population is growing much faster than their food supplies. It is also known that the population pressures have resulted in degrading a large area of arable land.

6 The Way Forward

The nexus approach is still a new concept and is constantly evolving. Like many other new concepts, it is natural not to have a common consensus on the nexus approach. Many understand it, value it, but also have slightly different views on it. The application of nexus approach to manage environmental resources, especially water, soil, and waste, is a new experiment. But, it is an experiment that shows promising prospects.

The intention of this book is to provide a platform to discuss different viewpoints related to the nexus approach when applied to environmental resource management and how it may help us adapt to the rapid pace of global change. While this introductory chapter provides a brief but broad overview, the subsequent chapters present the perspectives of a number of thought leaders. They discuss how the nexus approach could contribute to management of water, soil, and waste. We believe this book will provide a clear and unbiased opinion on the role of the nexus approach in environmental resource management. We also believe that this will finally help shape the much needed nexus thinking for the future.

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Part I
Climate Change Adaptation