PROCEEDINGS OF THE INTERNATIONAL KICK-OFF WORKSHOP

# ADVANCING A **NEXUS APPROACH** TO THE SUSTAINABLE MANAGEMENT OF **WATER, SOIL** AND **WASTE**

## Session Summaries and Case Studies

11-12 NOVEMBER 2013

**DÜLFERSAAL,**
**TECHNISCHE UNIVERSITÄT DRESDEN**
**DRESDEN, GERMANY**

**INCLUDING CASE STUDIES** FROM CHINA, ETHIOPIA, GHANA, INDIA, IRAQ, MAURITIUS, MEXICO, REPUBLIC OF KOREA, SERBIA, UNITED REPUBLIC OF TANZANIA AND FURTHER EXAMPLES FROM SOUTH ASIA AND AFRICA

UNITED NATIONS UNIVERSITY
UNU-FLORES

TECHNISCHE UNIVERSITÄT DRESDEN

Republic of Korea | Tanzania | Uganda | India | Mongolia

Proceedings of the
INTERNATIONAL KICK-OFF WORKSHOP

# ADVANCING A NEXUS APPROACH TO THE SUSTAINABLE MANAGEMENT OF WATER, SOIL AND WASTE

## Session Summaries and Case Sudies

Stephan Hülsmann, Mari Ito and Reza Ardakanian (eds.)

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DÜLFERSAAL, TECHNISCHE UNIVERSITÄT DRESDEN
DRESDEN, GERMANY

CONVENING ORGANIZATIONS


# About UNU-FLORES

**BACKGROUND**

The United Nations University Institute for Integrated Management of Material Fluxes and of Resources (UNU-FLORES) was established in Dresden, Germany in 2012. The institute is supported by the Federal Ministry of Education and Research (BMBF) and the Ministry for Higher Education, Research and the Arts (SMWK) of the Free State of Saxony, Germany. As part of the United Nations University (UNU), the institute helps build a bridge between the academic world and the United Nations. The UNU was founded in 1973 as an autonomous organ of the UN General Assembly and today encompasses 13 research and training institutes and programmes in 12 countries around the world. UNU as a whole aims to develop sustainable solutions for pressing global problems of human survival and development. Through a problem-oriented and interdisciplinary approach, UNU targets policy relevant research, education and capacity development on a global scale.

**VISION**

The Dresden-based institute of UNU-FLORES acts at the forefront of initiatives promoting a nexus approach to the sustainable management of water, soil and waste. UNU-FLORES supports the overall mission of UNU by serving as a think tank for the United Nations and its member states, in particular addressing the needs of developing countries and emerging economies. As a think tank, UNU-FLORES will be an internationally recognized hub and intellectual focal point promoting integrated management strategies. Additionally, UNU-FLORES will attract high-calibre students for postgraduate study and research programmes in cooperation with other research institutions. The institute will build the capacity of future leaders in the area of environmental resources management and develop innovative concepts for target- and region-specific knowledge transfer.

**MISSION**

UNU-FLORES develops strategies to resolve pressing challenges in the area of the sustainable use and integrated management of environmental resources such as soil, water and waste. Focusing on the needs of the UN and its member states, particularly the developing countries and emerging economies, UNU-FLORES engages in research, capacity development, advanced teaching and training as well as dissemination of knowledge. In line with UNU's general mission to promote sustainability, UNU-FLORES also considers impacts of global change on resources management.

**THE NEXUS APPROACH**

Advancing a nexus approach to the sustainable management of the environmental resources water, soil and waste is the main mission of UNU-FLORES. The nexus approach is based on the belief that vital environmental resources are strongly interconnected and require a integrated perspective to manage them sustainably. Such a nexus perspective must take into account different sectors and disciplines in both research and capacity development and strive for holistic management strategies.

**RESEARCH PROGRAMMES**

UNU-FLORES aims at a truly integrative and global perspective on resources management, considering interrelated resources in a comprehensive manner. This holds also true for impacts of global change and its nexus to green economy. In all of the following research programmes of UNU-FLORES, the institute will cooperate closely with other universities and research institutions in both research and teaching:

- Systems and Flux Analysis considering Global Change Assessment Unit
  *Integrated Resources Management under Conditions of Global Change*
- Capacity Development and Governance Unit
  *Evidence-based Decision Making for Planning and Management of Environmental Resources*
- Water Resources Management Unit
  *Water Resources Management within the Context of Inter-related Environmental Resources*
- Soil and Land-use Management Unit
  *The Soil-Water-Waste Nexus*
- Waste Management Unit
  *Sustainable Management of Waste as a Resource Interrelated with Water and Soil*

**EDUCATION AND CAPACITY DEVELOPMENT**

UNU-FLORES engages in the following areas of postgraduate education, capacity development and trainings:

- UNU-FLORES offers a joint Doctoral programme as well as other postgraduate programmes together with its partners, especially with the Technische Universität Dresden (TUD). The programmes will focus on each of the research areas of UNU-FLORES and will include course work according to a pre-defined scheme.
- Additional capacity development and training programmes will focus on the further education of professionals who are working in the area of environmental resources management.

A unique feature of all education activities will be the emphasis on the global dimension of the covered issues. One aspect of this global nature will be international exchange programmes for students and teachers as well as internships with other UNU and UN bodies.

For more information, please visit: flores.unu.edu

# Foreword

The international kick-off workshop on "Advancing a nexus approach to the sustainable management of water, soil and waste", which took place on 11-12 November 2013 in Dresden, Germany, was one of the major activities of UNU-FLORES in 2013, less than one year after the official opening of the institute in December 2012. From the very beginning during the planning process and even more now, some months after the workshop, it was and is considered an important milestone during the establishment phase of UNU-FLORES. The workshop succeeded in achieving various goals, the most important one being to prepare the ground for a bi-annual Dresden Nexus Conference. The first one (DNC2015) will take place on 25-27 March 2015 (http://flores.unu.edu/dresden-nexus-conference).

With the workshop and further on with DNC, we aim at establishing a platform dealing with the nexus approach to resources management both from a scientific and an implementation points of view. Bringing together stakeholders and experts from universities (including several UNU institutes), research institutes, UN agencies, international organizations as well as organizations and ministries from Germany, NGOs and representatives of selected member states, helped shaping and advancing the nexus concept, identifying research needs and opportunities and challenges of implementation to be followed up in future DNCs.

The international kick-off workshop also served to finalize the White Book (http://flores.unu.edu/white-book) on advancing a nexus approach to the sustainable management of water, soil and waste, which reflects the major topics of the workshop and which serves as reference material for DNC2015. A tangible outcome of collaborations initiated by the workshop is a forthcoming book on "Governing the Nexus" to which various participants contributed.

We prepared summaries of all sessions and collected all presentations on our website immediately after the workshop (http://flores.unu.edu/nexus-kickoff-workshop). These proceedings not only contain detailed reports of all sessions (including the wrap-up), but also an analysis of questionnaires we collected from participants after each session. In addition, various case studies on integrated management of water, soil and waste, which we collected during and after the workshop, most of which were presented during the event (but not included in the summary on the website), are reported here. The case studies, mainly completed after the workshop, cover a wide range of topics and approaches and were conducted in (alphabetical order) China, Ethiopia, Ghana, India, Iraq, Mauritius, Mexico, United Republic of Tanzania and contain examples from further countries in South Asia and Africa.

Looking back at the event we are grateful for the support and input we received from our co-organizers, co-conveners, our donors and all other partners, colleagues and interns involved. Looking ahead, we are approaching DNC2015 and are looking forward to three days of exciting discussions and exchange of ideas and experiences on how the nexus approach can help in addressing challenges of global change and achieving the targets of the sustainable development goals. I warmly invite all readers of these proceedings to participate!

Reza Ardakanian
Director, UNU-FLORES

## Table of Contents

## List of Abbreviations and Acronyms

| | |
|---|---|
| **BMU** | Federal Ministry for the Environment, Nature Conservation and Nuclear Safety |
| **BMZ** | Federal Ministry for Economic Cooperation and Development |
| **BRICS** | acronym commonly used to refer to the five major emerging economies: Brazil, Russia, India, China and South Africa |
| **CEDARE** | Centre for Environment and Development for the Arab Region and Europe |
| **CIPSEM** | Centre for International Postgraduate Studies of Environmental Management |
| **DAAD** | German Academic Exchange Service |
| **DIE** | German Development Institute |
| **DNC2015** | Dresden Nexus Conference on Advancing a Nexus Approach to the Sustainable Management of Water, Soil and Waste |
| **EU** | European Union |
| **EWI** | Eastwest Institute |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **FINISH** | Financial Inclusion Improves Sanitation and Health project |
| **HSE** | Hydro Science and Engineering (MSc Programme at TU Dresden) |
| **IMF** | International Monetary Fund |
| **IOER** | Leibniz Institute of Ecological Urban and Regional Development (Germany) |
| **IPSWaT** | International Postgraduate Studies in Water Technologies |
| **IWMI** | International Water Management Institute |
| **IWRM** | Integrated water resources management |
| **NGO** | Non-governmental organization |
| **RBF** | Results-based financing |
| **Rio+20** | United Nations Conference on Sustainable Development |
| **SDG** | Sustainable development goal |
| **SMWK** | Saxon State Ministry for Higher Education, Research and the Arts |
| **TU Dresden** | Technische Universität Dresden |
| **UFZ** | Helmholtz Centre for Environmental Research |
| **UNEP** | United Nations Environment Programme |
| **UNESCO-IHE** | United Nations Educational, Scientific and Cultural Organization Institute for Water Education |
| **UN-Habitat** | United Nations Human Settlements Programme |
| **UNU** | United Nations University |
| **UNU-EHS** | United Nations University Institute for Environment and Human Security |
| **UNU-FLORES** | United Nations University Institute for Integrated Management of Material Fluxes and of Resources |
| **UNU-INRA** | United Nations University Institute for Natural Resources in Africa |
| **UNU-INWEH** | United Nations University Institute for Water, Environment and Health |
| **UNU-MERIT** | United Nations University Maastricht Economic and Social Research Institute on Innovation and Technology |
| **UNW-DPC** | United Nations Water Decade Programme on Capacity Development |
| **WEF** | Water–Energy–Food |
| **ZEF** | Centre for Development Research, University of Bonn |

# 1. Introduction

*The participants of the international kick-off workshop in Dresden advanced "The Nexus Approach to the Sustainable Management of Water, Soil and Waste" together (Photo: UNU-FLORES)*

The twenty-first century brings many challenges which carry increasing complexities including climate change, population growth and demographic change and securing energy, natural resources, technological development and peace to name a few. These challenges affect the lives of individuals, society, our ecology and the environment to a smaller or larger degree and in parallel or consequentially. Methodologies have been developed to breakdown this complexity into smaller components in order to help solve each problem in an easy and effective fashion. However, many of these problems are interconnected and a solution to one may come at a cost to another. Thus, a nexus approach was put forward as a way in which to bridge various disciplines and sectors allowing engagement between them and to facilitate dialogue.

The International Kick-off Workshop on Advancing a Nexus Approach to the Sustainable Management of Water, Soil and Waste, held in Dresden, Germany, 11–13 November 2013, was intended to serve as a follow-up and extension of the Bonn2011 Nexus Conference, as outlined in the workshop concept note (see section 2). To this end, the workshop was organized as four sessions which addressed the following issues: [I] opportunities for adopting a nexus approach; [II] challenges for the nexus approach; [III] capacity development for research and education programmes; and [IV] institutional arrangements and governance structures. These four sessions were followed by a wrap-up and summary session. For each session in the workshop, goals were defined and key questions were identified (see section 3) in order to facilitate discussions. These key questions were presented to selected stakeholders who were asked to contribute (section 4). The agenda of the workshop was then developed based on the responses from participants to these key questions which were provided in advance (section 5). The workshop brought together experts from national and international universities and research institutes, government entities, United Nations agencies and institutions of the United Nations University (UNU) system. The summaries for each session, beginning with the opening address through to concluding remarks, are found in section 6. During the workshop, questionnaires were also distributed to participants to ensure that the ideas of all participants were captured. The responses were then analysed and summarized (see section 7), which showed a high-

level of commitment for integrated management. In addition, several case studies from the application of the nexus approach from different regions of the world were presented during the workshop. These case studies indicate a need for the integrated management of environmental resources worldwide (section 8).

The presentation slides and videos from the sessions of the kick-off workshop are available from the United Nations University Institute for Integrated Management of Material Fluxes and of Resources (UNU-FLORES) website (http://flores.unu.edu/nexus-kickoff-workshop). This workshop served as a starting point for the upcoming biannual conferences in Dresden, the first of which is the Dresden Nexus Conference on Advancing a Nexus Approach to the Sustainable Management of Water, Soil and Waste in 2015 (DNC2015; see http://flores.unu.edu/dresden-nexus-conference), see section 9. The draft white book, which was prepared for the kick-off workshop, has been updated and finalized based on comments from participants. The final version was published in order to provide reference material for the upcoming DNC2015 (http://flores.unu.edu/white-book).



## 2. Concept of the International Kick-off Workshop

The water, energy and food security nexus, initiated by the Bonn 2011 Nexus conference, was internationally acknowledged as an approach that builds synergies across sectors and may facilitate integrated management and governance strategies, overall promoting sustainability and the transition to a Green Economy. The nexus approach is based on the firm belief that vital environmental resources are strongly interconnected and require a nexus perspective to sustainably manage them. Thus, advancing a nexus approach to the sustainable management of environmental resources requires concerted action and cooperation on a global level and across sectors. However, there are still considerable knowledge gaps in the nexus approach, requiring well-defined nexus research programmes. Also, it yet has to find its way into the curriculum of respective study programs and examples of good and improved governance resulting from adopting a nexus perspective are rare. For a sustained follow-up to the nexus initiative a long-term commitment of leading institutions and thus an institutionalized support is indispensable.

Clearly, the nexus is a very broad concept, covering many aspects related to the areas water, food and energy. From the perspective of resources management, a nexus approach needs to be developed and implemented by integrating **water resources management** and **soil and land-use management** (and planning). Also to be considered and included in the nexus approach is **waste management,** especially concerning organic matter and the recycling of nutrients and concerning the treatment, remediation and rehabilitation of polluted aquatic and texrrestrial sites and habitats. For all these resources, sustainable management strategies have to be based on consistent and comprehensive **systems and flux analysis** approaches taking into consideration the **impacts of global change,** considering climate change as well as urbanization, population growth, demographic changes etc.

Besides addressing knowledge gaps and the need for better scientific understanding on why we need a nexus approach (focusing in particular on water, soil and waste), advancing a nexus approach requires special attention to the question what is required to implement it. It will be addressed in this regard, enabling environment, governance and the systems and organizational levels (institutional capacity development) as well as knowledge issues and education (individual capacity development).

**Objectives**

The kick-off workshop aims to provide an update on current initiatives advancing a nexus approach, focusing on research initiatives on the integrated management of environmental resources, in particular exploring the nexus of water, soil and waste. It is intended as a kick-off for a series of workshops and conferences. Besides research, issues of capacity development in a broad sense will be considered, including education and training as well as institutional capacity development. Examples and case studies on research projects, best-practices and curriculum requirements will be introduced and discussed to provide an up-to-date overview on the issue.

With respect to the nexus of water, soil and waste, the specific topics to be addressed during the workshop include:

1. Opportunities for adopting a nexus approach to the management of environmental resources and its relevance to the envisaged sustainable development goals and the post-2015 development agenda;

2. Challenges for the nexus approach in managing water, soil and waste under conditions of global change;

3. Capacity Development for research and education programmes addressing the nexus, in particular teaching and training programmes;

4. Institutional arrangements and governance structures that advance the nexus approach to management of environmental resources.

Workshop sessions will revolve around these major themes. For each theme there will be an introductory talk and some presentations to highlight case studies and best-practices from ongoing projects and programmes. In addition, panel discussions will work out

- knowledge gaps and propose avenues for joint research (topics 1 and 2),
- curriculum requirements (3.) and
- institutional prerequisites and identify hurdles in the implementation of nexus approaches as well as propose ways to overcome them (4.).

The ultimate goal of the kick-off workshop is to provide the conceptual background for the upcoming bi-annual conference and to compile a White Book based on the results obtained. The structure of the White Book should reflect the four main topics addressed. This White Book may represent a roadmap for research and action with respect to the nexus approach and of issues to be taken up in future workshops and conferences.

*The participants of the workshop actively contributed in discussions and via questionnaires, analyzed in section 7 (Source: UNU-FLORES)*

The draft White Book which had been prepared for the kick-off workshop was finalized according to comments received by the participants and has been published as reference material for the upcoming "Dresden Nexus Conference" (DNC). The first of this future regular, bi-annual events, DNC2015 is currently planned to take place in March 2015 (see section 9).



## 3. Goals and Key Questions

**Session I: Opportunities for adopting a nexus approach to the management of environmental resources and its relevance to the envisaged sustainable development goals and the post-2015 development agenda**

Goals:

- Provide a definition of a nexus approach to environmental resources´ management
- Identify relevant stakeholders
- Work out the importance of adopting a nexus approach with respect to SDGs
- Provide indications for the acceptance of a nexus approach and the status of implementation.

Key questions:

1. How to define a nexus approach to the management of environmental resources? Is there a common understanding of the concept?
2. Are the relevant stakeholders indeed identified and involved in the development of integrated management approaches?
3. How can the benefits of adopting a nexus approach be defined and quantified?
4. What kind of indicators do we have or do we need to measure the benefits of adopting a nexus approach?
5. Case studies: what are current practices in managing water, soil and waste in selected member states? In which sense do they attempt/succeed/fail to manage these resources in an integrated way?
6. Are there successful case studies (best practices) available for major regions of the world to showcase the benefits of integrated management approaches?

**Presentations**
(numbers refer to key questions)

Peter Krebs, TUD: 3, 4
Sunday Leonard, UNEP: 2, 3
Waltina Scheumann, DIE: 2, 3
Uchita de Zoysa, Centre for Environment and Development, Sri Lanka: 1, 2
Zita Sebesvari, UNU-EHS: 3, 5
Fritz Haubold, TUD: 1, 4
Graham Alabaster, UN-HABITAT: 1, 2, 3

**Case studies**

Deepak Sanan, Government of Himachal Pradesh, India: 5, 6
IPSWaT[1] presentation: 5, 6
Dorjsuren Ariuntuya, Mongolia: 5, 6.
Vikram Seebaluck, University of Mauritius: 5, 6
Sheikh Javed Ahmed, AfDB

[1] Joint presentation of IPSWaT scholars, a scholarship programme funded by BMBF

**Tuesday, 12 November**

**Session II: Challenges for the nexus approach in managing water, soil and waste under conditions of global change**

Goals:

- Identify challenges for the nexus approach with respect to scientific understanding and implementation focusing on
  - o Challenges of integrating sectors (water, soil, waste),
  - o Challenges of global change
- Identify best practice examples of monitoring programmes (quantity and quality of water, soil characteristics, land use, waste sites and associated fluxes) at local/national/regional level

Key questions:

1. Will global change increase the pressure to bring about integrated management approaches or will it rather increase competition between sectors (e.g. energy, agriculture)?
2. Do current management approaches adequately address implications of climate change, e.g. frequency, intensity and duration of floods and droughts?
3. Do we have the tools (e.g. models) to integrate sectors and disciplines for integrated management approaches?
4. Will new or improved technologies (and which) be required or at least be helpful to foster integrated management approaches?
5. Data scarcity: how far can remote sensing and satellite data replace or complement data from ground-based monitoring programmes? Do we need new approached in handling data scarcity (e.g. specific modeling tools)?
6. Overall: is there a need for more research on the nexus?
7. What are the challenges in implementing a nexus approach?
8. What are and where are best practice examples of monitoring programmes (quantity and quality of water, soil characteristics, land use, waste sites) at local/national/regional level?

**Presentations**

(numbers refer to key questions)

Danka Thalmeinerova, GWP: 1, 2
Michele Ferenz, EWI: 1
Jochen Schanze, IOER: 3
Niels Schütze, TUD: 4
Cedo Maksimovic: 2, 3, 4, 6, 8
Manfred Buchroithner, TUD: 4, 5, (6)
Stefan Uhlenbrook, UNESCO-IHE: 2, 4, 5,7



**Session III: Capacity Development for research and education programmes addressing the nexus, in particular teaching and training programmes**

Goals:

- Identify research topics to address knowledge gaps
- Define the objectives of Capacity Development for research and education programmes addressing the nexus and curricula requirements
- Identify case studies: ongoing research projects on integrated management of water, soil and waste and ongoing educational ptogrammes

Key questions:

1. Which are the research topics to be addressed?
2. What are best practices in establishing integrated and interdisciplinary research programmes given the often sectoral approach of donors?
3. Is the Nexus concept “mature” and developed enough to be covered in study programmes (see session I, question 1)?
4. Is there a need for specific nexus education programmes or should the concept be addressed in the framework of existing programmes on water/soil/waste management?
5. Which key issues and topics need to be addressed in a nexus curriculum?
6. Which tools and approaches for education and training are suited for which stakeholders? Do we need to design new tools and approaches?
7. How to combine research and education for a nexus approach?

**Presentations**

(numbers refer to key questions)

Pay Drechsel, IWMI: 1, 2, 4, 5
Manfred Lange, Cyprus Institute: 1, 2
Christopher Scott, University of Arizona: 1, 3, 4
Roland Müller, UFZ: 1, 2
Johan Bouma, formerly Wageningen University: 1, 3
Manzoor Quadir, UNU-INWEH: 3, 6, 7
Francis Gichuki, University of Nairobi: 5, 6, 7
Khaled Abu-Zeid, CEDARE programme: 1, 4
Rolf Baur, CIPSEM, TUD: 3, 6

**Session IV: Institutional arrangements and governance structures that advance the nexus approach to management of environmental resources**

Goals:

- Identify strategies for implementation of a nexus approach and
- Identify institutional structures and mechanisms that have proven helpful for implementing integrated and cross-sectoral management strategies

Key questions:

1. What are the advantages of a centralized versus a decentralized (top-down/ bottom-up) approach to implementing integrated management strategies?
2. Which institutional structures and mechanisms have proven helpful for implementing integrated and cross-sectoral management strategies?
3. How effective are inter-institutional/ministerial/organizational mechanisms in implementing integrative approaches?
4. Are these structures and mechanisms similar or what are the differences at various scales (from local to global) and in various regions?
5. Which type of economic incentives will be required/helpful to foster nexus approaches?
6. Is there/what is a common approach to institutional capacity development?

**Presentations**
(numbers refer to key questions)

Timothy O. Williams, IWMI-Africa: 2
Wolfgang Wende, IOER: 1, 2
Elias Ayuk, UNU-INRA: 3, 4
Jens Liebe, UNW-DPC: 3, 6
Dorcas Mbuvi, UNU-MERIT: 2, 5
Mario Suardi, Consultant: 5
Jürgen Preetzsch, TUD: 1, 2
Joash Nyitambe, Ministry of Water, Tanzania: 2, 5
Flavia Nabugere, Ministry of Water and Environment, Uganda: 2



## 4. Co-convening Organizations and Participants

| ORGANIZATION | NAME | FUNCTION |
|---|---|---|
| United Nations | | |
| **FAO** Food and Agriculture Organisation | Ölcay Ünver | Principal Officer - Deputy Director |
| **UNCCD** United Nations Convention to Combat Desertification | Sergio A. Zelaya-Bonilla | Coordinator Policy Advocacy on Global Issues and Platforms |
| **UNEP** United Nations Environment Programme | Sunday Leonard | Programme Officer |
| **UNESCO-IHE** United Nations Educational, Scientific and Cultural Organization - Institute for Water Education | Stefan Uhlenbrook | Vice Rector Academic and Student Affairs |
| **UN-HABITAT** The United Nations Human Settlements Programme | Graham Alabaster | Chief Waste Management & Sanitation, Urban Basic Services Branch |
| **UNW-DPC** UN Water Decade Programme on Capacity Development | Jens Liebe | Programme Officer |
| United Nations University | | |
| **UNU-EHS** Institute for Environment and Human Security | Zita Sebesvari | Associate Academic Officer |
| **UNU-INRA** Institute for Natural Resources in Africa | Elias Ayuk | Director |
| **UNU-INWEH** Institute for Water, Environment and Health | Manzoor Qadir | Senior Research Fellow |
| **UNU-MERIT** Maastricht Economic and Social Research Institute on Innovation and Technology | Dorcas Mbuvi | Researcher |
| International Organizations | | |
| **African Development Bank - AfDB** East Asia Regional Center (EARC) | Sheikh Javed Ahmed | Chief Water Resources Engineer |
| **CEDARE** Center for Environment and Development for the Arab Region and Europe | Khaled Abu-Zeid | Regional Programme Manager |
| **EWI** East West Institute | Michele Ferenz | Director of the Food, Water, and Energy Nexus Program |
| **GWP** Global Water Partnership | Danka Thalmeinerova | Senior Knowledge Management Officer |
| **GWSP** Global Water System Project | Anik Bhaduri | Executive Officer |
| **IWMI** International Water Management Institute | Pay Drechsel | Principal Scientist, Theme Leader |
| | Timothy O. Williams | Director, IWMI Africa |

| ORGANIZATION | NAME | FUNCTION |
|---|---|---|
| Universities and Institutes | | |
| **Ohio State University** | Rattan Lal | Director, Carbon Mgt. & Sequestration Center |
| **The Cyprus Institute** | Manfred Lange | Director, Energy, Environment and Water Research Center (EEWRC) |
| **University of Arizona** | Christopher Scott | Associate Professor |
| **Imperial College London** | Čedo Maksimović | Head of Urban Water Research Group, Department of Civil Engineering |
| **University of Nairobi** | Francis Gichuki | Professor for Irrigation and Drainage |
| **University of Mauritius** | Vikram Seebaluck | Senior Lecturer and Head Department of Chemical & Environmental Engineering |
| **University of the Free State** | Andries Jordaan | Director, DiMTEC-UFS |
| **Wageningen University** | Johan Bouma | Em. Prof. Soil Science |
| **University of Zurich** | Rolf Jakobi | Professor in Innovation Management, Lecturer |
| German Ministries and Organizations | | |
| **BMBF** Federal Ministry of Education and Research | Klaus Uckel | Head of division for Basic Policy Issues and International Strategy |
| | Helmut Löwe | Deputy Head of Division „Resources and Sustainability“ |
| | Claudia Bernarding | Devision International Strategy |
| **BMBF - IPSWaT** International Postgraduate Studies in Water Technologies | Cornelia Parisius | IPSWaT coordination, PT-DLR, European and International Cooperation |
| | Jovana Husemann (Serbia) | IPSWaT – University of Stuttgart |
| | Alisher Mirzabaev (Usbekistan) | IPSWaT – University of Bonn |
| | Lulu Zhang (China) | IPSWaT – TU Dresden |
| | Rania Abdalla Babiker Saad (Sudan) | IPSWaT – University of Halle-Wittenberg |
| | Johanny Arilexis Pérez Sierra (Dominican Republic) | IPSWaT – University of Stuttgart |
| | Maria Alejandra Arias Escobar (Colombia) | IPSWaT – University of Bonn |
| | Yohannis Birhanu Tadesse (Ethiopia) | IPSWaT – University of Hamburg |
| | Shobana Srinivasan (India) | IPSWaT – University of Hamburg |
| | Gabriela Margarita Espinosa Guiérrez (Mexico) | IPSWaT – University of Hamburg |
| | Firas Al Janabi (Iraq) | IPSWaT – TU Dresden |
| | Emilienne Tingwey (Cameroon) | IPSWaT – RENAC Berlin |



| ORGANIZATION | NAME | FUNCTION |
|---|---|---|
| **BMU** Federal Ministry for the Environment, Nature Conservation and Nuclear Safety | Thomas Strathenwerth | Head of Division "General, Fundamental, International and European Aspects of Water Management" |
| | Verena Klinger-Dering | Division "General, Fundamental, International and European Aspects of Water Management" |
| **BMZ** Federal Ministry for Economic Cooperation and Development | Leveke Neumann | Division 313 (Water; Energy; Urban development; Geosciences sector) |
| **SMWK** Saxon State Ministry for Higher Education, Research and the Arts | Markus Faller | Head of Division |
| **BGR** Federal Institute for Geosciences and Natural Resources | Thomas Himmelsbach | Head of Sub-Department Groundwater Resources - Quality and Dynamics |
| **DIE** German Development Institute | Waltina Scheumann | Senior Reseracher, Environmental Policy and Natural Resources Management |
| **DWA** German Association for Water, Wastewater and Waste | Rüdiger Heidebrecht | Head of Department Training and intern. Cooperation |
| **GIZ** Deutsche Gesellschaft für Internationale Zusammenarbeit | Sophie Müller | Section International Water Policy; Department Water, Energy and Transport |
| **IOER** Leibniz Institute of Ecological Urban and Regional Development | Bernhard Müller | Director |
| | Jochen Schanze | Head of Department |
| | Wolfgang Wende | Head of Department |
| **UFZ** Helmholtz Zentrum für Umweltforschung | Roland Müller | Head of Department |
| | Steffen Niemann | Senior Researcher |
| | Elisabeth Krüger | Coordinator Helmholtz Water Network |
| **ZEF** Center for Development Research | Joachim von Braun | Director |
| Member States | | |
| India | Deepak Sanan | Additional Chief Secretary, Agriculture, Government of Himachal Pradesh |
| Mongolia | Dorjsuren Ariuntuya | Officer International Cooperation of the Ministry of Environment and Green Development |
| Republic of Korea | Ilyoung Oh | 1st Secretary, Environment Attaché, Embassy in Berlin |
| Tanzania | Joash E. Nyitambe | Head of Information & Communication Technology Unit, Ministry of Water |
| Uganda | Flavia Nabugere | Minister of State for Water and Environment |

| ORGANIZATION | NAME | FUNCTION |
|---|---|---|
| NGOs and International Experts | | |
| **CED**<br>Centre for Environment and Development | Uchita de Zoysa | Executive Director |
| **WAMTI**<br>Indonesian Farmers and Fishers Society Organization | Agusdin Pulungan | President |
| – | Mario Suardi | Consultant |
| Convening Organizations | | |
| **UNU-FLORES**<br>United Nations University - Institute for Integrated Management of Material Fluxes and of Resources | Reza Ardakanian | Director |
| | Stephan Hülsmann | Academic Officer Systems and Flux Analysis |
| | Mathew Kurian | Academic Officer Capacity Development and Governance |
| | Mari Ito | Academic Officer Water Resources Management |
| | Kai Schwärzel | Academic Officer Soil and Land-use Management |
| | Hiroshan Hettiarachchi | Academic Officer Waste Management |
| **TUD**<br>Technische Universität Dresden | Susanne Strahringer | Vice-Rector for Academic and International Affairs |
| | Karl-Heinz Feger | Dean, Faculty of Environmental Sciences |
| | Christian Bernhofer | Vice Dean, Faculty of Environmental Sciences |
| | Peter Krebs | Director, Institute for Urban Water Management |
| | Jürgen Pretzsch | Chair of Tropical Forestry |
| | Manfred Buchroithner | Director, Institute of Cartography |
| | Fritz Haubold | Senior Researcher, Chair of Physical Geography |
| | Niels Schütze | Acting Chair of Hydrology |
| | Rolf Baur | Course Director, CIPSEM |
| | Marco Leidel | Institute of Hydrology and Meteorology |



# 5. Kick-off Workshop Agenda

**Monday, 11 November**
**Venue: Dülfersaal, Technische Universität Dresden**

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| 8:15-08:45 | **Registration** |
| 8:45-9:45 | **Opening Session**<br><br>**Welcome and Introduction**<br><br>Reza Ardakanian, Director UNU-FLORES<br><br>**Opening Remarks**<br><br>Susanne Strahringer, Vice-Rector of TU Dresden<br><br>Markus Faller, Saxon State Ministry for Higher Education, Research and the Arts (SMWK)<br><br>Klaus Uckel, Federal Ministry of Education and Research (BMBF)<br><br>David Malone, Rector of United Nations University (Video Message) |
| 9:45-10:15 | **Group Photo**<br>**Coffee Break** |
| 10:15-12:15 | **Session I:**<br><br>**Opportunities for Adopting a Nexus Approach to the Management of Environmental Resources and its Relevance to the Envisaged Sustainable Development Goals and the Post-2015 Development Agenda**<br><br>Moderator: Reza Ardakanian, UNU-FLORES<br><br>Rapporteur: Stephan Hülsmann, UNU-FLORES<br><br>**Introductory Talk: Nexus Approaches to Management Across Boundaries and Their Relevance in the Post-2015 Era** (20 min)<br><br>Olcay Ünver, FAO |
| | **Presentations**<br>(numbers refer to the key questions addressed) – each 10 min<br><br>**Improving Environmental Resources Management by a Nexus Approach**<br><br>Peter Krebs, TUD (3, 4)<br><br>**An Integrated Approach for Developing Sustainable Development Goals: Relevance to Environmental Resource Management**<br><br>Sunday Leonard, UNEP (2, 3)<br><br>**The Water, Food and Energy Nexus in Transboundary River Basins: Incentives for Cross-sector Coordination?**<br><br>Waltina Scheumann, DIE: (2, 3)<br><br>**Connecting People with the Nexus: Engaging Stakeholders in Sustainable Management of Water-Soil-Waste**<br><br>Uchita de Zoysa, Centre for Environment and Development, Sri Lanka (1, 2) |

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| | **Applying the Nexus Approach in the Context of Waste Water Irrigation and Livelihood Provision - Benefits and Challenges**<br>Zita Sebesvari, UNU-EHS (3, 5)<br>**The Concept of Landscape Sensitivity as a Means of Managing Landscape Perturbations**<br>Fritz Haubold, TUD (1, 4)<br>**Opportunities for Adopting a Nexus Approach to the Management of Environmental Resources in Urban Areas in the Post 2015 Development Agenda**<br>Graham Alabaster, UN-HABITAT (1, 2, 3)<br>Organizational Announcements |
| 12:15-13:15 | **Lunch** |
| 13:15-15:15 | **Session II:**<br>**Challenges for the Nexus Approach in Managing Water, Soil and Waste under Conditions of Global Change**<br>Moderator: Peter Krebs, TUD<br>Rapporteur: Kai Schwärzel, UNU-FLORES<br>**Introductory Talk: The Nexus Approach to Managing Water, Soil and Waste under Changing Climate and Growing Demands on Natural Resources (20 min)**<br>Rattan Lal, Ohio State University |
| | **Presentations**<br>(numbers refer to the key questions addressed) – each 10 min<br>**Nexus Thinking for Decision Makers: Present and Future Management Challenges**<br>Danka Thalmeinerova, GWP (1, 2)<br>**The Food-Water-Energy Nexus: Cooperation on Resource Security in a Multi-Polar World**<br>Michele Ferenz, EWI (1)<br>**Methodological Challenges for a Nexus Approach under Global Change Conditions - Findings from IWRM Research**<br>Jochen Schanze, IOER (3)<br>**Integrating Management of Water Resources Demand and Supply in Irrigated Agriculture - Challenges and Potentials**<br>Niels Schütze, TUD (4)<br>**Nexus Approach to Adaptation of Urban Areas to Climate Changes (Blue Green Dream's Paradigm for the Future Spatial Planning)**<br>Čedo Maksimović, Imperial College (2, 3, 4, 6) |



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| | **Detailed-scale Mapping of Soil Moisture and Landslide-proneness Using Spaceborne Sensors**<br>Manfred Buchroithner, TUD (4, 5)<br>**Global Change and Water – How Far Can the Nexus Approach Help to Meet Future Challenges?**<br>Stefan Uhlenbrook, UNESCO-IHE (2, 4, 5,7) |
| 15:15-15:45 | **Coffee Break** |
| 15:45-16:45 | **Presentations: Case Studies** – each 10 min<br>**Snotty Shimla: Past Imperfect, Present Tense**<br>Deepak Sanan, Government of Himachal Pradesh, India<br>**Towards Nexus Approach: Selected Case Studies Around the World: Ethiopia, China, Uzbekistan and Serbia**<br>Alisher Mirzabaev, IPSWaT[2] scholar<br>**Challenge of the Sustainable Water and Waste Management in Mongolia**<br>Dorjsuren Ariuntuya, Mongolia<br>**Water, Waste and Soil Management Practices in Mauritius and Prospects for Their Integrated Management**<br>Vikram Seebaluck, University of Mauritius<br>**Case Studies on Opportunities in Adopting Nexus Approach in the Agriculture and NRM Sector**<br>Sheikh Javed Ahmed, AfDB |
| 16:45-17:45 | **Panel discussion 1:**<br>**Opportunities and Challenges for the Nexus Approach in Managing Water, Soil and Waste**<br>Moderator: Peter Krebs, TUD<br>**Panelists:**<br>Olcay Ünver, FAO<br>Verena Klinger-Dering, BMU<br>Reza Ardakanian, UNU-FLORES,<br>Agustin Pulungan, Indonesian Farmers and Fishers Society Organization<br>Sophie Müller, GIZ |
| 17:45-18:00 | Wrap-up of 1st day (Moderators and Rapporteurs) |
| 19:00 | **Dinner – Grand Café and Restaurant Coselpalais** |

[2] Joint presentation of IPSWaT scholars, a scholarship programme funded by BMBF

**Tuesday, 12 November**

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| 08:30-10:15 | **Session III:**<br><br>**Capacity Development for Research and Education Programmes Addressing the Nexus, in Particular Teaching and Training Programmes**<br><br>Moderator: Stefan Uhlenbrook, UNESCO-IHE<br>Rapporteur: Hiroshan Hettiarachchi, UNU-FLORES<br><br>**Introductory Talk: Capacity Development for Research and Education - Teaching and Training Programmes Addressing the Nexus (20 min)**<br><br>Christian Bernhofer, TUD |
| | **Presentations**<br>(numbers refer to the key questions addressed) – each 10 min<br><br>**Applied Research for Development: Let's Talk Business**<br><br>Pay Drechsel, IWMI (1, 2, 4, 6)<br><br>**Novel Approaches to Address the Energy-Water Nexus in Water-scarce Regions**<br><br>Manfred Lange, Cyprus Institute (1, 2)<br><br>**The Water-Energy-Food Nexus: Enhancing Adaptive Capacity to Complex Global Challenges**<br><br>Christopher Scott, University of Arizona (1, 3, 4)<br><br>**New Ways for Implementing Decentralized Wastewater Treatment Concepts**<br><br>Roland Müller, UFZ (1, 2)<br><br>**The Nexus is there, but Needs Refinement: Defining a "Niche" for UNU-FLORES**<br><br>Johan Bouma, formerly Wageningen University (1, 3)<br><br>**Integrating Research and Education in Addressing Water-Soil-Waste Nexus**<br><br>Manzoor Qadir, UNU-INWEH (3, 6, 7)<br><br>**Tapping the Internet Resource to Advance the Soil-Water-Waste Nexus Agenda**<br><br>Francis Gichuki, University of Nairobi (5, 6, 7) |
| 10:15-10:45 | Coffee Break |
| 10:45-11:15 | **Presentations: Session III cont.**<br><br>**Water-Land-Waste Nexus Issues in the Arab Region**<br><br>Khaled Abu-Zeid, CEDARE programme (1, 4)<br><br>**Climate Change Adaptation: The Soil-Water Nexus**<br><br>Rolf Baur, CIPSEM, TUD (3, 6) |



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| 11:15:12:15 | **Panel Discussion 2:**<br><br>**Research and Education/Training Programmes Addressing the Nexus**<br><br>Moderator: Stefan Uhlenbrook, UNESCO-IHE<br><br>**Panelists:**<br>Christian Bernhofer, TUD<br>Pay Drechsel, IWMI<br>Rüdiger Heidebrecht, DWA<br>Thomas Himmelsbach, BGR<br>Karl-Heinz Feger, TUD<br>Johan Bouma, formerly Wageningen University |
| 12:15-13:15 | **Lunch** |
| 13:15-15:00 | **Session IV:**<br><br>**Institutional Arrangements and Governance Structures that Advance the Nexus Approach to Management of Environmental Resources**<br><br>Moderator: Bernhard Müller, IOER<br><br>Rapporteur: Mathew Kurian, UNU-FLORES<br><br>**Introductory Talk: Nexus Governance and Institutional Arrangements for Inclusive Planning and Management (20 min)**<br><br>Joachim von Braun, ZEF |
| | **Presentations**<br>(numbers refer to the key questions addressed) – each 10 min<br><br>**Nexus Approach: Challenges and Lessons for Institutional Design**<br><br>Timothy O. Williams, IWMI-Africa (2)<br><br>**Strategies for Soil Ecosystem Services and Landscape Planning**<br><br>Wolfgang Wende, IOER (1, 2)<br><br>**Rethinking Institutional and Governance Frameworks for Effective Water, Soil and Waste Nexus**<br><br>Elias Ayuk, UNU-INRA (3, 4)<br><br>**Cross-disciplinary Institutional Capacity Development with the Interagency Mechanism UN-Water**<br><br>Jens Liebe, UNW-DPC (3, 6)<br><br>**Building a Nexus through Wash Micro-financing**<br><br>Dorcas Mbuvi, UNU-MERIT (2, 5) |

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| | **Results-based Financing and its Potential Role Assisting to Advance the Nexus Approach**<br>Mario Suardi, Consultant (5)<br>**How to Ensure that the UNFCCC Reaches Local Land Users. Methodological Aspects and First Outcomes of Research Projects in the Andean Region and East Africa**<br>Jürgen Pretzsch, TUD (1, 2) |
| 15:00-15:30 | **Coffee Break** |
| 15:30-16:00 | **Presentations: Session IV continued** – each 10 min<br>**Water Point Mapping System (WPMS) Governance and Service Delivery. Case Study: Tanzania Rural Water Supply**<br>Joash Nyitambe, Ministry of Water, Tanzania (2, 5)<br>**Managing Water Soil and Waste, the Case of Uganda**<br>Hon. M. Flavia Nabugere (MP) Minister of State for Water and Environment Uganda |
| 16:00-17:00 | **Panel Discussion 3:**<br>**Institutional Arrangements and Governance Structures**<br>Moderator: Bernhard Müller, IOER<br>**Panelists:**<br>Joachim von Braun, ZEF<br>Hon. M. Flavia Nabugere (MP) Minister of State for Water and Environment Uganda<br>Elias Ayuk, UNU-INRA<br>Thomas Stratenwerth, BMU<br>Timothy O. Williams, IWMI-Africa |
| 17:00-17:15 | **Break** |
| 17:15-18:00 | **Wrap-up and Recommendations for the Planning of a Regular Nexus Conference Considering the Aspects Research and Implementation**<br>Moderator: Reza Ardakanian, UNU-FLORES<br>Rapporteur: Mari Ito, UNU-FLORES<br>Summary of panel discussions, final outcome and recommendations<br>**Closing Remarks**<br>Helmut Löwe, Federal Ministry of Education and Research (BMBF)<br>Leveke Neumann, Federal Ministry for Economic Cooperation and Development (BMZ)<br>Thomas Stratenwerth, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) |
| 18:00-20:00 | **Reception** |



# 6. Session Reports

## 6.1. Opening Session

*From left to right: Prof. Susanne Strahringer (TU Dresden), Markus Faller (SMWK) and Klaus Uckel (BMBF)*

### 6.1.1. Opening Remarks by Prof. Susanne Strahringer, Vice Rector for Academic and International Affairs, Technische Universität Dresden

Dear Professor Ardakanian, Ms. Nabugere, Mr. Uckel, Mr. Faller, ladies and gentlemen:

In the name of the entire rectorate, I would like to welcome you most warmly to this International Kick-off Workshop on Advancing a Nexus Approach to the Sustainable Management of Water, Soil and Waste at the Technische Universität Dresden (TU Dresden). Our university is very proud to welcome over 80 international experts from national and international academies, government entities, United Nations agencies and UNU institutes to Dresden. This workshop provides the opportunity to bring together our excellent researchers in Saxony with researchers from other parts of Europe, Africa, Asia, North and South America. The nexus approach is based upon the idea that the sustainable management of resources such as water, soil and waste can only be achieved through a nexus approach. To develop and implement this approach, boundaries between separate academic sectors and institutions must be removed. In fact, it is my firm belief that, in particular, such pressing global problems as resource supply, human development and welfare require working in an international, interdisciplinary network.

Since 2012, TU Dresden has been designated as one of the eleven universities of excellence in Germany. The internationalization and the enhancement of interdisciplinary work are central concerns in our institutional strategy within this framework of excellence. In addition, international summer schools and about 150 active university partnerships create an international and interdisciplinary environment which assist in the development of academic education and research and foster international cooperation.

Cooperation with UNU-FLORES was officially established in December 2012 when a framework agreement specifying the areas and means of cooperation was signed in Dresden. The sustainable management of environmental resources is one of the essential research topics of our Faculty of Environmental Sciences. In order to mutually enhance the skills and knowledge of our students, joint master's programmes with UNU-FLORES were initiated. For example, a working group consisting of UNU-FLORES and TU Dresden representatives has worked out a concept for a joint doctoral degree programme that has already been

confirmed by the Academic Committee of UNU and will start in autumn 2014. Joint research projects, doctoral and post-doctoral programmes are in preparation. In addition, the establishment of a partner institute of UNU-FLORES in Maputo, Mozambique will certainly help to intensify cooperation around research and teaching.

In collaboration with UNU, TU Dresden is willing to promote and commit to the sustained advancement of the nexus initiative. I am certain that this international kick-off workshop will stimulate a number of new research projects and solutions that will serve as a starting point for future regular nexus conferences in Dresden.

I hope you will enjoy your stay, including a full schedule of excellent topics, presentations and discussions, but also great experiences in Dresden and inspiring interactions with your fellow participants. I look forward to welcoming you all to future nexus events here in Dresden.

Thank you for your attention and have a very nice stay in Dresden, at the university and at this conference.

### 6.1.2. Opening Remarks by Mr. Markus Faller, Saxon State Ministry for Higher Education, Research and the Arts (SMWK)

Dear Professor Ardakanian, Ms. Nabugere, Professor Strahringer, Mr. Uckel, ladies and gentlemen:

First of all, I would like to express my sincere thanks to you, Professor Ardakanian, for inviting me to your workshop on Advancing a Nexus Approach to the Sustainable Management of Water, Soil and Waste.

Dr. Werner, the Director-General for Universities in the State Ministry for Higher Education, Research and the Arts, deeply regrets that he is not able to participate in person. Yet, he has asked me to act as his deputy and welcome you in the name of the State Ministry here to TU Dresden.

During the next two days, you will have a very important issue on your agenda, an issue which is essential to the survival of human kind.

We must make ourselves realize what an incredible amount of environmental resources, which are essential for surviving on our planet, are consumed every day and the implications this consumption of resources has, on the one hand, regarding any increase in the population and, on the other hand, rising prosperity in many parts of the world.
While the production of one glass of milk requires over 180 litres of water, more than 1 billion people have no access to clean drinking water. This deficiency in terms of access to a safe water supply and, furthermore, the inadequate treatment of wastewater are still the main causes of poverty, malnutrition and diseases.

Therefore, the global discourse on climate change again and again faces the challenge of proving the sustainability of its policy. This sustainability cannot be reduced to a problem of luxury related to questions regarding the provision of biofuels for cars in Europe, Asia or America. Securing access to basic nutrition for all mankind remains the most important task.

Let us look at another challenge: The expert on sustainability, Daniel Hoornweg from the University of Oregon, forecasted in the current issue of Nature that humanity will produce 11 million tons of waste in the year 2100. This is three times more waste than that produced today. How will we dispose of that waste?

All of you are more familiar with these questions than many other people. Answering these questions regarding the efficient use of available resources becomes a basic requirement for supplying the world's population as it continues to grow.



Their supply is only ensured if we succeed in acting across different relevant sectors. This action requires a strategy which considers the mutual dependencies between different fields, groups and levels. Now more than ever, we must appreciate that we live in a world that is horizontally and vertically connected which hardly tolerates isolated action. One state or one specific group alone will not solve our complex global problems. Thankfully, the insight that only global and shared action promises success is spreading step by step. Unfortunately, this realization often is not followed by a joint strategy given that national egos are at odds with this insight. But, let's wait for the outcomes of the present summit on climate change in Warsaw.

Ladies and gentlemen, these peculiarities will not burden your workshop given that the interconnected approach to a solution is gaining more and more recognition among experts. It is great that we no longer regard problems as "mine" or "your" problem, but instead have chosen to adopt the terms "our" or "we" as more and more important in our discussions. The discussions you will have today are, therefore, not only a strong scientific impulse, but also a strong impulse for intercultural understanding which is necessary for a peaceful solution to conflicts worldwide. Therefore, today you will talk about more than just the sustainable use of resources.

One starting point for these fundamental insights and experiences was the establishment of UNU-FLORES here in Dresden, which is dedicated to the nexus approach. The State Ministry for Higher Education, Research and the Arts as well as the Federal Ministry of Education and Research have supported the establishment of this institution here in Dresden from the beginning. Today, we can indeed talk about its successful establishment. Since its founding, our Ministry has been convinced that UNU-FLORES is situated within the ideal conditions to follow the nexus approach in cooperation with TU Dresden, the excellent scientific infrastructure of this region and the Free State of Saxony. Follow this approach as it flourishes, review it regularly and disseminate it worldwide!
Ladies and gentlemen, today we live in a world which is by and large interconnected. In addition, the sciences are increasingly interconnected and oriented towards interdisciplinary work. The particular subjects with specific scientific methods put themselves in the service of an overarching topic. When we consider junior scientific staff, we should not fail to point out that important interdisciplinary work depends on subject-specific excellence, because only subject-specific excellence can give birth to contributions which are constructive both within and across disciplines. Only this connection between different scientific subjects can lead to overarching discussions of synergies which can move us forward in solving global problems. Likewise, in your institute, the interconnectedness follows the interconnectedness of professional and personal competencies.

Consequently, we have planned to strengthen the overarching exchange between actors in the scientific landscape of Saxony. Many processes that support scientific purposes are attached to a specific location. Thus, we consider it reasonable to increase the coordination between actors within a scientific region. Following this approach, we defined regions in Saxony in which an exchange of information and experiences in scientific fora will be initiated. Representatives of public and private universities, non-academic research facilities, academies of science, state institutions, municipalities, students, associations, chambers and, finally, external experts shall contribute to the dialogue and intensify the contributions from these regions.

The concept of scientific regions is a central element in the development plan for Saxon universities. In this respect, we follow your example of the nexus approach.

I believe you are aware of your complex topic and its associated challenges. Your general subject is to enable the survival of human kind on our planet. When I look at the agenda, I am confident: all of you are approaching these pressing challenges with the necessary austerity.

This workshop is a beginning, not an ending. I wish you a successful workshop with good results that you will be able to follow up on in further workshops.

I warmly welcome you to the city and to TU Dresden.
Thank you very much for your attention.

### 6.1.3. Opening Remarks by Mr. Klaus Uckel, Federal Ministry of Education and Research (BMBF)

Professor Ardakanian, Vice-Rector Strahringer and Mr. Faller:

Thank you very much for your invitation. We are very pleased to be here. You should know a little bit about our priority setting and from this you may understand how important meeting with you over the next two days here in Dresden is for us. Today is the opening up of the carnival season in Cologne and we decided to be here. For somebody who is in charge of Rhineland, that is really a challenge. So our priority is to be here. Thank you again for your invitation.

For the German Federal Government in general and my ministry, the BMBF, in particular the, cooperation with the United Nations University has been a crucial element for international cooperation in research and science since the foundation of the UNU in 1973.

Aside from Japan as the headquarters of the UNU, Germany is the only other country in the world where two UNU institutes and the UNU Vice Rectorate are located, here in Dresden and in Bonn. We are very proud to have you with us. We are pleased that the nexus approach in Dresden is complementing the focus of the institute in Bonn on sustainability and the environment. It is highly relevant for humanity to solve global challenges. The BMBF is happy to support this additional branch in the international research landscape. The UNU institutes help to build a bridge between the academic world and the United Nations cosmos and policy. UNU-FLORES in particular helps to develop sustainable solutions for pressing global problems and human survival and development.

UNU-FLORES and its partner institute in Mozambique are valuable elements to foster cooperation between the German Federal Government and institutions of the United Nations in the context of our internationalization strategy. The development of the partner institute in Maputo goes in line with several pillars of the German policy on education and research: on the one hand, a cooperative approach to partnership in science and research with developing and emerging countries based on the principle of excellence; and on the other hand, the integration of the African scientific community in information exchange and research on an international level.

I would like to encourage your efforts to look beyond "classic" partnerships between UNU institutes or local universities. Dresden, its region and Germany are highly developed to foster scientific cooperation and provide excellent research networks and infrastructures. But, looking beyond national borders, UNU-FLORES is placed in the heart of Europe. The European Union (EU) is now spending around €70 billion for its next research framework programme called 'Horizon 2020'. The UNU institutes shall take advantage of German activities within the EU. Many German universities, institutes and research organizations are very active and successful in diverse EU cooperative networks and projects. In this context, I was glad to learn that UNU representatives will participate in the upcoming information events for Horizon 2020.

Going beyond the Horizon 2020 programmes, there are further initiatives in the scientific fields within the European research area: for instance, joint programming initiatives or the EUREKA clusters. There are at least three joint programming initiatives which touch upon the nexus approach UNU-FLORES has chosen: food security, agriculture and climate change; connecting climate knowledge for Europe; and water challenges for a changing world. These represent long-term initiatives and involve many Member States (and even partners from beyond Europe). I am convinced that exchanges with them can enhance the impact and success of the work UNU-FLORES is doing.

Let me give you some personal remarks and reflections from my personal observations regarding why I am engaged in these purposes as well. In February of this year, I travelled with my family to the peninsula of Yucatan looking for some hideaways to the south close to the waters of Belize.

I was traveling from Tulum further south along very tiny roads on the coastline. I hit Mahahual and I was going further to Xcalak, which is impressive. It is one of the most beautiful coastlines I have ever seen in the whole world and believe me I have travelled a lot. But, there was nobody, and I wondered about these empty places with no hotels, no houses, no people, plentiful mangrove jungles, fantastic coast lines and plastic waste. Nobody would be able to develop this region further without first solving the ocean of plastic in the Atlantic Ocean. This area of the Yucatan is where the currents hit the coastline. It is a lost economic value, a lost environment and pleasure lost from our lives. It's a tragedy to find the most beautiful coral reefs I have ever seen and such hidden places nobody knows about. Who would like to spend their holiday among mountains of garbage? And you find plastic bottles from 1970 from India and elsewhere in this place. It's a tragedy and it is a part of the road to the nexus to solve this in future times.

The nexus approach is based on the belief that vital environmental resources are strongly interconnected and require a unique perspective to manage them sustainably. I am confident:

- that this workshop will provide an overall update on current initiatives within this context;
- that it will serve as a good basis for similar conferences in the coming years; and
- that it will serve to finalize the White Book on the Nexus of Water, Soil and Waste.

Last but not least, I am confident that all of you will feel like a sustainable part of the nexus. My ministry will continue to follow your activities – within the Directorate for International Cooperation as well as within the thematic directorates. The nexus approach needs thinking beyond borders – geographically and thematically. In this sense, the Ministry of Education and Research will do its best to match the expectations of the scientific community towards policy.

I am looking forward to your presentations and the discussions.

Thank you very much for your attention.

### 6.1.4. Opening Remarks by Dr. David M. Malone, Rector, United Nations University

Hello, my name is David Malone. I am the rector of the United Nations University and also an Under-Secretary-General of the United Nations. I'm delighted to join you today, alas, only electronically, because I was in Dresden six weeks ago spending time with Reza and his impressive new team, visiting other partners of UNU-FLORES around Dresden. I am very impressed at how much of a knowledge hub it has become and delighted to meet with UNU-FLORES's partner university, the Technical University of Dresden. In every respect, I think UNU-FLORES is lucky to have set up in Dresden, and I hope eventually Dresden will feel that it is also very fortunate to have this small but high-quality institute of the UN University within its boundaries.

As you all know, UNU-FLORES focuses on the integrated management of water, soil and waste, and an integrated approach to these resources is tremendously important. UNU wants to focus on policy-relevant research work; in fact, the integrated management of water, soil and waste is a major policy challenge, not just for countries of the industrialised North, but particularly for countries of the developing regions and continents of the world. We'd like the subject, of course, to be addressed in an interdisciplinary fashion and across sectors. We take this for granted, but I think it may be worth repeating. I know from Reza and his colleagues that there is a remarkable group of stakeholders pulled together for today's workshop. Of course, this includes German ministries, universities, agencies, other international organizations and non-governmental organizations all of whom have played an important role and will play an even more important role in future in making the case for the nexus approach of managing water, soil and waste in an integrated way.

This kick-off workshop – and I know that this will just be the first of several workshops in future – comes at an important time. Why? The United Nations Conference on Sustainable Development (Rio+20) has occurred, and there is a considerable focus on sustainability in international priorities. But, the Post-2015 United Nations

Development Agenda is also being actively discussed in New York and elsewhere, whereby the high-level panel's report has projected the debate now among Member States, and the Secretary General's report has refined a number of concepts from the high-level panel report and added a few more. So, we're off to the races towards 2015: the next set of goals for the United Nations system and more broadly. The integrated management of water, soil, and waste, while not necessarily a goal in itself, must be an important underpinning of development anywhere in the world, including in the industrialized world. This is not just about the developing world, of course, but about all of us, because none of us can afford to waste any of these resources.

I wanted to thank you for having me with you in this virtual fashion. I'm very sorry I cannot be with you. I look forward to hearing from Reza and his colleagues how the workshop went. I'm very optimistic about it. I'm a huge fan of the new institute in Dresden, UNU-FLORES, and we look forward to great things from its work, which can only be accomplished through stakeholders like you. Many thanks.

*Dr. David M. Malone, Rector of the United Nations University and "a huge fan" of UNU-FLORES, welcomes the participants of the kick-off workshop electronically (Source: UNU-FLORES)*

## 6.2 Report from Session I

**Opportunities for adopting a nexus approach to the management of environmental resources and its relevance to the envisaged sustainable development goals and the post-2015 development Agenda**

Moderator: Dr. Reza Ardakanian, UNU-FLORES
Rapporteur: Dr. Stephan Hülsmann, UNU-FLORES

Session I of the kick-off workshop dealt with 'Opportunities for adopting a nexus approach to the management of environmental resources and its relevance to the envisaged sustainable development goals and the post-2015 development agenda.' The key questions put forward addressed the definition of the nexus approach and whether there is a common understanding about the concept, the identification of stakeholders, defining and quantifying benefits of adopting a nexus approach and the identification and definition of indicators and indices. A further aim was to collect case studies and best-practice examples which showcase the benefits of integrated management approaches (see section 8).



*Dr. Olcay Ünver (FAO) warned of integration overkill (Source: UNU-FLORES)*

The session started with an introductory talk by Dr. Olcay Ünver, Food and Agriculture Organization (FAO). He stressed the importance of an integrated approach to the management of water, soil and waste, the key resources for food production, which is FAO´s particular concern. He pointed out that the nexus approach by nature aims at integration and needs to integrate across sectors. There is still a need to better understand how to tackle complex relationships between environmental resources (defining system boundaries and indicators) and to prioritize policy options and action. The nexus concept is not 'owned' by a single sector and, thus, is different from integrated water resources management (IWRM). Overcoming silos requires joint action for environmental resources management, which is a responsibility of all sectors. On the other hand, Dr. Ünver warned of integration overkill; we cannot practically integrate everything. The different approaches of specific sectors (e.g., water and energy) imply that, when it comes to actual implementation and management processes, integration may not be feasible. Therefore, pragmatic approaches aiming at coordination and cooperation may be more appropriate in some cases. The strategic objectives of FAO – namely, (i) to help eliminate hunger, food insecurity and malnutrition; (ii) to make agriculture, forestry and fisheries more productive and sustainable; (iii) to reduce rural poverty; (iv) to enable inclusive and efficient agricultural and food systems; and (v) to increase the resilience of livelihoods from disasters – being output oriented and reframing issues across sectors (e.g., forestry and fisheries) are well in line with a nexus approach. Indeed, various FAO activities do have a nexus perspective, such as addressing energy-smart food systems. Finally, Dr. Ünver stressed the importance of the nexus approach for sustainable development goals (SDGs), not as an explicit goal, but as an important undercurrent of SDGs addressing food, water and energy. The relationship between sustainability science and the nexus approach is discussed in more detail in chapter 1 of the white book (http://flores.unu.edu/white-book).

The importance of the nexus approach for SDGs was taken up by Dr. Sunday A. Leonard, United Nations Environment Programme (UNEP), who stressed the general importance of environmental issues in SDGs, which are different from the Millennium Development Goals (MDGs). As the 'leading global environmental authority within the United Nations system', UNEP´s role was to provide input on the environmental dimension of SDGs during the process of defining them. Single goals which are integrated by nature must be simple to understand including their social, economic and environmental aspects. Each of them includes a mix of integrated and non-integrated targets (e.g., reducing water pollution by X per cent by 20XX). In addition to defining the targets of SDGs, it is important to define indicators enabling the assessment of progress in achieving them. These indicators should be clear and unambiguous, specific and measurable, policy relevant and sensitive to policy interventions and include absolute and relative changes. Defining

them is a still an ongoing process. An aspect taken up in the discussion was that, even if the required monitoring data or even the monitoring programmes for these indicators are not readily available or put in place, it was considered useful to formulate SDGs, since they may foster the implementation of respective monitoring programmes.

*Dr. Sunday A. Leonard, UNEP, explains the importance of the nexus approach for SDGs. (Source: UNU-FLORES)*

The importance of indicators was also stressed by Professor Peter Krebs, TU Dresden. He emphasized the current challenges of environmental resources management, including depletion, deteriorating quality, incomplete recycling, complex flux patterns, etc. Aspects of global change add to the problem (see also the report from session II). While sectoral management concepts (on water, soil and waste) are rather advanced and in many cases put in place, the interfaces between them are less well understood. Using the example of phosphorous — a non-renewable, limited resource which has, however, a high recovery potential — the need for an integrated approach linking water, soil and waste was demonstrated. Following such substances (after categorizing) across compartments and scales will be important for defining the required indicators.


*Criteria for selecting goals and targets to obtain integrated SDGs and a Post-2015 agenda (Source: An Integrated Approach for Developing SDGs, Presentation by Sunday A. Leonard)*



Turning to governance issues, Dr. Waltina Scheumann, German Development Institute (DIE), illustrated the opportunities and challenges related to the governance of water and energy in cross-boundary watersheds and dams. In particular, she addressed the issue of incentives for cooperation between states and sectors, highlighting how to avoid conflicts and harness the potential in a socially inclusive and environmentally friendly way. In the case of border rivers, cooperation is easier than in a transboundary situation where upstream and downstream water use must be balanced, while unilateral action is possible. Concerning cooperation between sectors, incentives for the energy sector to work with the water, environmental and forestry sectors is rather obvious given its dependence on the reliable flow of high-quality water with little sediment load, etc. The water sector strives to secure and optimize water allocation to all users, not only the hydropower sector. Balancing the needs and wishes of various users in transboundary situations is challenging, and some examples of such management schemes (e.g., Danube and Nile) demonstrate that whoever initiates cooperation between sectors usually claims the leading role. A better understanding of sector coordination in transboundary settings and how to address imbalances between sectors and sustainability is required. During the discussion, the importance of the political dimensions (see the report from session IV) was stressed, since water might be utilized when striving for political control.

Mr. Uchita de Zoysa, Centre for Environment and Management, put the nexus approach into the larger societal context, asking whether it may contribute to a profound transformation of society towards sustainability. He argued that too often people are decoupled from management, but that implementing a nexus approach to the management of water, soil and waste requires involving all stakeholders in the process. Doing so may indeed foster sustainable development. The nexus of water, soil and waste should be linked to the broader nexus between social equity, environmental sustainability and economic prosperity. In the current agenda towards SDGs, the nexus initiative could provide strategic pathways towards this end. These issues are elaborated on in more detail in the selected case studies (see section 8). One such aspect brought up during the discussion was that, when bringing these considerations 'down to earth', it is essential to provide cases where sectors found a win-win situation, since people will usually ask what is in it for them.

Dr. Zita Zebesvari, United Nations University Institute for Environment and Human Security (UNU-EHS), provided an example of the nexus approach was applied by reporting on waste water irrigation in Vietnam. This praxis may represent one of the most useful applications of the nexus approach, holding great potential for environmental protection as well as for food production and securing livelihoods. This system has a tradition in Vietnam in the form of combining a fish pond (taking up the wastewater) with a garden/orchard and a pigsty or poultry production. It is, however, under pressure from, for example, the contamination of water resources by industrial effluents and the increasing use of pellet fish food. In the example of Hanoi, the scattered responsibility for wastewater issues is obvious; no department or institution is fully responsible for wastewater management. Informal wastewater use now requires coordination, integration and formalization. Its formalized practice would need to be monitored with respect to public health, ecosystem health, agricultural production and food security and livelihoods. Water safety plans should be amended applying a nexus perspective.

Dr. Fritz Haubold, TU Dresden, introduced the concept of landscape sensitivity as a means to manage landscape perturbations. The integrative management of water, soil and waste, in particular, land-use management, certainly affects landscapes, which by definition are shaped by natural and/or human actions. Broadly, landscapes can be classified along a gradient of low to high sensitivity. Less sensitive landscapes have a high threshold at which perturbations will alter their character and qualities with a delayed response. Typically, they are characterized by a high diversity. Highly sensitive landscapes have a low threshold and show instant and sustained responses to perturbations typically associated with low diversity. The management of landscapes requires specific tools, monitoring and indicators and should be considered as another dimension and spatial scale within the nexus concept.

Turning from rural to urban environments, Dr. Graham Alabaster, United Nations Human Settlements Programme (UN-Habitat), argued that the most pressing problems for managing water, soil and waste are not necessarily the megacities, but other large cities in developing countries which grow more in terms

of area than in terms of population with much of this growth taking place in the so-called slums. This is a huge challenge for the provision of infrastructure such as water, waste and energy and for the efficient use of resources, since the per capita costs of services increase substantially when population density is low. Nexus approaches in these urban areas need to be adopted for the urban planning of water, waste and energy infrastructure and for strengthening synergies with the rural hinterland for agricultural products and the recycling of waste products. Various examples for opportunities were outlined, such as building bio-latrines linking sanitation and energy (biogas) production and further waste-to-energy approaches and increasing energy efficiency in supplying water. Capacity development activities for stakeholders engaged in water and waste management (in particular, in operation and maintenance) are a key element for progress (see also the report from session III). Short-term interventions responding to a clear demand have proven very useful. During the discussion, the issue of capacity development was emphasized, with a specific emphasis on the fact that the success of Capacity development activities depends heavily on community engagement.

**Summary of session I**

In summary, session I dealt with 'Opportunities for adopting a nexus approach to the management of environmental resources and its relevance to the envisaged sustainable development goals and the post-2015 development agenda.' It was stressed that an integrated approach to the management of water, soil and waste, the key resources for food production, is highly relevant for SDGs. Integrative management across sectors may sometimes be too ambitious; striving for coordination and cooperation may be more realistic and an important first step, partly realized in intersectoral and transboundary watershed management. The nexus approach to managing water, soil and waste still requires a stringent definition and explanation among stakeholders and the public. An additional aspect and dimension to be considered is the landscape and its sensitivity to perturbations. In order to be able to assess the benefits of a nexus approach, the definition of indicators is essential. This is not a straightforward task, but would address resource use efficiency, productivity and the minimization of losses. Stakeholder and community engagement was considered of prime importance when striving for sustainable development, for which the nexus approach should be a precondition. Opportunities are evident both in rural (e.g., wastewater irrigation) and urban (e.g., service provision for water, waste and energy) settings.

In the evaluation of session I, it was concluded that key questions were addressed, but not all were comprehensively answered, which was, however, as expected. The definition of nexus was an issue in several presentations and has been addressed in the White Book (http://flores.unu.edu/white-book) as well as in the first Annual Report of UNU-FLORES (2013).

Obviously, no single 'correct' definition is available, and, given that the nexus concept by nature is broad and can be viewed from different angles, it may indeed be futile to strive for one definition. The nexus of water, food and energy security might be understood best from the Bonn2011 Nexus Conference (Hoff, 2011) and subsequent follow-up activities. UNU-FLORES (and by extension, the kick-off workshop), by asking which environmental resources must be managed in an integrative way to put this nexus into practice, translates it into a nexus approach to the management of water, soil and waste. Case studies on the nexus are available, but additional examples representing the most appropriate way to explain the nexus concept and its benefits are required. More robust indicators need to be developed to allow for the quantification of the benefits of adopting a nexus approach. Moreover, its application the geosciences and agriculture seemed to be missing or neglected. The most surprising aspect of session I included the challenges posed by urbanization which may be even more pronounced in smaller cities rather than in megacities and that the key to successfully coping with these challenges may not be the provision of infrastructure, but the engagement of people. Controversial aspects from session I centred around the definition of the nexus (see above) and whether the nexus approach would lead to the transformation of societies. It was argued that if society becomes increasingly aware of the benefits of successful applications of the nexus approach and from case studies, a transformation could occur gradually.



## 6.3 Report from Session II

**Challenges for a nexus approach in managing water, soil and waste under the conditions of global change**

Moderator: Professor Peter Krebs, TU Dresden
Rapporteur: Dr. Kai Schwärzel, UNU-FLORES

Session II dealt with the identification of challenges for a nexus approach with respect to scientific understanding and implementation. The discussion focused on whether global change will increase pressure on a shift towards integrated management approaches or would increase competition between sectors. Another key question addressed during this session was whether current management approaches adequately address the implications of climate change. The keynote speaker for this session was Professor Rattan Lal, Ohio State University. He established the framework for the following presentations.

*Prof. Lal is optimistic regarding the implementation of new agricultural methods: "More change will happen between now and 2050 than during the past 10-12 millennia since the onset of agriculture" (Photo: UNU-FLORES)*

In his introductory remarks, Professor Lal stressed that, on one hand, more food is needed because of unprecedented population growth. On the other hand, less good-quality land and soil are available due to agricultural intensification since the 1960s and increasing urbanization. Professor Lal reported that 24 per cent of terrestrial ecosystems are already degraded and more are prone to anthropogenic perturbations. He showed that the human impact on Earth is transforming biogeochemical and hydrological processes and cycles. As a result, food and water insecurity are increasing in many parts of the world. Professor Lal stated that facing these challenges requires some revolutionary approaches. One of these approaches is the sustainable intensification of agricultural production by adopting a nexus approach. Such an approach requires an understanding of how resources such as soil, water and waste are interlinked. In his talk, Professor Lal illustrated the connectivity between the water–energy (e.g. water footprint of biofuels, see figure on next page), water–waste, soil–waste, soil–climate and food production–water–energy nexuses. He emphasized the importance of urban farming, including skyfarming or vertical farming, as an innovative option towards enhancing food production by utilizing the food–waste nexus in urban ecosystems. In this context, he discussed the role of soil-less cultures. Finally, Professor Lal stressed that the 'business as usual' approach will jeopardize natural resources. Therefore, reducing the use, reusing and recycling of resources at all levels of the production chain is the way forward.or vertical farming, as an innovative option towards enhancing food production by utilizing the food–waste nexus in urban ecosystems. In this context, he discussed the role of soil-less cultures. Finally, Professor Lal stressed that the 'business as usual' approach will jeopardize natural resources. Therefore, reducing the use, reusing and recycling of resources at all levels of the production chain is the way forward.

Dr. Danka Thalmeinrova, Global Water Partnership, discussed nexus thinking for decision makers. The challenges of water resources in relation to agriculture are that (i) the demand for water is increasing and the search for new sources of water is costly; (ii) water quality is decreasing due to pollution and overuse; and (iii) competing demands within and across sectors exist. The challenges of land in relation to agriculture are increasing soil degradation and changes in land use. At the same time, water experts are disconnected from land experts. Dr. Thalmeinrova stated that thinking in departmental silos is very common across all spatial

| Crop | m³ $H_2O$/GJ | | | |
|---|---|---|---|---|
| | Brazil | The Netherlands | USA | Zimbabwe |
| Cassava | 30 | - | - | 205 |
| Groundnuts | 51 | - | 58 | 254 |
| Maize | 39 | 9 | 18 | 200 |
| Miscanthus | 49 | 20 | 37 | 64 |
| Palm Oil | 75 | - | - | - |
| Poplar | 55 | 22 | 42 | 72 |
| Sugarcane | 25 | - | 30 | 31 |
| Rapeseed | 214 | 67 | 113 | - |
| AVERAGE | 62 | 24 | 57 | 142 |

... Adapted from Gerben-Leenes et al., 2009)

*The Water Footprint of biofuels various substantially in different countries and under different climatic conditions, which needs to be considered in integrated management approaches (Source: Lal 2014, White Book)*

scales. For instance, in most river systems, water management focuses only on water resources. Another example can be found in the African Land Policy Framework, where water as a resource is not considered in the corresponding guidelines. Dr. Thalmeinrova argued that there is no need for individuals to think about the nexus, but to think carefully about payment for consumption. Companies consider the nexus if it increases their profit. Dr. Thalmeinrova stressed that the state should have the highest interest in understanding the nexus, but there is not enough interest in undertaking institutional and/or legal reforms as a basis for supporting nexus thinking. The benefits of adopting a nexus approach were discussed using the case of waste management which demonstrates that technical solutions exist, while administrative barriers hamper the implementation of such measures. Dr. Thalmeinrova concluded that there is a need to move from traditional water monitoring (water shortage) to nexus-related water monitoring (climate and water cycles). Finally, there is a need to enhance the capacities of institutions to address the trade-offs between sectors.

Dr. Michele Ferenz, EastWest Institute (EWI), talked about nexus governance in a multipolar world. Dr. Ferenz stressed that outside actors — including private actors — often have tremendous influence over local dynamics and outcomes. Moreover, the cast of characters is changing in a highly dynamic, international, geopolitical and economic context as the following examples illustrate. The geopolitical landscape is shifting from West to East. That is, there is a shift in the share of global growth and economic weight, whereby emerging powers such as the so-called BRICS[3] are coming into their own. Moreover, predictions suggest that there is a continuing divergence between the real economy and financial economy which may increase risk in a particular system. Finally, there is also a shift in finance from West to East. It is expected that developing countries will account for 25 per cent of global financial capital by 2020. At the same time, many countries are still struggling with political instability or fragility. Dr. Ferenz discussed the challenges to post-1945 institutions. The rise of new powers representing more diverse interests makes achieving compromise more difficult. Reforms to international institutions are, thus, inevitable. For instance, 61 per cent of all International Monetary Fund (IMF) votes are held by only 14 Member States. At the same time, regional organizations are growing. The question becomes, what can be done to deal with these challenges, including those related to the impact of global change on resources? EWI focuses on bringing together those who normally do not cooperate with one another: high-level influencers from both established and emerging global powers including non-governmental organizations (NGOs), business interests and international security actors. To do so, EWI uses methods which have been successfully applied to peace negotiations. Thus, there are two work streams: nexus

[3] BRICS is the acronym commonly used to refer to the five major emerging economies: Brazil, Russia, India, China and South Africa.



barrier-breaking dialogues and conflict hotspot avoidance dialogues. Dr. Ferenz explained that the starting point for nexus barrier-breaking dialogues is the review and reform of national and international policy focused on countries where the food–water–energy nexus is under extreme pressure, and where, from a domestic institutional perspective, governance is not able to deal with these issues. The starting point for conflict hotspot avoidance dialogues is trained on fragile or conflict-affected states where food, energy- or water-related risks are severe enough to trigger or perpetuate a crisis. According to Dr. Ferenz, the goal of conflict hotspot avoidance dialogues is to design packages of economic assistance that support military stabilization and political reform efforts.

Professor Jochen Schanze, who holds appointments at TU Dresden and the Leibniz Institute of Ecological Urban and Regional Development (IOER), provided an overview of the methodological challenges in adopting a nexus approach under the condition of global change. He stated that applying a nexus approach requires bridging theories, methods and practices from different sectors. Professor Schanze raised questions about identifying which aspects are relevant for consideration and which disjunctions should be overcome. Based on findings from integrated water resources management (IWRM) projects, Professor Schanze concluded that adopting a nexus approach requires methodological integration towards the coherent and consistent collection of systematic data, the interoperability of methods and models for systems simulation, the representation of retrospective and prospective dynamics, the interactive tool-based visualization of knowledge for stakeholders, a comprehensive description of (fragmented) governance regimes and (cross-) sectoral approaches for capacity assessment and development.

Dr. Niels Schütze, TU Dresden, presented a case study from work carried out in the Sultanate of Oman. In this study, agro-hydrological modelling and economic analysis were combined to improve the water supply-and-demand management of an irrigated agricultural system prone to salt water intrusion. Dr. Schütze's talk focused on the challenges associated with and potential of implementing an integrative modelling approach. He stressed that traditional supply-oriented water resources management (e.g., by building dams and other infrastructure for water storage and distribution) must be complemented by demand management strategies (e.g., water pricing, increased water productivity, etc.) in order to improve both the availability of water and the efficiency of water use simultaneously. Dr. Schütze demonstrated that integrated water resources demand-and-supply management requires (i) integrated data collection, monitoring and assessment of demand and supply related indicators; (ii) integrated (predictive) modelling which combines hydrological models with socio-economic models to study the interaction between hydrology, water management and society; and (iii) the development of numeric tools for optimization which are able to find 'what's best' solutions (in terms of, e.g., productivity, sustainability, employment, welfare and economic effectiveness). This is especially true and challenging if other resources (such as soil and waste) are considered within a nexus approach. Dr. Schütze concluded by pointing out that increasing the scale of integration is accompanied by technical problems such as increased complexity, computational effort and/or uncertainty.

Professor Čedo Maksimović, Imperial College London, provided an overview of the Blue Green Dream (BGD) paradigm (see http://bgd.org.uk/ for further details). The aim of BGD is to enhance the synergy of urban blue (water) and green (vegetated) systems and provide effective, multifunctional solutions for supporting urban adaptation to future climatic changes. In his talk, Professor Maksimović showed that BGD tackles a wide range of environmental issues such as floods, droughts, extreme heat in urban areas, water, air and noise pollution and biodiversity. He stated that BGD may maximize ecosystem services, minimize the environmental footprint and increase cities' adaptive capacity to changing climatic, demographic and socio-economic conditions. Professor Maksimovic concluded that urban water systems and urban vegetated areas must be planned, designed, constructed, operated and maintained not as separate systems but in combination with one another.

Professor Manfred F. Buchroithner, TU Dresden, demonstrated how remote sensing can be used for studying soil erosion, mass movements and surface soil moisture. He discussed how such methods provide spatial information for planning and the implementation of appropriate land and soil management.

*He dreams "The Blue Green Dream": Prof. Čedo Maksimović (Source: UNU-FLORES)*

Professor Stefan Uhlenbrook, United Nations Educational, Scientific and Cultural Organization Institute for Water Education (UNESCO-IHE), focused on the question of whether a nexus approach is suitable for meeting the challenges of global change on water resources. He argued that hydrologists are beginning to understand the connection between different sectors, but there is still work to be done in establishing truly integrated water management. A major problem centres on the lack of data in developing and emerging countries in comparison with developed countries. This data shortage makes the parameterization of hydrological models difficult, increases the uncertainty of model outputs and may result in the misinterpretation of predictions and, ultimately, in taking the wrong management decisions. Remote sensing may help to overcome some of the data shortage, but these technologies cannot replace measurements on the ground. Professor Uhlenbrook stated that the establishment of dense monitoring networks (such as weather stations, gauging stations, etc.) is needed, in particular, in sub-Saharan Africa.

**Summary of session II**

The presenters agreed that future challenges will speed up the process towards truly integrated management. There was also agreement that the current management practice does not necessarily address the implications of global change. However, the interconnected management of resources such as water, soil and waste is suitable for addressing some of these issues. Such a procedure may serve to replace short-term thinking with long-term sustainable thinking. Environmental resources should not be managed separately, but in combination with one another. As a basis for implementation, nexus-based innovative communication with policymakers must be developed. Stakeholders must be convinced by practical examples that implementation which adopts a nexus approach is good business. In this context, simple indicators are needed to show the impact of a nexus approach on ecosystem services. For the implementation of a nexus theory, method and practice must be bridged. The establishment of nexus thinking will only succeed if regional implementation strategies are economically feasible.

It was shown that suitable tools exist, or at least the kinds of models needed to support the integrated management of resources have been identified. However, the main problems related to integrated modelling are the lack of input and calibration data as well as model parameters. Moreover, bringing together processes which take place along different spatial and temporal scales is a huge challenge for the development and application of a model. The presenters agreed that bad governance as well as low political will, an inadequate level of understanding of a nexus approach at the level of action, sectoral fragmentation and sectoral interests hamper the implementation of a nexus approach. It was concluded that individual and institutional capacity development will help to solve these obstacles.

There was no consensus amongst the presenters regarding the need for more research on a nexus approach. However, there was agreement among the contributors that we should not wait for new research results. This would be a waste of time. Much can already be accomplished with existing knowledge, while follow up research should fill existing gaps in knowledge. Rethinking existing research results from a nexus perspective might be an initial point of action. This includes translating known scientific data into action plans. Case studies are very important because they can demonstrate how a nexus approach works in practice and how additional benefit can be achieved through the interconnected management of resources.

*Panel 1 discussing opportunities and challenges for the nexus approach in managing water, soil and waste; from left to right: Sophie Müller (GIZ), Reza Ardakanian (UNU-FLORES), Olcay Ünver (FAO), Augustin Pulungan (Indonesian Farmers and Fishers Society Organisation), Verena Klinger-Dering (BMU) (Source: UNU-FLORES)*

## 6.4 Report from Session III

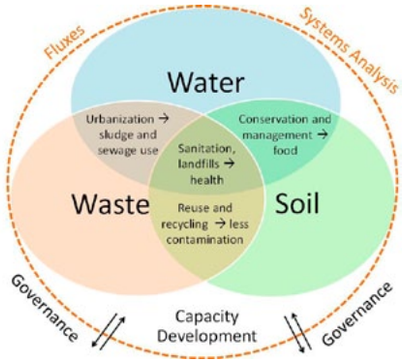
**Capacity development for research and education programmes addressing the nexus, in particular teaching and training programmes**

Moderator: Professor Stephan Uhlenbrook, UNESCO-IHE
Rapporteur: Dr. Hiroshan Hettiarachchi, UNU-FLORES

Session III was dedicated to a discussion of the research and educational programmes appropriate for a nexus approach. The goals of the session were to identify existing knowledge gaps, define capacity development for research and education programmes addressing nexus and identify case studies that can support educational programmes.

An introductory talk was given by Professor Christian Bernhofer, TU Dresden, on 'Capacity development for research and education: teaching and training programmes addressing the nexus.' He summarized the educational aspects of capacity development on several levels: the individual, organizational and enabling environments. He described how research influences teaching by advancing the knowledge and training of teachers. Professor Bernhofer also pointed out that the nexus is about linking individual research topics such as those on water and waste through urbanization which lead to higher sewage reuse. According to him, most of the development-related postgraduate programmes in Germany are focused on one aspect of

the nexus, but none tackle all aspects. Furthermore, globally there is not much difference in this situation. He suggested integrating resource management programmes such as the Hydro Science and Engineering (HSE) Master Course at TU Dresden, the International Postgraduate Studies in Water Technologies (IPSWaT) programme, the Water Science Alliance, the Centre for International Postgraduate Studies of Environmental Management (CIPSEM) and the Erasmus Mundus Programme in Flood Risk Management. He stressed the usefulness of blended learning through e-courses and workshops as well as the importance of teamwork. Finally, he proposed incorporating nexus courses into programmes which already exist in order to enrich their modules through the inclusion of nexus stakeholders.




*Water, Soil and Waste and examples of interdisciplinary research and teaching questions related to multiple components of the nexus presented by Prof. Bernhofer (Source: Capacity Development for research and education - Teaching and training programmes addressing the nexus, Christian Bernhofer & Marko Leidel, White Book)*

The first presentation of the session was delivered by Dr. Pay Drechsel, International Water Management Institute (IWMI). The title of the presentation was 'Applied research for development: let's talk business.' He stressed the importance of having entrepreneurs and businesses that work not as pilot projects, but as projects fully subsidized by aid agencies. He used the example of composting stations as a win-win situation. He argued that frameworks need to be not only theoretical but also operational, and identified the key issues that need to be addressed in nexus curriculum as risks, opportunities and the optimization of benefits versus risks. He also surmised that the real challenges for implementing projects include finding the right partner, attracting them and understanding the economics and settings. Dr. Kurian asked the speaker if the business was focused on plant size – factoring in labour and energy costs – as an economy of scale? The answer was to always look at the largest possible plant, existing demand and market analysis first and, then, to look at the plant size oriented to demand since demand is always the limiting factor.

Professor Dr. Manfred Lange, Cyprus Institute, presented on 'Novel approaches to address the energy–water nexus in water-scarce regions.' He said the Eastern Mediterranean region is a climate change hotspot and it may lead to substantial impacts on the water–energy nexus through increased energy and water needs. Most countries in this region have increased cooling needs in summer and, with that demand, they may dip below the water supply threshold within the next century. Desalination is the typical solution to satisfy water needs, but the current technology is energy hungry. He also argued that renewable energy sources (e.g., solar power) need to be focused on harvesting and storing heat. In a remark from the audience, Professor Maksimovi suggested bringing the ideas presented here together with BGD.

'The water–energy–food nexus: enhancing adaptive capacity for complex global challenges' was the title of the presentation by Professor Christopher Scott, University of Arizona. He presented a summary of the historical development of the concept of a resources-related nexus from its inception in 1983 to the Bonn2011 Nexus Conference. He presented information from India (a green economy with a water–energy–food (WEF) nexus) to prove his points. The research topics to be addressed have been identified as follows: how are mutual WEF connections expressed in resource, institutional and security terms and which interdisciplinary approaches can address such challenges and provide solutions? A further question Prof. Scott addressed is related to the maturity of the concept, which was supported by examples associated with policy, institutional expertise, natural resource use and environmental science. Concerning the need for specific nexus education programmes he argued that they need to move beyond resource management and engineering and have to consider geographical and temporal scales. In response to a question from Mr. de Zoysa, the speaker mentioned that securing the basic needs for one region should not infringe upon another region's security.

Dr. Roland A. Müller, Helmholtz Centre for Environmental Research (UFZ), presented 'New ways to implement decentralized wastewater treatment concepts.' He talked about the most adequate strategies for implementing infrastructure and financing schemes. He also suggested comparing the treatment efficiency for different infrastructures together with decision makers from the region, and the importance of involving universities and including feedback from decision makers. Describing regional implementation processes can be productive causes since these can provide stories of success. At the end of his presentation, he addressed KQ 1 and KQ 2, and suggested demonstrating and implementing a nexus approach in regional implementation concepts and identified cooperation with donors and round tables in decision-making as the best practices to be used in integrating and establishing interdisciplinary research.

*Prof. J. Bouma: "The NEXUS is there but needs refinement!" (Source: UNU-FLORES)*

Professor Johan Bouma, formerly of Wageningen University, presented 'The nexus is there, but needs refinement: defining a niche for UNU-FLORES.' In his presentation, he proposed that more traditional research on this topic may not be needed. He also added that it is important to show what happens if we do not use an interdisciplinary approach. Retention times in soils for effluents and case studies put into socio-economic context were presented as new ideas for the nexus. He also talked about the importance of a step-by-step approach (select case studies, look for gaps in existing research, define problems and set goals), including identifying stakeholders and listening to their ideas. In essence, he said the nexus is there, but it needs to be refined.

'Integrating research and education in addressing the water–soil–waste nexus' was the title of the presentation by Dr. Manzoor Qadir, United Nations University Institute for Water, Environment and Health (UNU-INWEH). He stressed the importance of capacity development on wastewater in developing countries and addressing wastewater in school curricula or in postgraduate studies, in a shift from traditional education and training to multidisciplinary and problem-solving education. He argued that there is a critical shortage of young professionals capable of refining and implementing a nexus approach especially in developing countries due to the lack

of partnerships. He also reported on two initiatives by UNU-INWEH: an international master's programme on integrated dryland management and problem-based learning and research. In his view, the nexus must be manageable, compatible with the local situation, inexpensive, sustainable and resilient to external conditions.

Professor Francis Gichuki, University of Nairobi, delivered the presentation 'Tapping the internet as a resource to advance the soil–water–waste nexus agenda.' During his presentation, he identified the challenges for a nexus approach as gaps in capacity, policy formulation and implementation, integrated project planning and evaluation, the management of Decision Support Systems, liberating partnerships and resources and specialized technologies and skills. He added that integrating efforts towards the introduction of issues related to the nexus into curriculums should focus on promoting a systems approach, multidisciplinary problem solving, the development of case studies and internships which focus on topics which apply a nexus approach.

Professor Khaled Abu-Zeid, Centre for Environment and Development for the Arab Region and Europe (CEDARE), delivered his presentation on 'Water–land–waste nexus issues in the Arab region.' According to him, almost all Arab countries are under water stress (blue water). The following were the most prominent among the ideas he presented: green water is helping the situation related to rain-fed agriculture and accounts for much more agricultural use than blue water; green water can be transformed in to blue water; the importation of virtual water is used much more than local water in food production; food product wastage is also water wastage; the Arab sub-region is home to the largest volume of desalinated water produced in the region; and wastewater and irrigation drainage is not being utilized. He also identified financial resources, the proximity of arable land, environmental and health concerns, the cultural perceptions of people and laws prohibiting reuse as the primary institutional constraints in wastewater reuse.

Dr. Rolf Baur, CIPSEM and TU Dresden, provided the final presentation in this session, 'Climate change adaptation: the soil–water nexus.' He argued that experts, future leaders and NGO participants are the ideal target group for a nexus approach. In order to address how knowledge is transferred to receiving countries, it is important to examine several important keys to success: for example, how do authorities exchange information with the scientific community and how do they apply results to formulate policies? He also added that sectoral views need to be bridged with transversal perspectives. A question from the audience (Mr. Pulungan) posited whether a nexus approach should be adopted first or if it was more important to adopt a nexus mind-set first? It was argued that they should occur together, because one needs to have detailed knowledge as well as an overview.

**Summary of session III**

*Which of the research questions were sufficiently answered by the contributors and which were not?*

KQ 2 (best practices) and KQ 3 (maturity) were covered well. We heard loud and clear that the nexus concept is mature enough and were also provided with some examples of best practices. KQ 1 (research topics), KQ 4 (new nexus educational programmes versus existing programmes) and perhaps KQ 5 (key aspects of the curriculum) were touched upon. KQ 6 (new tools for different stakeholders) and KQ 7 (how to combine research and education for the nexus) were not addressed sufficiently.

*Where was the greatest agreement and greatest disagreement among the presenters?*

There seems to be good agreement about the nexus concept being mature enough (KQ 3) and some agreement on incorporating the idea of a nexus approach into existing curriculum (KQ 4). There was no visible disagreement amongst participants during this session. But, rather, there were many different viewpoints.

*What were the most surprising outcomes of the presentations and the related discussions?*

There was no consensus on the definition of a nexus approach. Current education and research interests predominantly focus on water and energy with some interest on soil and waste. Most surprisingly, the interest on waste is predominantly focused on human waste.



## 6.5 Report from Session IV

**Institutional arrangements and governance structures that advance a nexus approach to the management of environmental resources**

Moderator: Professor Bernhard Müller, IOER
Rapporteur: Dr. Mathew Kurian, UNU-FLORES

Session IV of the kick-off workshop focussed on 'Institutional arrangements and governance structures that advance a nexus approach to the management of environmental resources.' Presentations addressed key questions regarding centralized versus decentralized approaches, types of institutional structures and mechanisms, the effectiveness of inter-institutional, ministerial and organizational mechanisms, similarities and differences across various scales and regions, the types of economic incentives that could foster nexus approaches and the idea of common approaches to institutional capacity development. Throughout the session, contributors frequently referred to points made the previous day, highlighting the linkages between the various sessions as well as individual presentations.


*The moderator of the 4th session: Prof. Bernhard Müller from IOER in Dresden (Source: UNU-FLORES)*

Professor Joachim von Braun, Centre for Development Research (ZEF), set the scene with his introductory talk on 'Nexus governance and institutional arrangements for inclusive planning and management.' He pointed out that governance is an essential ingredient, normally found at the tail end, and is defined by the enabling factors and incentives that are key to making the nexus work – that is, it is a last mile issue. For meaningful implementation, both hardware and software are necessary in addition to the realization that strategies and practical steps must be adjusted to the local nature of the nexus. He went on to define the basics of governance, which, in order to actually make an impact, require broad participation, implementation of the rule of law and the verification of performance. Because no nexus governance body exists, which means that water, soil and waste are governed separately despite their interrelation, there is a particular need to close gaps and develop governance platforms that allow for coordination and action. With regards to the question of centralized versus decentralized approaches, Professor von Braun reminded participants of the challenges surrounding the delivery of services at the appropriate level while bearing in mind and adapting to local circumstances. According to Professor von Braun, two aspects form the core elements for achieving adequate service delivery. One is political empowerment, which focuses on strengthening demand and ensuring accountability. However, demand is often underemphasized, despite being the driver for nexus system changes. Instead, the focus usually rests on the second element, the supply side or the need to improve the efficiency of public sector management. He further stressed that the nexus must be adapted to the enormous diversity of local circumstances and encouraged the movement away from best practices and towards establishing the best fit for specific settings. Due to the diversity of approaches, it is necessary to create a strategy involving global actors, social groups and global learning, as well as tactics through alliances with related nexus movements. He is of the belief that the nexus

cannot be realized at the intergovernmental level, but, rather, through government-to-government networks which would lead to greater inclusivity and flexibility. Professor von Braun's ultimate conclusion is the recognition that capacity development must occur at the local levels and should be supported by strong local governance. With regards to the role of UNU-FLORES, he highlighted five potential areas of involvement: (i) the strengthening of institutional effectiveness, (ii) facilitating the involvement of consumers and businesses, (iii) supporting and sharing innovation, (iv) assisting with experimenting and evidence-based assessments and (v) serving as a facilitator by integrating and giving a voice to the different aspects, elements, stakeholders, etc., in order to warrant the nexus serving as an undercurrent for the post-2015 development agenda.


*Dr. Timothy O. Williams, IWMI-Africa, emphasized the importance of institutional design and organizational practice. (Source: UNU-FLORES)*

Turning to the challenges of institutional design, Dr. Timothy O. Williams, IWMI-Africa, first clarified the distinction between institutions and organizations before discussing their relevance within the discourse on nexus. In order to construct a framework, a better understanding of the issues and the organization of our thinking must be achieved, keeping in mind that the same challenges arise in different places. It is also necessary to identify the end goal – that is, the outcomes and impact. This will allow for an approach which justifies the struggles and difficult processes necessary for achieving a nexus given that it adds overall value. Dr. Williams described institutions as the rules of the game. They oblige actors, incorporate enforcement characteristics and provide incentives. The last two elements are particularly crucial since they have been neglected in the past. Organizations, on the other hand, exist within the institutional context which provides their legitimacy. They are groups of individuals who are bound by a common purpose. Due to the lack of a body governing a nexus approach, a framework is needed. Dr. Williams emphasized two components to this framework: institutional design (rules, etc.) and organizational practice (implementation, compliance with rules, etc.). The necessary capacity to ensure compliance is a precondition for the framework to be effective. He also highlighted challenges which negate the added value of implementing and achieving a nexus approach. These include the absence and inadequacy of rules, contradictory rules or weak rule enforcement and weak organizational capacity or dysfunctional inter-organizational relationships.

Professor Wolfgang Wende, IOER, used his experience as a landscape planner to illustrate that, because it must incorporate many different aspects, planning actually represents the nexus. He pointed out that a major part of the overall problem is the attempt to integrate information from specialized sources and experts who do not necessarily value or understand the interconnections. As a result, governance must play a key role by providing the management tools to incorporate a nexus approach. He went on to briefly introduce the European landscape convention, which has the potential of becoming a global instrument. In order to adequately carry out landscape planning, an assessment is needed. Because experts in their respective fields do not see the benefits of assessments, additional barriers to implementing the nexus in practice must be overcome. Professor Wende stressed that the essence of the nexus is the integration of the various parts into a single concept. In order to do so, clear measurements need to be developed guaranteeing implementation. While a centralized framework has its advantages and serves as an overarching structure, decentralized efforts are just as crucial. They ensure the integration of local knowledge and raise the effectiveness of planning exercises in practice. Furthermore, local stakeholders should feel and be held responsible. Only when people at the local level take on a leadership role and drive implementation can the system function effectively. Consequently, although governance is important, local stakeholders must be involved and integrated into the institutional design.

By reiterating the significant interdependencies and linkages between water, soil and waste, in addition to their cross-cutting nature between scales, sectors and disciplines, Dr. Elias T. Ayuk, United Nations University Institute for Natural Resources in Africa (UNU-INRA), situated the understanding of these complex interactions at the core of any institutional and governance frameworks. He views an integrated approach as a means to overcome crucial challenges by addressing competing interests and claims, creating appropriate mechanisms and, most importantly and often neglected as a factor, building mutual respect and trust. Although integrated approaches have already been adopted in some areas, there is a need to retool the existing institutional frameworks in order to address and deal with challenges adequately and effectively. This includes the creation of a shared vision and enabling environment, the facilitation of cross-sectoral dialogues and broad participation to increase effectiveness, the exchange of information and the development and implementation of legal and institutional frameworks for cooperation and involvement at the lowest levels. Experience shows that the latter, in particular, improves overall effectiveness. Most importantly, Dr. Ayuk argued, is the establishment of a coherent system. He recommended rethinking the governance structure. For inclusiveness to exist, to facilitate access to and the sharing of information and to foster capacity building activities at different levels, a number of elements must be in place. These include the participation of a wide range of stakeholders, the considerations of institutional versus geographical scales, coordination across all levels of governance (local, national, regional and global) and the creation of incentives. This also includes the regular review of measurements and management costs as well as any benefits and trade-offs. Lastly, he talked about the essential enabling conditions which consist of platforms for social innovation and management, political will, capacity building, awareness-raising and champions or change agents.

Dr. Jens Liebe, United Nations Water Decade Programme on Capacity Development (UNW-DPC), introduced UNW-DPC using a project on the safe use of wastewater in agriculture as an example of a true nexus project. In order to create a healthy and safe environment, the project aimed at supporting management, promoting safe practices and supporting human resources. He emphasized the considerable benefits of collaborating with the relevant actors and transferring their combined knowledge to key decision-makers and stakeholders. When it comes to the execution of a project, not only inputs but also outputs, outcomes and, in particular, impacts must be considered. Dr. Liebe stressed the importance of participant selection, which in the case of UNW-DPC included government officials, researchers, representatives from NGOs, etc. Furthermore, he talked about the appropriateness and effectiveness of different modes of delivery. UNW-DPC recognized that mere knowledge transfer did not lead to the creation of better links between key players. However, a more interactive approach increased those linkages substantially. Dr. Liebe then went on to describe the steps to follow towards a common method for institutional capacity development. These include (i) engaging stakeholders, (ii) assessing capacity assets and needs, (iii) a capacity development programme, (iv) implementing the capacity development response and (v) evaluating the capacity development. In this regard, the most crucial ingredients are the facilitation of networks and cross-ministerial cooperation, the building of trust which serves as the basis for collaboration and a multiministerial platform with an accepted leader. He concluded his presentation by reminding the audience to identify ways to solve problems by implementing a nexus approach and not to create new governance models for the sake of the nexus.

The presentation by Mrs. Dorcas Mbuvi, United Nations University Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT), considered microfinancing as a possible incentive to foster a nexus approach since it offers opportunities and possibilities. Mrs. Mbuvi described microfinance

as the giving of grants to poor and/or financially excluded communities. First, she talked about the origin of financial flows, which can be external (market related, remittances, etc.) or local (private or public). She pointed out that most funding is project-specific with flows reaching particular regions and sectors, albeit with a general increase in foreign direct investment (see World Bank data). The fragmentation of flows, competing priorities and physical, institutional or financial market constraints cause significant gaps which could be overcome through microfinance. Using the Financial Inclusion Improves Sanitation and Health (FINISH) project as an example, she explained how multisectoral and multi-actor partnerships, including the private and public sectors, civil society, communities and households, could improve water and waste management substantially. Concluding her presentation, she emphasized the key aspects of nexus sustainability: effectively uniting diversity, generating collaborative intent, anticipating uncertainties and shocks and defining incentives for all stakeholders.

The importance of incentives and efficient methods for financing projects was also stressed by Mr. Mario Suardi, consultant. His presentation looked at results-based financing (RBF), where payments are made after results have been delivered and independently verified. This method ensures transparency and accountability when it comes to the allocation of resources, allows for flexibility and freedom in choosing how to arrive at the envisaged results and maintains focus on data gathering and verification. In particular, the latter could feed into a better understanding of how different nexus sectors are impacted by different activities. In this way, RBF serves as a framework for how money is used towards investments in development interventions. Mr. Suardi mentioned a number of tools which could deal with the challenges highlighted in the Bonn2011 conference, such as knowledge gaps, institutional concerns or the lack of a framework of incentives. He then turned to further explaining RBF. The overarching aim of RBF is the generation of behaviours which contribute to the nexus by means of setting long-term goals, leaving the choice of the method to the individual government while ensuring accountability. This process must involve the lowest level, so that even farmers are aware of and understand how to participate in the nexus. The underlying advantage of RBF is the creation of specific, focused incentives tailored to the particular entity.

Reaching the needs, interests and reality of rural communities was the main focus of Professor Jürgen Pretzsch's, TU Dreden, presentation. He underlined the limitations of international conventions and the need to determine their actual impact locally. Employing a bottom-up international debate is a long process involving a number of steps, such as the diagnosis of mitigation strategies, an assessment of strategies and instruments and an assessment of implementation. Professor Pretzsch then discussed the establishment of field laboratories which serve as platforms for knowledge exchange among stakeholders, especially those at the local levels. Using Peru as an example, his team identified 20 different strategies to deal with climate change which is an indication of the lack of coordination and local community inclusion. He also made reference to the nature and advantages of carrying out activities such as these through a university setting. Independent researchers are often better able to develop good relationships and contacts. Furthermore, he stressed the benefits of extensive student participation and a new type of teaching in field laboratories. In this way, local knowledge and customs are incorporated into relevant strategies. Professor Pretzsch also encourages PhD students to engage in research in their own countries so that they can become key experts driving change and development in their natal communities. At the end of his presentation, he summarized the main lessons learned: the importance of local knowledge, tailor-made development paths, positive narratives with case studies reaching local communities and value-added strategies.

**Summary of session IV**

Session IV of the kick-off workshop examined six questions. Those questions related to centralized versus decentralized approaches were examined and those relating to institutional structures and mechanisms were also elaborated upon where issues of decentralization and accountability were addressed. The presentation on landscape planning touched upon issues relating to structures and mechanisms at different scales. The presentations on microfinance and RBF illustrated the importance of involving different sectors and levels, especially the lower levels, as well as the importance of transparency and accountability, etc. There was overall agreement that there are no blueprint approaches to planning and institutional reform. Instead, one should move away from best practices towards good fit approaches according to the session's introductory speaker. The major contribution of the session was a clear conceptual framework that distinguished between institutions and organizations.

## 6.6 Report from Session V

**Wrap up and recommendations for the planning of a regular nexus conference to consider aspects of research and implementation**

Moderator: Dr. Reza Ardakanian, UNU-FLORES
Rappourteur: Dr. Mari Ito, UNU-FLORES

**Closing remarks**

Dr. Helmut Löwe, BMBF, praised the international kick-off workshop for its informative presentations and exceptional programmes on the nexus approach. Dr. Löwe related the term nexus to its connection with Latin. He emphasized that this term should not be inflated to avoid 'allergic' reactions. Nexus, which has existed since 1983, is not a recent invention and has already been a part of BMBF activities, albeit more commonly referred to as interdisciplinary cooperation. BMBF has several major programmes related to water implemented through an interdisciplinary perspective. For example, IWRM projects implemented across the globe, with spending reaching €120 billion, feature capacity development, the social sciences and cooperation with the private sector. Likewise, a national water funding framework for sustainable water management is a research funding competition, which includes specific topics related to water and energy, water reuse and water and food, that supports exceptional projects for three years and brings scientists, economists and other stakeholders together. An international programme on sustainable water management to fund master's and PhD students from six countries – Indonesia, Iran, Jordan, Kazakhstan, Mongolia and Vietnam – helps build knowledge in these countries and is run by the German Academic Exchange Service (DAAD). Finally, 'Innovationsforum Wasserwirtschaft' aims to bring science into practice through meetings that bring people from the scientific community and the private sector together to find new solutions which are then released on the market. Dr. Löwe concluded his remarks by stating that a lot of work on nexus-related issues has been conducted, but that they may not have been labelled as such.

*Discussion on how to advance the nexus approach to manage water, soil and waste (Source: UNU-FLORES)*

Ms. Leveke Neumann, Federal Ministry for Economic Cooperation and Development (BMZ), thanked the participants and summarized that the workshop provided a lot of information relevant to the nexus. Given that BMZ was quite active in promoting nexus through the Bonn2011 Nexus Conference, BMZ is pleased that the topic has been taken up so widely. Furthermore, she argued that participants should not be discouraged by

*From left to right: Dr. Helmut Löwe (BMBF), Ms. Leveke Neumann (BMZ) and Mr. Thomas Stratenwerth (BMU) agree in the importance to advance the nexus approach to water, soil and waste in the future.*

the 'inflation' of the nexus. Ms. Neumann presented three important aspects to advance a nexus approach: (i) policy coherence, (ii) the level or scale of nexus and (c) knowledge management. First, policy coherence requires good governance, a way to communicate the concept of the nexus and the involvement of other stakeholders from various sectors (e.g., economics, finance, law, energy, urban planning, art, etc.) into action. Questions to consider include, for example, what can be done to make science interesting for policymakers, what can science do to promote policy coherence and how can the economic aspect be integrated into the nexus. Ms. Neumann phrased these steps as 'putting yourself in the shoes of the people with whom we want to communicate the nexus concept.' For the second aspect, the level or scale of nexus includes the local, national, regional and global contexts. Ms. Neumann pointed out the importance of the selection and use of suitable instruments for each level. For the local level, rather than talking, the presentation of cases would have a better impact. Cooperation is key and some actions include the global sustainability regime and the Nairobi Nexus Dialogue, which is supported by the German government. It is important to find out who is doing what kinds of activities, and to cooperate and ensure that we advance in the same direction. Finally, knowledge management is about how to manage, disseminate and share knowledge. Germany is supporting various conferences and activities including a policy forum on nexus and shares information on these events in order to advance a nexus approach.

Mr. Thomas Stratenwerth, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), started his presentation with the nexus concept adopted at the Bonn2011 Nexus Conference. That event focused on the WEF nexus without considering land management, soil or other components so as not to complicate the nexus interconnections. This was because a focused conceptualization was more effective for promoting a nexus approach. Waste was, therefore, seen as an extra component, even though it was stressed that waste also serves as a resource. Nexus has matured enough to warrant its promotion. However, further research is also needed to investigate nexus, such as the aspects of the interconnections at different levels. In addition, communication from researchers is important in order to allow for an understanding of the nexus. Examples of the application of nexus include the use of the WEF nexus which allows decision makers to understand food security. The World Bank's macroeconomic approach can be used to examine the WEF nexus and identify room for improvements to the form it takes. For the upcoming SDG negotiations, the WEF nexus needs to be brought into the negotiations to guide the formulation of SDGs. The focus should not only be trained on developing countries, but also on developed and all countries and how they may be connected to one another. It is important to cooperate with partners around the world. UNU-FLORES will be an important partner for the identification of examples of specific solutions to problems and the mechanisms which make them successful. It is also necessary to initiate new research, for example, through PhD programmes, on addressing questions that have yet to be answered. The scientific and other communities need to be connected and knowledge must be aggregated and disseminated. Thus, a repository will become important. Mr. Stratenwerth repeated the need for considering developed countries, because the integration of a nexus approach in developed countries will require the reformulation of existing structures, which will be a challenge.



# 7. Analysis of Participant Questionnaires

A questionnaire was distributed among participants during each session in order to provide another opportunity for participants to comment on the content and workshop sessions. Questions were formulated so that they allowed a simple yes, no or undecided answer, while also offering the opportunity to provide written feedback.

## 7.1 Session I

The table below provides a summary of the responses to the questionnaire for **session I.**

Table 1. Responses from participants of session I.

| No. | Question | Yes | No | Undecided |
|---|---|---|---|---|
| 1 | Are the existing definitions of the nexus sufficient enough to raise public awareness? | 13 | 28 | 8 |
| 2 | Are the benefits of adopting nexus approach to the management of environmental resources sufficient enough defined? | 15 | 23 | 11 |
| 3 | Are those benefits quantifiable? | 17 | 15 | 17 |
| 4 | Do we have indicators for the assessment of the benefits of adopting a nexus approach? | 17 | 18 | 14 |
| 5 | Does advancing the nexus have relevance for achieving MDGs and SDGs? | 45 | - | 4 |
| 6 | Did the session achieve its stated goals? | 33 | 7 | 8 |

From almost 50 responses, only 13 and 15, respectively, felt that the nexus concept was sufficiently clear and that the benefits of adopting it were sufficiently defined. With regards to the question of whether the benefits of adopting a nexus approach are quantifiable, the responses were equally distributed across all response options, which was similar for the question regarding whether indicators are available. Despite these uncertainties, participants unambiguously felt that the nexus is relevant for achieving MDGs and SDGs. The majority of participants responded positively about the outcome of the session. For several questions, it became obvious that the difference in assessment between those saying yes or no was rather subtle and that the same arguments were used by both groups.

Concerning **question 1,** those who responded positively thought that the concept is sufficiently clear in principal, but that further efforts are required to convey it to the wider public and to link the various aspects of the nexus. Another line of reasoning was that one should not be distracted by fruitless discussions about an exact or correct definition. The nexus might best be explained (and further developed and defined) via case studies and examples.

The latter point was also put forward by those participants who felt that the nexus was not sufficiently defined. In particular, some felt that too many deviating definitions across disciplines and scales are being put forward, making it is unclear how they relate to each other. Still, as a result of various conferences, workshops, publications, etc., in recent years, general awareness of the nexus concept has been increasing among stakeholders, but has not yet reached the general public.

Comments provided for **question 2** among those who felt that the benefits of the nexus approach were sufficiently defined nevertheless highlighted that, as of yet, these benefits at least partially remain

hypothetical, have not been sufficiently communicated and have not yet found their way into implementation processes. Those who felt that the benefits are still unclear highlighted the same issues, so the disagreement was rather subtle. Similar to question 1, respondents suggested that more case studies showing the benefits are required. Such examples would need to be communicated effectively (requiring visualization) in order to advocate the benefits of a nexus approach to the public and to decision makers.

**Question 3** was closely related to this issue and focused on whether the benefits were quantifiable. Participants who answered 'yes' argued that increased productivity and the efficient use of resources, improvements in service delivery and increased overall health and well-being would be quantifiable, however, not necessarily in an easy and straightforward manner. More research is required, which was also mentioned among those who answered 'no'. Both sets of respondents stated that research is needed in order to identify and define indicators. A thorough impact assessment would be required for defined scales and within defined boundaries. Criteria would need to be developed similar to those which exist in fields such as ecosystem services including commodities or return ratios for non-renewable resources.

Those participants who thought indicators were available to assess the benefits of adopting a nexus approach mentioned various examples such as economic indicators, soil fertility, welfare costs or gross national happiness indices **(question 4).** In part, it may be easier to demonstrate the costs of sectoral approaches rather than to quantify the benefits. Those who felt that indicators have yet to be defined argued that more tangible and measurable variables are required rather than those which are defined as, for example, ecosystem health. Appropriate monitoring programmes need to be implemented once the indicators are defined.

Concerning the relevance of nexus for SDGs **(question 5),** the idea that water and soil form the basis of many SDGs was put forward, since food and energy are closely linked to climate and biodiversity. Waste needs to be considered for closing cycles (e.g., nutrients, organic matter, etc.) and due to its links with energy. The relevance of nexus also relies on the expected synergies and increased efficiency, which would foster sustainable development. Conversely, the problems addressed in SDGs largely result from the mismanagement of water, soil and waste.

## 7.2 Session II

The table below provides a summary of the responses to the questionnaire for **session II.**

Table 2. Responses from participants of session II.

| No. | Question | Yes | No | Undecided |
|---|---|---|---|---|
| 1 | What are the main challenges for implementing a nexus approach? | (see below) | | |
| 2 | Will a nexus approach help to maintain and enhance environmental resources under the condition of global change? | 38 | - | 4 |
| 3 | What are the main challenges in adopting a nexus approach in order to adapt to global change? | (see below) | | |
| 4 | Is there a need for more research on the nexus? | 36 | 1 | 6 |
| 5 | Do you think this session achieved its stated goals? | 33 | 1 | 8 |

For **question 1,** regarding the main challenges for implementing a nexus approach, the majority of responses could be classified into the following categories: inter- and multidisciplinary aspects; a lack of communication or cooperation across different sectors; difficulties in putting the theory or science into practice (including an understanding of the local conditions, regional implementation strategies, etc.); a lack of understanding or interest at the political and/or action level (and/or a lack of long-term thinking at the political and/or action level); a lack of examples or case studies; complexity; and a lack of capacity and/or financial resources, etc.

Almost all who responded to the questionnaire (38 out of 42) agreed that a nexus approach may help maintain and enhance environmental resources under the conditions of global change **(question 2).** Their reasons included the closing of resource cycles (including recovery, recycle, reuse and the minimization of resource use); the promotion of cooperation among different disciplines or sectors; and the promotion of integration and efficiency (while the need for caution related to a loss of flexibility, etc., was also pointed out).

Regarding **question 3,** identifying the main challenges related to adopting a nexus approach in order to adapt to global change, most responses fell into the following broader categories: difficulties in finding a focus, defining global change and/or measuring global change; developing a process that could transfer theory, global thinking and discussions (talking) into practice, local action and considerations for regional differences; a lack of political interest and/or will; and a lack of capacity and/or financial resources.

The majority of respondents agreed that there is a need for more research on the nexus **(question 4).** The topics for research were diverse, but many identified the need for research on integration (e.g., integrated modelling, the linkage between science, economics and other sectors, decision-making support, etc.), the establishment of case studies and scenarios, the development of methodologies and tools and carrying out impact assessments. A few respondents were undecided, because they thought what was most needed would be an improvement in the political, social and/or implementation spheres or a better use of existing knowledge rather than new research.

Many people (33 out of 42) thought session II achieved its stated goals because the session provided a good presentation of ideas, approaches and discussions **(question 5).** Those that were not sure if the session achieved its goals thought that some presentations did not address the nexus, the goals were not clear or the session was only a discussion on the model not on the implementation of a nexus approach.

## 7.3 Session III

The table below provides a summary of the responses to the questionnaire for **session III.**

Table 3. Responses from participants of session III.

| No. | Question | Yes | No | Undecided |
|---|---|---|---|---|
| 1 | Is the nexus concept mature and developed enough to be covered in study programmes? | 31 | 4 | 5 |
| 2 | Is there a need for specific nexus education programmes or should the nexus concept be addressed in existing programmes on water, soil or waste management? | 16 | 15 | 8 |
| 3 | Which key issues and topics need to be addressed in a nexus curriculum? | (see below) | | |
| 4 | Are the objectives of capacity development for research and education programmes sufficiently defined? | 19 | 6 | 14 |
| 5 | Do you think this session achieved its stated goals? | (see below) | | |

The majority of the respondents (31 out of 40) thought that the nexus concept is mature and developed enough to be covered in a study programme **(question 1).** They reasoned that the nexus concept already exists or that there is sufficient knowledge to advance the nexus concept without labelling it as such. However, respondents

who answered 'yes' and 'no' suggested that a clear definition of nexus is necessary for its actual application and the inclusion of a component on implementation with economic and managerial considerations is warranted.
For **question 2** on the need for dedicated educational programmes on the nexus, regardless of their response, many pointed out that study programmes on integrated management or interdisciplinary studies already exist and that existing programmes, including sectoral studies that could provide solid foundations for a nexus approach, should be used as a starting basis and can be improved upon, integrated into and well balanced in setting up dedicated nexus study programmes.

In terms of the key issues and topics that need to be addressed in a nexus curriculum **(question 3),** the responses varied, but could be classified into the following categories: interconnections between different disciplines especially the physical sciences (including a life-cycle approach); economic and socio-economic aspects; methodologies and tools; and actual application and implementation.

With regards to the objectives of capacity development for research and education programmes **(question 4),** regardless of their answers, respondents suggested the need for defining whose capacity is the focus of such programmes. The objectives of capacity development should be region-specific or problem-specific. Finally, some respondents suggested that determining who is committed to leading capacity development is important, since otherwise capacity development would not be accomplished.

Many respondents thought that session III achieved its stated goals **(question 5)** not because the session provided a solution, but because the ideas and opinions presented in the discussions made the participants aware of important points that require consideration. Several respondents, however, thought that the discussion should be more focused and that practical issues should have been addressed.

## 7.4 Session IV

The table below provides a summary of the responses to the questionnaire for **session IV.**

Table 4. Responses from participants of session IV.

| No. | Question | Yes | No | Undecided |
|---|---|---|---|---|
| 1 | Do you think the session achieved its stated goals? | 25 | 2 | 6 |
| 2 | How do you see the role of UNU-FLORES in the process of advancing a nexus approach? | (see below) | | |
| 3 | Would you like to be consulted or participate in regional workshops leading up to the Dresden International Conference scheduled for March 2015? | 32 | 2 | 1 |
| 4 | Would you like to collaborate with us in the future to organize regional ministerial consultations or workshops that advance a nexus approach? | 31 | 2 | 3 |
| 5 | Would you like to collaborate with us to disseminate best practice guidelines and policy relevant case studies relating to a nexus approach either through our planned publications or educational programmes? | 32 | 3 | 1 |
| 6 | Would you like to actively shape future nexus conferences? | 26 | 3 | 2 |
| 7 | Considering our performance in organizing this kick-off workshop, do you have any suggestions on how to improve the quality of upcoming workshops, conferences, etc.? | (see below) | | |



The majority of the respondents thought that session IV achieved its stated goals **(question 1),** largely because the presentations and discussions were good and interesting. Furthermore, many respondents suggested a need for communication and cooperation among different stakeholders. However, some participants also thought the content was too general or placed too much emphasis on intersectoral coordination while aspects of the actual application should have been discussed or stressed more.

The participants' suggestions on the role of UNU-FLORES in the process of advancing the nexus approach **(question 2)** were diverse, including the development of case studies or practical projects; the development of guidelines and monitoring systems; capacity development and awareness-raising, advocacy or the dissemination of information; and bridging interests and coordination.

The majority of the respondents (32 out of 35) would be interested in participating in regional workshops leading up to the Dresden Nexus Conference to be held in 2015 **(question 3).** Aspects of their possible contributions were also diverse and based on their expertise and interest. But most respondents would like to contribute in the form of presentations or the facilitation of discussions.

Similarly, many participants (31 out of 36 and 32 out of 36, respectively) would be interested in collaborating with UNU-FLORES in organizing regional ministerial consultations or workshops that advance a nexus approach **(question 4)** and disseminating best practice guidelines and policy relevant case studies related to a nexus approach either through planned publications or educational programmes at UNU-FLORES **(question 5).** The majority of the respondents would also like to actively shape future nexus conferences **(question 6)** as steering committee members, panellists, contributors or conveners.

Suggestions for improvements to the quality of future workshops and conferences **(question 7)** included a need for more time, the selection of fewer presentations or increasing the duration (the number of days) of the workshop or conference, the organization of round tables, dynamic interactions or exercises in smaller groups in keeping with the term 'workshop' and more in-depth discussions rather than presentations and discussions compared to those included in this international kick-off workshop.

# 8. Case Studies

## 8.1. Introduction

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Among the prime goals of the International Kick-off Workshop on advancing a nexus approach to the sustainable management of water, soil and waste was to provide an overview of the state of the art of various ongoing initiatives on developing, adopting and implementing integrated management strategies for these closely intertwined resources (see previous sections). It was recognized already during the preparation of the workshop that case studies would be essential to demonstrate the benefits of a nexus approach, to provide examples for implementation and to learn about the needs of member states. Given the mandate of UNU-FLORES to act as a think tank for the UN system and to member states on integrated management of water, soil and waste, it seemed indeed crucial to collect first-hand information from member states as well as from researchers and decision makers working on nexus topics and projects.

The importance of case studies was emphasized repeatedly also during the workshop serving various needs:

1. Case studies would help in explaining the meaning of the nexus approach. Given that there is no clear-cut and straightforward definition of the nexus approach, providing examples was considered the most appropriate and effective way of demonstrating what a nexus approach means.
2. Only practical examples and respective data will allow make progress in quantifying benefits of a nexus approach and deriving a nexus index to this end.
3. Such practical examples will make the most convincing case for adopting a nexus approach to stakeholders and decision makers in charge of managing water, soil and waste.

The need for providing examples as an effective means of explaining the nexus was put forward during various discussions at the kick-off workshop. In fact, it was considered futile to strive for a clear-cut and stringent general Nexus definition. Efforts should rather be placed on developing and implementing nexus approaches and identify existing ones which may originally have been framed and considered as example of integrated water resources management (IWRM), sustainable land management, integrated solid waste management or the like. From the perspective of UNU-FLORES, it is important to emphasize the need for a nexus approach to the management of water, soil and waste due to the strong interrelations of these resources (Lal 2013). Integrated management approaches have been developed independently for water, soil and waste and became widely accepted in particular concerning IWRM. Many IWRM projects and initiatives, when taking a broader view beyond the water sector, can serve as an example for a nexus approach or at least contain nexus elements and the same holds true e.g. for sustainable land management. As laid out in its first annual report (UNU-FLORES 2014) the nexus approach to managing water, soil and waste represents the resources perspective to the widely known and accepted Water, Energy and Food Security Nexus, promoted mainly by and since the Bonn 2011 conference (Hoff 2011, ).

Providing a platform to discuss case studies and to bring together stakeholders both from academia as well as from the governance and implementation side was a major goal of the kick-off workshop and will be further pursued in the regular Dresden Nexus Conference series. The collection of case studies presented here thus represents a first attempt and a first step to build up a knowledge base for integrated management of water, soil and waste with examples from different parts of the world, which will ultimately feed into a nexus observatory.

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**The case studies presented during the kick-off workshop**

The case studies collected and presented at the kick-off workshop reflect the broad nature of the nexus concept and differ widely in scope. They can be categorized into three sections: (i) Current approaches of managing water, soil and waste, (ii) Concepts and tools for integrated management and (iii) case studies at local and national level.

The case study from Mauritius by Vikram Seebaluck, University of Mauritius, provides an overview of *current approaches of managing water, soil and waste* in a Small Island Developing State facing unique development challenges with respect to its environmental resources capacity which is limited due to its smallness and isolated geography. Based on this analysis and the identified challenges of a still largely sectorial management, it is concluded that a nexus approach would be a promising and innovative way to enhance resource use efficiency and sustainability for promoting economic growth in the context of sustainable development in the country. The view that while facing unique challenges, the case of Mauritius at the same time represents a particularly well-suited example to develop and implement an integrated approach to managing environmental resources is supported by recent studies (The Republic of Mauritius | 2014; Fischer et al. 2013).

Among the resources considered in the kick-off workshop, waste and its management was found to pose particular challenges, especially in developing countries. The case of solid waste management in Ghana by Effiom Oku and Kwabena Asubonteng, UNU-INRA, represents one example. Virtually all aspects of waste management are poorly developed, from collection to separation and recycling to disposal. Besides limited capacities (technically, institutionally and individually), the major challenge of waste management is seen in changing the public perception of the problem and of waste as a resource. Therefore, working towards a nexus approach to waste management, with positive feedbacks to soil and land-use management, water management, health implications and economic benefits, requires addressing capacity development and governance from the outset.

The second section of the cases studies on *concepts and tools for integrated management* starts with a concept paper by Uchita de Zoysa, Centre for Environment and Development, Sri Lanka. He emphasizes an aspect which had been raised by Oku and Asubonteng and which represents a recurrent theme in several other case studies described below: the engagement of the public and of involved stakeholders already during the development and in particular during the implementation of nexus approaches. Different scenarios in a water-soil-waste nexus are discussed in their mirrors to a governance nexus, putting it in the perspective of sustainable development which considers ecological sustainability and social equity.

The economic framework required for implementing nexus approaches is one of the aspects addressed in the joint paper of Perez Sierra et al. Representing a collection of papers dealing with methodological aspects of a nexus approach, they also elaborate on low-energy-demand natural systems for waste water treatment as an example of a water-waste-energy nexus, the use of urine as agricultural fertilizer as an example of a water-waste-food nexus and biofiltration for the treatment of waste gases as one element of integrated waste management in a nexus context. All the examples provided represent technologies which are available and which do not require massive investment or high-tech infrastructure, making them particularly suitable for developing countries.

An example of (relatively) high-tech, but still easily available methodology with high implementation potential and first applications already up and running for nexus management solutions is provided by Joash Nyitambe, Ministry of Water of Tanzania. He introduces the case of water point mapping using GPS devices or mobile phones, feeding into an online database and being visualized in digital maps as a planning and monitoring tool. Governance aspects are at least equally critical as technological aspects for the further development and the acceptance of the system by all stakeholders. Community-owned Water Supply Organizations are supposed to have a leading role for operation and maintenance of the water supply system – pointing again to the importance of engaging the people for implementing nexus management solutions.

A more scientific approach was taken in the collection of papers presented by Husemann et al. This paper represents the first of 5 contributions which make up the final section *Towards Nexus Approach: Case Studies at Local and National Level*. Based on various PhD projects undertaken within the scholarship programme "International Postgraduate Studies in Water Technologies" (IPSWaT), organized and supported by the German Federal Ministry of Education and Research (BMBF), see also Perez Sierra et al. their results indicate that:

- linking waste water treatment with energy production may be a cost-effective measure providing a feasible option of implementing a water-waste-energy nexus approach;
- model-aided analysis of water fluxes may help to increase water use efficiency and improve wastewater management;
- a nexus approach to water, soil and waste management might help to escape from, or even reverse, the vicious cycle of land degradation as exemplified for Ethiopia;
- nexus-oriented policies can synergize land, energy and water management schemes to face the growing needs for water, food and energy, e.g. in South Asia;
- climate change adaptation of urban (storm) water systems needs to take institutional and social dimensions into consideration and can be addressed by taking a comparative approach in case of data-scarcity;
- a nexus approach is required for developing adaptive management strategies for harmonising soil management and water supply security in the dry regions of China.

All examples provided in Husemann et al. clearly contain nexus elements, while the projects had originally been established in the framework of IWRM.

The contribution of Sheikh Javed Ahmed, African Development Bank (AfDB), provides examples how the cooperation between donors, scientists, implementers and local communities succeeded in rehabilitating and restoring degraded areas and watersheds in Africa. The described measures provided training and, at least for the project period, work and income for many people and hopefully improved the livelihood for the involved communities in a sustainable way.

Sasha Alexander and Sergio Zelaya of UNCCD summarize some of the currently available approaches of sustainable land management which integrate also water and waste management aspects and which have successfully been implemented in Africa, mainly at the local or farm level. Scaling up of these approaches remains challenging but should be fostered as major building block of sustainable development and for achieving the envisaged SDGs.

The case study from Korea by Ilyoung Oh, Embassy of the Republic of Korea, reports on nonpoint source water pollution management programmes at national level. To tackle this problem soil and land use management, as well as waste management and water management need to be integrated to derive tailor-made measures for urban and rural areas, including research and education on inter-sectoral material flux, policy design and governance.

The aspect of engaging people in development projects (whether nexus related or not), emphasized in various of the described case studies represents also the main take-home message from the "Sanitation Story of Himachal Pradesh, India", by Deepak Sanan. Although not explicitly addressed, the nexus perspective of this successful example of ending open defecation via an approach known as Community Led Total Sanitation (CLTS), namely the link to water and soil and land-use management are clear enough to include it here. While this example of CLTS makes a strong case for the importance of community engagement and the close link between governance and capacity development, it also shows that the commitment and enthusiasm of single stakeholders (with positive feedback loops to/from the communities) can make a difference.

Overall, the case studies presented here provide evidence that a nexus approach to the sustainable management of water, soil and waste is feasible and provides many opportunities for enhancing resource use efficiency. While for some specific applications or geographic regions more case studies might be required, more focus should be placed on:

- assuring the sustainability of existing case studies by securing required follow-ups in maintenance of infrastructure, capacity development etc.;
- scaling up from pilot projects to implementation at larger scales at provincial, national and even regional level.

Concerning the latter, the case studies from Korea (I. Oh) and India (D. Sanan) may provide some lessons to learn by showing how a nexus-related programme may develop and improve over time and that the close cooperation and interaction of stakeholders at all levels can change the public perception and the common way of dealing with particular problems (e.g. open defecation). Both examples share the experience that achieving sustained changes in environmental management practices takes time, which calls for long-term visions and programmes rather than short-termed projects at local levels.

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## 8.2. Current Approaches of Managing Water, Soil and Waste

### 8.2.1. Water, Soil and Waste Management Practices in Mauritius and Prospects for their Integrated Management

Vikram Seebaluck, University of Mauritius

**Water, Soil and Waste Management Practices in Mauritius and Prospects for their Integrated Management**

Vikram Seebaluck[1]

**Abstract**

This paper synthesizes the current practices for water, soil and waste management in Mauritius followed by the key challenges and targets in these sectors. It then identifies and analyses the possible nexus between the three areas and recommends options for their integrated management for specific sectors from the point of view of promoting the sustainable use of these environmental resources. The paper reviews information available from research done so far in the said areas for the country as well as those from the relevant regulatory institutions including related strategic plans. It is found that the rapid development of the country has come at a cost to the quality of its natural resources being impacted upon, which requires redress to sustainably use the limited environmental resources available in the island over the long term. The integrated management of water, soil and waste for specific sectors through a nexus approach is perceived as a promising and innovative way to efficiently and jointly use these resources for promoting economic growth in the context of sustainable development in the country.

**Key socio-economic and environmental statistics for Mauritius**

The Republic of Mauritius, a subtropical Eastern and Southern African country in the Indian Ocean, together with its dependencies has a total land surface area of 2,040 km$^2$ and an Exclusive Economic Zone (EEZ) of over 2.3 million km$^2$ which is yet almost unexplored. Its population accounts to around 1.3 million and the country has a high population density of 634 people per km$^2$ (CSO, 2013).

Mauritius is classified as an upper middle income developing economy. The country has a vibrant open economy, stable democracy and high standard of living. It has always enjoyed successive GDP growth of more 3% over the past three decades (around 4-6% before the recent financial economic crisis) and the income per capita is at present about 8,700 USD (CSO, 2013), the second highest in Africa. The economy is highly diversified based on a sugarcane industry, textile and manufacturing sector, tourism industry and financial services sector; information and communication technology, seafood industry, property development, healthcare, education and training have recently emerged as important economic sectors.

Despite its small size, low endowment of natural resources and remoteness from world markets the country meets with most of the Millennium Development Goals and its key human development indicators (HDI) stands at 0.737 which is relatively higher than that of the sub-Saharan region which is 0.475 on average (UNDP, 2013). The ecological footprint of the country was 4.26 global hectares per person (2010) which however tends to increase with continued economic development (MID, 2013). The challenge is thus to achieve sustainable continuous development while reducing the environmental burden on the country and preserving its ecosystem. The basic key socio-economic and environmental statistics for Mauritius are given in Table 1.

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Table 1: Key basic socio-economic and environmental statistics for Mauritius (2012)
Data sources: MID, 2013; CSO, 2013; UNDP, 2013

| Indicator | Quantity |
|---|---|
| Total land area | 186,600 ha |
| Population | 1,291,100 |
| Population density | 634 people/km$^2$ |
| GDP growth rate | 3.2% |
| GDP per capita | 8,734 USD |
| Human Development Index (HDI) | 0.737 |
| Forest area (as a % total land area) | 25.6% |
| Irrigated area (as a % total land area) | 10.7% |
| Land protected area (as a % total land area) | 8% |
| CO2 emissions per capita | 2,800 ppm |
| Mean annual rainfall | 1,609 mm |
| Estimated total water utilisation | 800 Mm$^3$ |
| Daily domestic water consumption per capita | 160 litres |
| Daily solid waste generated per capita | 0.9 kg |
| Primary energy requirement per capita | 1.13 toe |
| Ecological footprint | 4.26 Gha/person |

**Water, soil and waste management in Mauritius**

*Water resources*

Mauritius is a water-stressed country and water scarcity would pose a serious constraint for ensuring future sustainable development in the country. In 2012, the country overall water utilization was 800 Mm$^3$ and was used for the agricultural sector (46%), power generation (27%) and the remaining for domestic, industrial and tourism sectors (27%) (CSO, 2013). Growing demand of this resource for agriculture, tourism, industrial developments and in particular the increasing per capita domestic water requirement which currently stood at around 160 litres (classified as high by international standards), are creating major challenges in this sector. The total water demand for 2040 is projected to be 1,200 Mm$^3$ per year which is in excess of projected supplies and close to the utilizable renewable potential of 1,233 Mm$^3$ per year (MID, 2013). In addition, it is important to analyze these figures by taking into consideration the fact that the country is affected by droughts from time to time while climate change impacts are causing fluctuations in rainfall patterns which are exacerbating water scarcity in the country. The mean annual rainfall, recorded over the long term between 1905 and 2007 has decreased (MID, 2013) while it has been noted that there is an increasing number of consecutive dry days and decreasing number of rainy days. The gradual shorter duration of rainy days are accompanied by heavy or torrential rain that recently resulted in flooding as well as the inability to collect a maximum amount of the rain water which quickly flowed to the sea after maximum water absorption by the soil.

During the past two decades, significant investment has been made to increase storage capacity, supply and improve water quality. Water is abstracted from about 350 river-run offtakes permitting an annual average mobilization of around 450-500 Mm$^3$ of surface water while around 200-300 Mm$^3$ is obtained from the 11 man-made reservoirs; these water resources are mainly used for agriculture and power generation. Around 125-150 Mm$^3$ of water is derived from the five main aquifers in the country which is mainly used for domestic

application. Indeed, around 50% of domestic water is derived from groundwater resources, especially in times of drought, and it becomes imperative to protect these freshwater aquifers from sources of pollution. It is important to highlight that the geology of Mauritius consists basically of basalt rocks only and the complex nature of its formation has given rise to basalt of various densities (impermeable to porous) that acts as water collectors: aquifers in the country has thus high permeability in excess of $10^{-5}$ m/s (Proag, 2006).

The main sources of water pollution in Mauritius arise from the dumping of solid wastes in rivers, discharge of domestic and industrial effluents and run off from agricultural fields. Most housing units use onsite disposal systems like septic tanks, absorption pits and cesspits while about 22% of population have to date been connected to public sewers through the national sewerage programme, representing some 77,917 housing units and some 93,000 $m^3$ of wastewater per day and this volume is expected to reach 179,000 $m^3$ by 2015 (mostly from the urban regions) (MID, 2013). Most hotels treat their effluent using small waste water treatment plants and re-use the treated effluent for irrigation while industries design and use appropriate wastewater treatment plants to ultimately discharge treated wastewater according to national norms (MOESD, 2013).

Agricultural water pollution results from the extensive use of agrochemicals and pesticides which leach or run-off to water bodies in particular on sloppy areas thereby adversely affecting the drinking and lagoon water quality. Large planters (mostly cane growers) tend to use the right dose of agrochemicals and pesticides while small planters (mostly vegetable planters) tend to make excessive use to increase crop yield but which besides polluting water bodies also results in pesticides residues in agricultural produce that can lead to human intoxication.

*Soil and land use*

Soil type in Mauritius is comprised of two major categories namely latosolic immature soils (reddish prairie and brown forest) and latosols mature soil (low humic, humic, hydrol humic and humic ferruginous) which provide the resources for appropriate land use (Parish et al., 1965). The natural fertility of soils in the country is low since they require nitrogen, phosphate and potash to grow crops economically. It has been found that the soil fertility also generally declines with increasing rainfall and increasing age of the parent rock. Thus, not all crops in particular the staple ones are grown in the country while the optimum uses of the soils and lands are sought.

The high population density in the country puts considerable pressure on land use for forestry, agriculture and developmental needs. Forest area has decreased from around 31% to around 25.6% in 2012 (CSO, 2013). Agricultural land area occupied around 43% while built-up areas covered about 28% of the country area. There is actually competing land use for agricultural, industrial, tourism, urban and infrastructural developments. Despite the legislative framework on land use planning in the country, pressures on land use, along with unsustainable practices, have led to overuse and degradation, especially in environmentally sensitive areas.

Forestry in Mauritius plays multifunctional roles in the protection of watersheds, conservation of soil, providing habitats for fauna and flora, flood control, carbon sequestration and for greening the country for ecotourism and the provision of leisure and recreation. The forests are thus extremely important to the country in providing these vital protective functions which are crucial for the environmental sustainability and economic development of the country.

It is important to highlight that Mauritius is almost self-sufficient only in its vegetable production while it imports about 75% of the other food items (MAIFS, 2013) which amount to around 19% of the country's total imports bill. The country is thus vulnerable to the rapidly changing global food supply system characterized by volatile prices, climate change and the growing use of land and crops for biofuel production. It is therefore imperative to judiciously use the available land in the country for food production and wherever appropriate for biofuel crops to decrease its dependency on imported fossil fuels and thereby improve its energy security. However, besides competing land use, other factors like decreasing soil fertility, water scarcity and a lack of interest and capacity building of the young generation in agricultural activities should be addressed in dealing with this challenging issue.

Mauritius has been dependent on a sugarcane monocrop economy very long ago but despite that this industry nowadays contributes to only around 2% of the GDP, the crop is still grown on around 30% of the country land area due to the multi-functional roles and benefits that it brings to the nation. The sugar industry has however recently been subjected to major reforms due to changes in international trade policies and agreements in the agricultural sector which have far reaching effect resulting in under-investment and marginal land moving out of cane production coupled with considerable social, environmental and economic consequences. Changes in land use with the availability of around more that 12,000 of hectares of marginal land (MSIRI, 2006) for alternative uses provides opportunities for other developments, but one attractive option is the production of biofuel crops which could safeguard or even improve the economic return from these lands thereby maintaining the livelihoods of the many planters/operators in this sector as well as providing multiple other environmental benefits (MAIF, 2006). As per the Sugar Sector Strategic Plan 2001-2005 (MAIF, 2005), provisions were made to reduce the area under sugarcane cultivation from 76,500 ha in 2001 to some 60,000 ha by the year 2010, in view of fully mechanizing sugarcane fields. The 16,500 ha of land formerly identified was revised to 12,341 ha and includes prime land for conversion into other uses and the different categories of difficult or marginal land that rendered sugarcane cultivation economically not viable (MSIRI, 2006). More recently, according to an integrated assessment study by UNEP (2009) three scenarios have been developed with respect to release of land under cane cultivation namely: Scenario I - abandonment of land under sugarcane cultivation (difficult areas of 4,642 ha found on the seaward mountain slopes); Scenario II - conversion to agricultural uses other than sugarcane (average of 1,200 ha per year), and; Scenario III - conversion to non-agricultural uses viz Integrated Resort Scheme, Real Estate Scheme, Ecotourism and Residential (insignificant land area when compared to scenario I & II).

As an island state, the coastal environment is an important asset for the socio-economic development of Mauritius in particular for the tourism industry. However, rapid development on the coast such as expansion of built-up areas and in some cases unplanned construction, land reclamation and clearing, tourism development, climate change and sea level rise are affecting these regions. Presently, some 7 km of beaches are affected by erosion (MID, 2013). A comprehensive framework for coastal zone management has been developed and a number of measures have been taken to abate the impacts of erosion in the coastal areas, ban sand extraction, provide coastal rehabilitation, promote coral reef and lagoonal water quality monitoring and the creation of Marine Protected Areas, among others.

*Waste management*

In 2012, around 387,925 tonnes of Municipal Solid Waste (MSW) were landfilled (CSO, 2013) while more than 7,000 tonnes were composted. MSW is collected by Local Authorities and disposed of at the only landfill on the island, which is nearing saturation point. The daily amount of solid generated per capita is around 0.9 kg and is composed mainly of organic wastes to about 70%. Most of the wastes generated are generally collected with little exposed to open dumping. But some of them do find their way in nature and accumulate and block drains causing flooding during heavy rainfall and ultimately reaching water bodies causing water pollution.

The organic nature of MSW provides opportunities for its conversion into organic fertilizer. Composting is thus locally practiced both at domestic and industrial scales. Small scale composters are used in many households for transforming organic kitchen and yard waste into compost used in gardening. On a larger scale, an industrial MSW composting plant has recently been constructed for the production of organic fertilizers for use in the agricultural sector. Other types of waste such as plastics (PET), glass and metals are recycled and re-use or exported. The country also faces the challenge with regards to hazardous waste management for which the disposal infrastructure is limited to a hazardous waste cell at the landfill. Taking into account the projected growth in the number of residents and tourists visiting the country and the increasing patterns of consumption and production in particular with improvement in the standard of living,

it is expected that the total waste generation may increase by about 50% by 2030 (MID, 2013). Hence there is an urgent need to adopt an integrated approach for waste management focusing on waste reduction, reuse, sorting and recycling with the introduction of cost recovery mechanisms.

Waste generated from industrial plants are generally converted into useful end products, for instance the large quantity of cane bagasse waste (around 300 kg from each tonne of cane processed) generated from the sugar industry is used for the production of electricity while ash and mud/scum generated in the factory are returned as nutrients to the cane fields. In alcohol production plants, the waste (vinasse or stillages) generated voluminously at a rate of 13-16 litres per litre of alcohol produced is used for fertigation (irrigation of fields) or concentrated in a CMS (Concentrated Molasses Stillage) plant to produce a pasty organic fertilizer that is applied to the soil.

Agricultural waste which is mainly from sugarcane, the main agricultural crop grown on around 30% of the country land area, is generally left in the fields as source of nutrients return to the soil and also for preserving the soil moisture and controlling weed growth thus necessitating lower use of herbicides. However, given the relatively high energy content of these residues (cane leaves and tops and trash) it carries good potential application for being collected and converted into electricity in existing cogeneration power plants in the country. The environmental impacts of its removal from cane fields however need to be assessed and studies undertaken in this area have indicated that a minimum amount of around 30% of these residues should be left in the fields to obtain the corresponding benefits (Seebaluck et al. 2009). On the other hand, forestry wastes are generally left in the forests as they do not yet carry potential applications.

**Challenges and targets**

*Water sector*

Water resources capacity are being consolidated through the construction of new dams, exploitation of new boreholes, installation of pumping stations on rivers, reduction of network losses and the review of the water rights legislation for allocation of permits for a more equitable distribution. On the institutional front, all the organizations involved in water governance namely the Water Resources Unit, Central Water Authority, Irrigation Authority and Wastewater Management Authority are envisaged to be reformed and integrated into a single water governing entity to address the complexities and inefficiencies of fragmented water management by several independent water institutions. To meet future water demand and supply, efforts should be geared towards preventing surface and groundwater pollution, promoting sustainable watershed management, reducing unaccounted water loss and optimising the reuse of treated wastewater. It would be equally important to control activities/land use in common aquifers recharge zones and also to assess the impact of saltwater intrusion in the aquifers nearing coastal regions (MENDU, 2007). Protection perimeters and levels for rivers, lakes, reservoirs and boreholes should be established.

Indeed, a major part of the water piping network in the country is very old which tend to leak and burst with increasing water pressure. The leakage level has been found to be very high in Mauritius which also leads to low water pressure and flow rate to the end users. The Non-Revenue-Water is estimated to be around 35% and despite that it would be costly, it is vital to replace the old pipe networks not only to reduce the leakage level but also to offer better water services to end users and possibly at reduced cost. In parallel, water demand should be managed through water conservation programmes in households and its optimum use in industries through appropriate sensitisation, tariffs and water pricing; the latter is felt to be very low in Mauritius which is around 0.39 USD/$m^3$ (CSO, 2013). Furthermore, working partnerships should be established with all major water consuming industries to ensure that they do not pollute water resources: this could be undertaken through cleaner production techniques, regulations, economic instruments and water quality monitoring.

It should be highlighted that several countries are turning to the sea to help alleviate the growing problems of fresh water shortages while some of them are using partially treated sea water (purification, disinfection and biochemical treatment) as pilot project for non-potable use especially when it has been found that the latter accounts to around one third of the household consumption of fresh water. For instance, the use of sea water to flush toilets is more hygienic and economical. These opportunities however arise for countries nearing the sea or island state like Mauritius. On the other hand, complete desalination plants are increasing both in numbers and in size to provide for the increasing fresh water needs as is the case of some hotels in the country.

Given that about half of the available country water resources is devoted to the agricultural sector for irrigation (46% in 2012), the production of crops requiring low water use in particular those to be grown on the large parcels of released marginal lands which are no longer profitable for cane cultivation should be promoted. Modern and efficient water irrigation techniques should concurrently be used together with the use of climate models and forecasts to optimize water use for irrigation. The allocation of significant amount of water for power generation (27% in 2012) should equally be reviewed despite the fact that cheap electricity is produced from hydropower plants: the right balance of water need for power generation compared to its use for alternative sectors that would likely bring larger contribution to the economy should be assessed from the different perspectives.

*Soil and land use*

Given the limited availability and competition of land for alternative uses in Mauritius, it is important to develop an integrated planning approach to optimize this resource in particular to ensure that the prime agricultural land and environmentally sensitive areas like wetlands and mountain slopes are protected. Sustainable land use planning should thus take proper account of land use impacts on the environment and the efficient use of these scarce land resources. Built-up areas in particular infrastructural needs should be enhanced to promote economic development but these should be accompanied with architectural coherence to preserve the natural environment in the country. Clear delimitations should be set and reinforced with respect to residential, industrial and agricultural zonings including those on the coastal regions. Encroachment on environmentally sensitive areas in particular coastal and inland green areas by inappropriate intrusion of concrete structures should be avoided.

To minimize the use of agrochemicals and pesticides in the agricultural sector, biological and non-chemical control methods as well as agro-ecological farming should be promoted to sustain long term productivity of agricultural land; these could be integrated nutrient and water management, integrated crop management, integrated pest and disease management, rainwater harvesting, crop rotation, use of organic products, green manuring and recycling of agricultural wastes/composting. The cultivation of more drought and heat resistant crop varieties should also be promoted in appropriate areas.

*Waste management*

The ever growing volume of waste, limited disposal capacity and current low rates of recycling are major challenges of solid waste management. At the present waste growth rate, the total amount of waste requiring management would reach around 472,500 tonnes by 2015 (MID, 2013). The parent Ministry has developed an appropriate strategy with a focus on improvements in waste collection, increased resource recovery and provision of adequate disposal infrastructure and appropriate treatment technologies. The target is to achieve a 40% recycle rate by 2015 with an emphasis on the production of organic fertilizer for use in agriculture. Household production of compost would enable the reduction of waste at source together with the subsequent collection, transportation and disposal costs.

The anti-social behavior of littering and illegal dumping including disposal of bulky wastes in open areas in particular in drains and rivers should be reduced through proper reinforcement of existing legislations. The recent flood experienced in the country after the short period of torrential rain could be partly due to drains blocked by litters thus deviating the huge amount of water off the drains to the roads and low platforms. Minimization of littering and illegal waste dumping would also avoid the proliferation of rodents, pests and insect vectors thus enhancing sound environment and health management.

The concept of cleaner production or industrial ecology should be promoted in process industries to favour low use of environmental resources and subsequently produce 'zero-waste' or relatively low quantities of waste that should as far as possible be re-use, recycled or converted in other useful products. The sugar industry provides a concrete example of this concept with its processing of sugarcane into sugar as main product while the wastes generated in the process are used for the production of electricity and bio-ethanol: other waste products so generated can subsequently be transformed in other useful products such as organic fertilizers, industrial products and chemicals, food and feed amongst others (Johnson & Seebaluck, 2013).

**Options for integrating the management of water, soil and waste environmental resources**

The management of water, soil and land, and waste has so far been managed independently despite that there exist common linkages between these sectors that could provide opportunities for holistically managing these environmental resources more efficiently. Opportunities for this nexus approach have been reported by several authors for the sustainable management of water, soil and waste (UNU-FLORES, 2014). Such attempts should however deal with the overall development of projects, not only the economic perspective but very importantly include the environmental as well as social aspects comprised in the different stages of the project that are intended to contribute to its long term sustainability.

The most appealing and important sector for demonstrating the integrated use and management of environmental resources is the agricultural and more wholly the agro-industrial sector. It extends from agriculture (agronomy, land/soil resources and climate) to industry (processing, waste handling/recycling, cleaner production), markets (policies/regulations, trade/investment and implementation/strategies), impacts (socio-economic and environmental) to finally integration (risk analysis/competitiveness, experience/comparison and stakeholder perspectives). Agro-Ecological Zoning (AEZ), an important tool for identifying and assessing available and suitable land for crop production or other purposes based on soil, climate, water/rainfall availability, topography amongst others, is nowadays becoming important in agricultural development to provide better land use. For instance, water use for crops under rainfed conditions should be optimized versus irrigation with respect to agro-climatic zoning including the topography to avoid chemicals and pesticides leaching and run-off into water bodies. Waste management can equally be involved in agriculture by collecting part of the agricultural waste generally left in the fields for processing into other products in particular the attractive energy products. On the processing front, optimization of resource use efficiency (e.g water) and cleaner production (low materials input and low wastes generation followed by recycling – organic nutrients return to the field/soil) can offer valuable and practical options for judiciously using environmental resource and promoting green productivity. Green productivity not only preserves environmental resources but also gives a competitive economic and marketing edge so desired in this current global economic environment and should be regulated by markets (policies, strategies and investment); markets are increasingly being characterized by responsible and sustainable production that should comply with acceptable standards related to quality, environmental management and social accountability. Ultimately, assessment of the impacts and analysis of the risks and competitiveness as well as relevant stakeholder perspectives complete the project cycle. This sector thus provides the best application for the integrated management of environmental resources through nexus approach which is not only limited to countrywide or regional applications but could extend to larger boundaries.

Many countries and regions are nowadays called upon to develop strategies to ensure food and energy security through proper land use. For instance, Giampietro et al. (2013) investigated into the possibilities and scenarios for using the sugarcane output in Mauritius for biofuels production and/or replacing sugarcane with food crops cultivation to improve food self-sufficiency wherein an innovative accounting framework for the food-energy-water nexus was used. In general, the displacement of food crops from fertile agricultural land should be avoided and therefore reducing the risks associated with the negative impacts of land use change. On the other hand, the arid and semi-arid areas characterized by low fertility and moisture are increasingly being used for biofuel crops to create meaningful livelihoods and providing energy access or security. However, these crops should possess characteristics such as reduced water and nutrients requirements, high tolerance to salinity, water logging and reduced erosion susceptibility besides their adaptation to the climatic conditions (Seebaluck et al., 2014). Such food and fuel projects can be highly enhanced, in particular to avoid the international 'food versus fuel' debate, through the proper analysis and management of the needs for environmental resources.

As documented in this paper, there is likely to be a water shortage in Mauritius in the long term, possibly even with the development and mobilization of additional water resources. Fischer et al. (2013) assessed alternative land and water use options in view of anticipated climate change and socio-economic trends in Mauritius and it was reported that total water resources availability is expected to diminish due to climate change while water demand for agriculture, industrial and domestic use is increasing. There is thus a need to reallocate the water resources to the primary sectors namely agriculture and power generation which actually consumes more than two thirds of the water mobilized in the country. The increasing water needs to consolidate existing pillars like the industrial sector or emerging ones should probably be met in view of their potential larger contribution to the economy. The integrated output-based management of the environmental resources to be used in the different sectors should thus be compared with respect to the country relevance and used to develop new strategies for water re-allocation to the economic sectors. Once again a nexus approach and analysis would be highly beneficial.

Proper waste management does also carry a nexus with soil and water. Given the mostly organic nature of the waste generated, emphasis should be placed on its transformation into organic fertilizer as far as possible at alternative small to larger commercial scales plants. This would reduce the burden of waste collection, transportation and disposal to certain extent. Use of organic fertilizers would highly benefit the soil and reduce the application of chemical fertilizers thus putting less pressure on the exploitation of the latter and its associated environmental impacts.

To develop the nexus between water, soil and waste, it becomes equally important to collect reliable and adequate data based on common nexus indicators in these three sectors in order to monitor progress in facilitating integrated planning and implementation. The scope and quantity of information about the respective environment and the ecosystems would enable improvement for subsequent planning, protection and management and also to better account for conflicts between the environment and development. In addition, collaborative mechanisms should be promoted in bringing together the public and private sectors, communities, NGOs and voluntary sectors for awareness, capacity building and monitoring for the integrated use of environmental resources.

**Conclusion**

As a Small Island Developing State (SIDS), Mauritius faces unique development challenges with respect to its environmental resources capacity which is limited due to its smallness and isolated geography. It remains particularly vulnerable to the profound economic a nd environmental changes sweeping across the globe. The rapid development of the country has come at a cost with the quality of its natural resources being impacted upon. The increasing pressure on the use of its key environmental resources namely land and water coupled with the need for increasing waste disposal has brought along unsustainable practices. Resolving these challenges and threats and moving to a sustainable future is the case that should be currently addressed for promoting green economic growth. It is felt that the management of water, soil and waste through a nexus approach based on common environmental sustainability indicators would lead to an innovative integrated approach in managing these resources and contribute in providing a sustainable development pathway for the country.

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## 8.2.2. Urban Solid Waste Management: Case of Ghana in West Africa

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**Abstract**

This paper assesses solid waste management in Ghana, focusing on its challenges and opportunities in the adoption of a nexus approach to managing waste in Accra and Kumasi, the two most populous cities in Ghana. The daily waste generation is 2000 and 1500 tonnes for Accra and Kumasi respectively, with over 20 per cent left uncollected. The Municipal Governments and private sector collaboration in waste collection and transportation to dumpsites without treatment has proven to be unsustainable. Organic materials constitute a majority portion of waste, indicating high potentials of its conversion to renewable energy and soil conditioner, among others. The main waste collection and handling methods identified include community waste collection, "flyaway" waste and organized waste collection. The transportation methods range from head portal, tricycle, mammy truck to heavy-duty truck. The dumpsites are un-engineered, with animals and scavengers collecting objects of interest. The unsegregated waste is usually burnt to reduce load, producing a lot of smoke (from different waste components) that pollutes the air. Leachates also produce odour nuisance and pollute nearby water bodies and groundwater. The current approach to solid waste management in Ghana fails to recognize the capital in waste and the beneficial linkages to other environmental resources. The nexus approach is holistic and may provide employment and revenue generation from reuse and conversion of waste to clean energy and manure with less emissions and health implications. The adoption of such an integrated approach in Ghana is hampered by limited capacities, both institutionally (policy and institutional regulations on ownership and governance) and individually (inadequate skilled manpower and limited knowledge platforms).

**Introduction**

Waste management in Ghana is not only a contentious environmental issue, but also a developmental challenge. This is because of the linkage it has with population, health and social development. A survey of residents of Ghana by World Bank (2010), ranked waste management in Ghana as the third most important urban services behind sanitation and drainage challenges in cities. The achievement of Millennium Development Goal (MDG) nos 7 (environmental sustainability) is tied to proper city waste management (Alhassan et al. 2011). The challenge is worrying and even featured in the forefront of Ghana's recent presidential election campaigns in 2012. Increasing population and urbanization have expanded waste burden and management challenges beyond the capacities and budgets of the two most populous metropolitan areas in Ghana: Accra and Kumasi. It is not uncommon to see light poly waste materials flying by roads in cities, beaches and sea. Indiscriminate dumping of waste in bushes, streets, and even in water bodies and in the fringes of municipal market centres is frequent. When it rains uncollected garbage piled at various sites in residential areas is washed into the drains. Stagnant ponds of water mixed with decomposing garbage produces leachate (flux) that pollutes ground and surface waters. Un-engineered dumpsites are also a major source of leachate. These wastes and leachate release offensive odour in the air and sometimes the stench is so much that nearby residents cannot stand it. Domestic wastewater is mostly discharged directly into drainage systems that empty into water bodies such as rivers, lagoons and streams (IESS 2011). The Korle Lagoon and infamous Lavender Hill are well known as sites where untreated sewage from the Accra metropolis is discharged directly into the Gulf of Guinea. Corcoran et al. (2010) reports that over half of the world's hospital beds are occupied with people suffering from illnesses linked to contaminated water and that more people die as a result of drinking unwholesome water than are killed by all forms of violence, including wars. For instance, the residents of Achimota in Accra in January 2013 demonstrated over the ghastly odour emanating from the Achimota dumpsite. They cited among others that no less than 200

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cholera cases are treated in Achimota General Hospital every month due to various forms of contamination; housefly infected foods and wells (source of drinking water). The dumpsite has been the dumping place for refuse from all the communities around Achimota area (Kyei 2013) .

Waste management in Ghana is the responsibility of the Ministry of Local Government and Rural Development, which supervises the decentralized Metropolitan, Municipal and District Assemblies (MMDAs). The regulation is vested in the Environmental Protection Agency (EPA) under the auspices of the Ministry of Environment and Science. The MMDAs are responsible for the collection and final disposal of solid waste and sewage through their Waste Management Departments and their Environmental Health and Sanitation Departments (Ibrahim 2011). Municipal governments have brought in private waste managers to collect from homes and location points within the city and transport to dumpsites. The combined efforts of government and private partners are inadequate due to poor infrastructure, weak institutions and policies, unskilled manpower for the sector and financial constraints.

**Country profile**

Ghana is located in the western part of Africa (Figure 1). The country has 10 regions with a total population of 24.4 million that generates 13,000 tonnes of solid waste daily (The Green Ghanaian 2013). Unfortunately, waste management infrastructure and skilled sectorial manpower are inadequate. Accra is the capital city of the country with a population of 4,010,054 but next to Kumasi with a population of 4,780,252 (Ghana Geospatial Forum 2014).

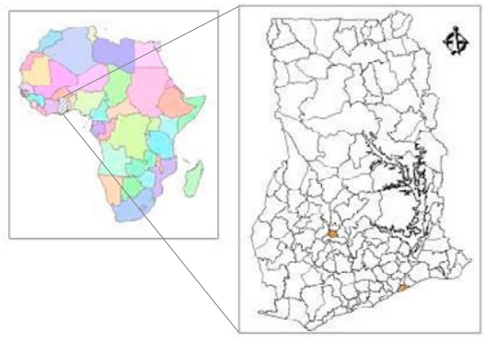

*Figure 1: Map of Africa showing Ghana and highlighting the Kumasi and Accra Metropolitan Areas*

**Waste challenges**

The increasing urban population and consumption lifestyle have led to high consumption trends resulting in the generation of large volumes of and diverse forms of waste far beyond the management capacity of the Municipal Governments. Ghana generates about 13,000 tons of solid waste per day with inadequate skilled labour and waste management infrastructure according to Noah Demedeme Lanason, Director of the Environmental Health and Safety Unit (Spyghana 2013). The quantity of solid waste generated in Accra daily is between 1,800 - 2,000 tons, out of which 500 tons are left uncollected daily (The Green Ghanaian 2013). The corresponding values for Kumasi are 1,500 and 150 tons. These figures do not account for the waste dumped in illegal spots. The Centre for Energy Environment and Sustainable Development (CEEDS) (2013) reports that 57 per cent of the waste ends up in illegal waste dumps adjacent to rivers or inside watercourse and drainages. The Municipal Governments involved the private sector in management of household waste. This has been in the collection. Home collection of waste to dumpsite is the practice; however, the collection is effective in high-income residential areas and ineffective in low-income areas and slums. Households that cannot afford to pay for waste collection or not easily accessible to these companies dispose their waste at central collection



points, which attracts less cost. These include large containers that are collected at a central point and then emptied from time to time by the waste collecting agency or at community dump hills. Others dispose the waste in bushes along the streets; some create dumpsite in bushes around their compounds as in Plate 1, while some dump the garbage in drains during heavy rains as in Plates 2, 3 and 4. In some parts of the low-income residential areas, communal bins are placed at different points within the community for members to drop their garbage. The creation of illegal open drop points is common as some community members consider the distance to the communal bins too long to trek. This has led to the indiscriminate deposition and disposal of waste in the city creating an unsanitary environment. Indiscriminate dumping of refuse, lack of segregation, non-engineered dumpsites, difficulty in collection due to poor road network, poor re-use culture, waste reduction, recovery, recycling and management of the collected garbage at dump sites are still major challenges in the sector. The value of waste composting for organic fertilizer to improve soil productivity, create employment and income and social inclusiveness is at low ebb in Ghana and appears not to be a priority for now.

*Plate 1. Community dump (Source: Authors' photograph - 2013)*

*Plate 2. Waste load in a river channel (Source: Authors' photograph - 2013)*

*Plate 3. Waste load and weeds growing from nutrient rich water in drainage (Source: Authors' photograph - 2013)*

*Plate 4. Waste load in a Korle Lagoon in Accra (Source: Authors' photograph - 2013)*

**Major composition of solid waste in Accra and Kumasi**

Kumar and Pandit (2013) report that larger cities generate more waste than small cities and the amount of solid waste generated is directly related to the economic status of families. This paper represents a case study of the situation in the cities of Accra and Kumasi. Studies on composition of solid waste in Accra and Kumasi are presented in Figures 2 and 3. Organic substances were the most prevalent waste material, indicating high potentials of its conversion to energy and soil conditioner for building soil security to absorb climate shocks and improve crop and soil productivity.

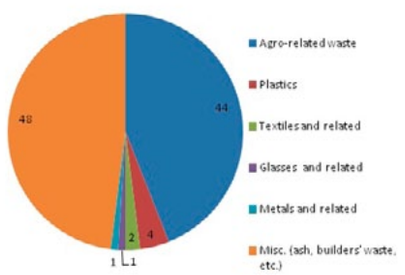


*Figure 2: Composition of waste (per cent) by dry weight in Kumasi, Ghana (Source: Mensah 2010)*

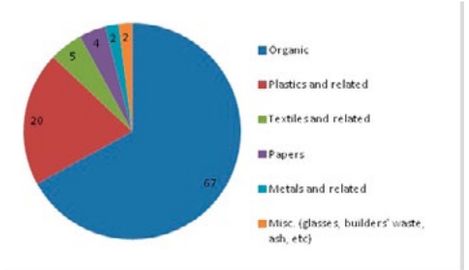


*Figure 3: Composition of waste (per cent) by dry weight in Accra, Ghana (Source: Alhassan et al. 2011)*

**Waste management system**

*Collection and handling*

Three waste collection and handling methods can be identified, namely community waste collection, "fly-away" waste and organized waste collection. The community waste collection is a common practice in low income but high-density areas within the city where accessibility is a challenge and residents are unwilling to pay for waste collection. As shown in Plate 1, an undeveloped piece of land of the surrounding bush is used in dumping of the garbage. The dumpsite is managed by unskilled workers assigned by the assembly operative of the local area. His main duty is to spread the waste and to ensure the heap is level with periodic burning of the combustible materials to reduce the quantity. The polluter pay system is employed. He gets stipend or allowance for the job from what the polluters pay. Visitors appreciating his work also drop money at the site for him. This has been the old practice but not sustainable due to the complex nature of waste and related health implications.

In the "fly-away" method, people package the garbage in polythene packets or damaged containers and do not take the waste to any designated collection point. They dump the packet in the street or open plots and wind scatters it throughout the large surrounding areas. Some people drop or empty the packet into open drains in the night and/or during rainfall where it is transported by the force of flowing water, contaminating the water bodies and, in some cases, deposited into the rivers or elsewhere in the city (as in Plate 2 and 3). Some local flooding could be attributed to solid waste that blocks drainage systems and gutters in Accra. In the organized waste collection, the Municipal Governments engage the services of private waste management companies, namely Zoomlion Waste Management Company, Ako Waste Management Limited, Gee Waste Limited and Daben Construction Service Limited to collect and transport the waste to the landfill or open dump fields. At the site, the wastes are indiscriminately dumped without proper management. It is common to see waste materials from the dumpsite blown by high velocity wind and scattered in the surrounding communities or neighbourhoods aside from offensive odour. Additionally, smoke from fire set to the heap of waste clouds the dumpsite site and surrounding atmosphere. Rushbrook and Pugh (1999) reported that one of the characteristics of improper management is when wind is able to carry waste materials away from a dumpsite. Scavengers are readily seen at the site where they spread the waste heaps, sorting and picking out waste materials that can be recycled.

*Transportation of waste*

There are several ways of transporting waste both from households to collection points and from the collection points to landfill sites. Waste movement from households range from head portal with various containers, pans, old buckets, baskets, especially locally produced containers. Assisted collection is done through bicycle, tricycle with carriage, mammy truck and heavy-duty truck. Both the tricycle and heavy-duty truck are used in the collection and transportation to dumpsites. Use of tricycle in waste collection has been introduced by the Zoomlion Ghana Limited to provide effective collection of waste where vehicles cannot access. The tricycle (as in Plate 5) is constructed with a container at the rear for hauling the garbage. The tricycle collects the waste and moves it to a designated temporary collection point where it is then transferred into a vehicle for onward transportation to the dumpsite.

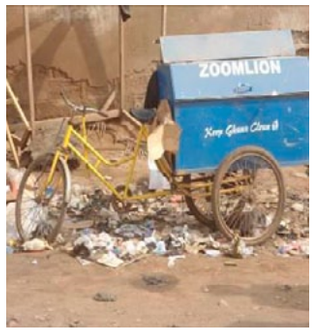


*Plate 5. Tricycle used to cart waste to temporary collection points. (Source: Authors' photograph (2013)*

*Disposal of solid waste and dumpsite management*

The Institute for Environmental and Sanitation Studies (IESS) (2012) reported increased levels of domestic waste production and inability to maintain the environment through proper waste management as one of the threats to massive economic growth in Ghana. The situation has not changed to date. Presently the non-engineered landfill method of waste management is in place. The disposal sites in the two cities are open dumping fields as in Plates 6 and 7.

The site receives mixed waste of both hazardous and non-hazardous materials every day including degradable, non-degradable and e-waste. There is neither pre nor post-waste treatment both at off and on-sites. The open dump field is accessible to animals and scavengers (Plate 8). The Institute for Environment and Sanitation Studies (2012) further identified some negative environmental impacts this system has caused to include: soil contamination, the production and leakage of toxic substance (leachate) that contaminates adjoining soil and water bodies like rivers, households' wells and underground water as well as the air (Plate 9), production of gas (mostly methane and carbon dioxide) with potential greenhouse effects, harbouring of disease vectors, offensive odour and pollution of the road from vehicles transporting waste to and from the dumpsites, which degrades the visual aesthetic of the cities.

*Plate 6. Community waste collection spot (Source: Authors' photograph - 2013)*

*Plate 7. Dump site with mixed waste (Source: Authors' photograph - 2013)*

*Plate 8. Scavengers sorting and packaging plastics from dump site for resale. (Source: Authors' photograph - 2013)*

*Plate 9. Leachate from Mallam disposal site entering houses. (Source: TISWM - 2011)*

**Potential for adapting a water-soil-waste nexus approach in Ghana and the challenges**

Waste management system and strategies are generally classified as "strongest", "strong", "modest", "weaker" or "weak" using the Yale University Environmental Performance Index (EPI). Waste management in Ghana in 2012 was ranked as "weaker", scoring 47.5 per cent and placing 91st out of 132 countries benchmarked (Propel Steps 2013). The World Bank (2013) reported that Ghana's poor waste management practice was the primary reason for its low ranking even in 2010. The World bank further reports that population growth and poor waste management have resulted in large waste build ups and illegal sea dumping across Ghana. Municipal solid waste management in the country was ranked among the top causative agent of health challenges and environmental degradation in Africa (Achankeng 2003). According to the researchers report, 20 – 50 per cent of the budget of African cities goes to waste collection with only 20 - 80 per cent collected. Whether uncollected or collected but deposited in open and un-engineered dumpsite sites, waste contributes to land and water degradation. In addition to health challenges and environmental challenges is the emission of poisonous and greenhouse gases (GHG). Globally, Hoornweg and Bhada-Tata (2012) projected a 70 per cent increase in urban solid waste, with developing countries facing the greatest challenges because of rapid urbanization. Their report further projected an increase in annual budget for solid waste management from the current $205 - $375 billion by 2015 given the increase in waste generation from 1.3 billion tonnes to 2.2 billion tonnes per year by the same period. In Ghana, waste and environmental sanitation will for some time pose serious health, development and environmental challenge to the country. Presently, the Agbogloshie slum in the Oduw basin in Accra, Ghana is a "multiwaste" dumpsite site ranked in 2013 among the seven most polluted sites in the world (Blacksmith Institute 2013). Some e-waste is recycled at the site but with crude methods and in an unprotected manner. This could contribute positively to GDP if organized and properly moderated.

In May 2012, Ghana, Nigeria, Cote d' Ivoire and Senegal assembled waste management professionals from these four countries in Ghana to answer the question 'how can West Africa improve solid waste management sustainably?'. According to Africanrealty (2012), the gathering recommended 'collection', 'transfer', and 'disposal' or 'treatment' giving weight to 'reuse', 'recycling' and 'composting'. This recommendation is usual and traditional; it does not link waste or consider waste management as influencing other environmental resources. In Ghana, the solid waste management challenge can be linked to poor quality water and sanitation associated with poor city waste management, placing burden on the health of citizens and reducing productive man-hour.

The present waste management system in Ghana could be described as poor. The processing and management of waste at the dumpsites to minimize the consequences on humans and the environment is near absent. Where waste management is poor or below acceptable standards, risk is posed to humans, animals and the environment (eSchool 2013). Poor waste management could be linked to soil, water and air contamination, greenhouse gas (GHG) emissions and leakage and wastage of clean energy as presented in Fig. 4. According to Hoonrnweg and Bhada-Tata (2012), waste poorly managed on the one hand, has an enormous negative impact on health, local and global environment and economy. On the other hand, the cost of damage downstream will be higher than what it would have cost to manage the waste properly in the first place. The traditional method of waste management ignores the linkage between waste materials and other environmental capital such as land and water. Schwaerzel, Huelsmann and Ardakanian (2013) discredit this traditional approach citing the interconnectedness of environmental resources, such as the use, management or alterations to one environmental resource as having an impact on other resources.

A holistic waste management system is the adoption of the water-soil-waste nexus approach canvassed and placed on the table by the United Nations University Institute for Integrated Management of Material Fluxes and of Resources (UNU-FLORES). It is a green growth strategy that treats waste as an economic and environmental resource for green and clean energy, greenhouse gas (GHGs) mitigation (carbon sequestration), public health and sanitation (socially inclusive growth) and environmental sustainability. This holistic management approach is aimed at keeping material resources (fluxes) within the system and prevents leakage of the flux (energy, leachate, nutrients, etc.).

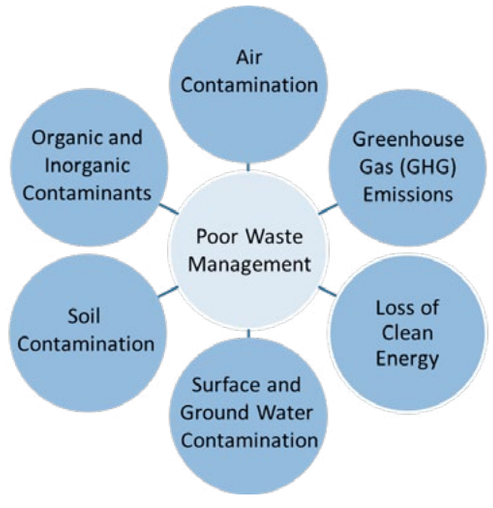


*Figure 4. Inter-linkage of water-soil-waste*



The water-soil-waste nexus approach, if used appropriately, can help preserve non-renewable resources, save energy (below [carbon sequestration] and above ground [clean energy]). In addition, it can generate employment and revenue, protect human and environment health and reduce greenhouse (GHG) emissions. Some of the advantages mentioned above for the nexus approach had earlier been pointed out by Metro Vancouver (2010). This could be another entry window for Ghana to enter into Green Economy. The energy and waste sectors have been identified as major contributors to GHG emissions in Ghana. Although the adoption of such a pathway has high initial cost implications, it is economically, socially and environmentally sustainable in the long-term. In addition to city sanitation and the health and well-being of citizens, the nexus approach inherently mitigates climate change and energy security (clean energy). Ghana is energy unsecured (Modern Ghana 2012), whereas the waste that 20 -50 per cent of Municipal council's budget go into its management is an untapped clean, safe, adequate, reliable and sustainable source of energy waiting processing and utilization. Adapting the water-soil-waste nexus approach is critical considering that demographic pressure, urbanization and climate will have significant impact on the availability and use of environmental resources such as energy, water and land. Already these factors are taking their toll in Accra, Kumasi and other urban centres in Ghana, with major impact on the environment and its resources including soil, water and air, as well as human (health) and the nation's health budget. In Ghana, this nexus approach will be corrective of the past approaches and curative of the present and future challenges and thus should be seen as a green growth pathway and boon for the sustainable management of water, soil and waste.

In applying the nexus concept, the following consequences will have to be addressed and dealt with:

- Attitudinal change: call for a change in mind-set is relevant and fitting. For instance, a study to assess the Accra residents' willingness to separate waste at source gave 10 per cent for "Yes", 5 per cent for "No" and 85 per cent for "No Response" (Alhassan et al. 2012). Public education and promotion of public awareness on the water-soil-waste nexus need to be circulated using all media outlets for communication including social media and gsm mobile short messages. Communication through religious worship temples and houses could be a veritable effective medium in Ghana situation as well.
- Waste governance and envisage conflict: when waste becomes an economic resource rather than a "waste", why will the generators of waste pay for waste (money) to be collected?
- Policy and institutional regulation: The journey to adopting a nexus approach in Ghana will involve the government, private sector, non-profit sector and residents. It will require the government deciding between the current practice of waste management (face a more damaging future) or devising means to sustainably manage waste (adapting water-soil-waste nexus approach) as an economic resource (assures jobs, clean environment and enhancement of ecosystem services, provision of clean energy and economic returns). The government will need to draw-up, invest in and follow an ambitious road map to a water-soil-waste nexus approach in order to avert future calamity and work into becoming a sustainable future city. This will involve an adequate regulatory framework, policy and strong institutions to manage and regulate the transition and guide the pathway.
- Technological capacity and Public Private Partnerships (PPPs): technological capacity will be a critical factor and one of the major gaps. The PPPs could fill this gap given the right political climate, government policy and legislation.

- Knowledge capacity: the water-soil-waste nexus approach is innovative and will be driven by scientific knowledge. This will require new mind-sets, curriculum, training, re-training and knowledge upgrading. The knowledge and capacities of Government officials, members of parliament, the press and other stakeholders will also need to be re-tuned in the new direction or approach.

- Bernhofer and Leidel (2013) consider the lack of skilled manpower as a major challenge in establishing the nexus approach of water, soil and waste. This is equally true for Ghana even as the traditional waste management system still faces dearth of skill manpower.

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## 8.3 Towards Nexus Approach: Concepts and Tools for Integrated Management

### 8.3.1 Connecting People with the Nexus: Engaging Stakeholders in Sustainable Management of Water-Soil-Waste

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**Abstract**

The multiple crises' of the world compels us to seek holistic approaches towards a profound transformation towards sustainability. The nexus approach needs to be analysed and assessed on its ability to either provide such profound transformations or significantly contribute to it in a holistic manner. If its potentials can be substantiated, then the investigation needs to go further into analysing the objectives and strategies of a nexus approach. This paper questions if the nexus approach to sustainable resource management is another strategy to continue with the prevalent growth based development model. Widely being associated with the climate change discussion, the paper also seeks to understand if the nexus approach is promoting a climate compatible development model and seeks to find out if it can go beyond and support a radical ecological democracy approach. The paper then presents a few scenarios to ascertain if the nexus approach is an inclusive governance model for sustainable resources management. Different scenarios in a water-soil-waste nexus are thus visualised in their mirrors to a governance nexus. A preliminary mapping of different stakeholders is presented to demonstrate the larger interest that a nexus approach needs to consider. The objective of this paper is to raise concerns that can pave the way towards greater comprehension on the nexus approach as a strategic approach to an inclusive transition to sustainability.

**Is the nexus approach meant for profound transformations towards sustainability?**

'Nexus' is not a new concept. Oxford Dictionaries define a nexus as a connection or series of connections linking two or more things. However, the more recent focus on developing a nexus approach to resource management (Hoff 2011) may generate different interpretations and raise many questions worth of a study. Pondering deeper into the concept leads us to realizing that there is no common understanding of a nexus approach to sustainable resource management; or at least there are divergent views on a nexus approach.

During the past decades we have seen numerous approaches proposed to alter or modify the prevalent development model. Approaches such as decoupling environment from economic growth, efficiency as a means of productivity, green growth strategies, green economy drives, etc. have all been viewed by critiques as attempts to continue with the growth based development model. One wonders if the current interest in promoting the nexus approach is another such attempt towards maintaining the growth based development model.

De Zoysa, Vasishth and Ruskin (2012) stated "It is clear that humanity, embedded within our planetary system, is approaching a level of self-awareness and of consciousness that might well permit our global, regional and local democratic institutions to reflect, for the first time, the conditions necessary for an honest occupation of the twenty-first century. As our civilization enters this new planetary phase, we become increasingly aware that we face unprecedented threats and challenges. But our growing awareness of our surging interdependencies makes possible as well the radical transformations toward a shared destiny. We recognize that a failure on our part to close the ominous gap between the requirements and challenges imposed by this new phase in our "full world" planetary development, and our abilities to evolve beyond

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the constraints imposed by entirely obsolete ways of thinking can, at the very least, prove catastrophic to our planetary system. This calls for a Sustainability Transition, one that envisions a profound and historical transformation in the world-views and values that shape the organizing principles of human society. These necessarily new ways of thinking, and the urgently needed transformation in our values, attitudes and beliefs, must emphasize human solidarity, affinity with nature, and a dramatic re-emphasis on the idea of a decent quality-of-life for all."

The validity of a Nexus approach must thus rest in its ability to provide profound transformations towards sustainability. Figure 1.1 proposes that a nexus approach to sustainability should have convergence between environmental sustainability, social equity and economic prosperity.

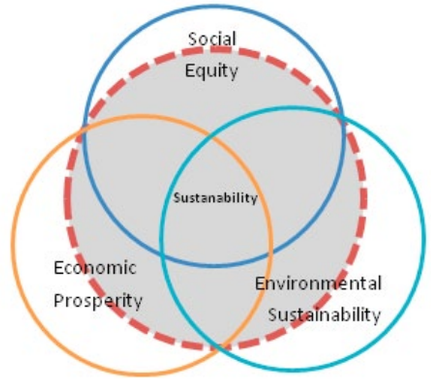



*Figure 1.1: A Nexus Approach to Sustainability*

**Is the nexus approach another attempt to maintain the growth based development model?**

The prevalent growth based development model has not only failed to lift a large section of humanity above unacceptable levels of poverty, but has also greatly increased the inequities between the wealthy and the poor and has led to ecological unsustainability and climate change. It is fundamentally flawed in that it is predatory of both nature and people, ecologically unsustainable, and socio-economically inequitable.

The prevalent development model continues to deconstruct the interrelated nature of global issues, delink interdependencies of the natural environment, marginalise actors and stakeholders from governance, and then tries to find alternative ways of presenting justifications through subsystems of integrated management tools.

The Nexus approach now being proposed to be linked with the efforts towards a transformation agenda raises more fundamental questions.

1. Can the nexus provide a holistic approach to a sustainability transition or is it attempting to address few components of the global challenge?
2. Is the nexus approach seeking correlation between the different subject issues or convergence between broader dimensions of global issues?
3. Is the nexus taking a project based strategic approach to resource management or a systems thinking approach?
4. Is the nexus approach different to or an extension of decoupling (economic growth from social and ecological aspects, see below) ?
5. Is the nexus approach a continuation of resource efficiency or can it also seek alignment with a conceptual framework of sufficiency?

Approaches such as decoupling environment and economic growth or efficiency approaches towards increasing productivity and reducing waste are attempts within the same paradigm that promotes a growth based development model. The International Resource Panel of UNEP (2011a) says resource decoupling means reducing the rate of use of resources per unit of economic activity. Relative decoupling of resources or impacts means that the growth rate of the resources used or environmental impacts is lower than the economic growth rate, so that resource productivity is rising. Absolute reductions of resource use are a consequence of decoupling when the growth rate of resource productivity exceeds the growth rate of the economy.

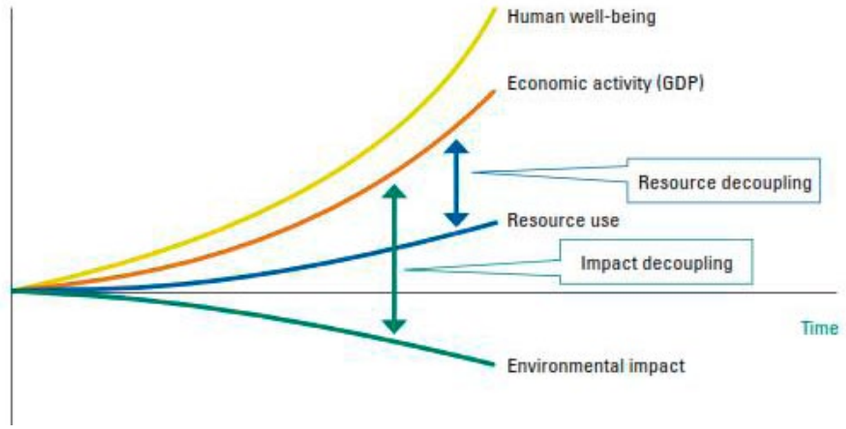



*Figure 2.1: Two aspects of decoupling (source: UNEP 2011b)*

Approaches to decouple environment from economic growth appear to be based on several assumptions (see figure 2.1). Firstly it assumes that economic growth, measured by GDP, will increase human wellbeing. Secondly it assumes that efficiency will decouple resource consumption from economic growth. However, there is no evidence to show that decoupling approaches consider distributive growth for equitable consumption; hence, by the virtue of reducing the impact on the environment it assumes that wellbeing would rise along with growth. By ignoring the principle of prosperity of all and the necessity of inclusive or distributed growth, the approach of decoupling may fall short of ensuring actual wellbeing meant to be for all societies and individuals within the planet.

The comprehension of a Nexus approach needs to be examined in the background of past approaches of particularly Western science and management thinking against more philosophical ideology for holistic existence. Figure 2.2 raises questions if the nexus may be another modification strategy to continue with the prevalent economic development model.

In the Peoples' Sustainability Treaties (2012) it is argued that, at the root of the flaws in the current economic development model lies an implicit, dominant theory of single-minded economic purpose: namely to achieve continuous economic growth, as measured principally by GDP, by relying on "free markets" without strong enough instruments to deal with their negative impact on human and ecological well-being. Similarly, the current discourse on the Green Economy runs the risk of being little more than an effort to "green-wash" the existing "brown" economy. It is imperative that this be avoided! The ancillary goals of poverty alleviation and sustainable human and ecological development should, instead, be brought front and centre, and the notion of a "green economy" should be recast into a robust mechanism for attaining a multiplicity of development goals.

Proposing that we are at a turning point in history, the New Economics Institute (2013) says rising temperatures are now recognized as a sign of our planet in crisis and inequities between rich and poor,



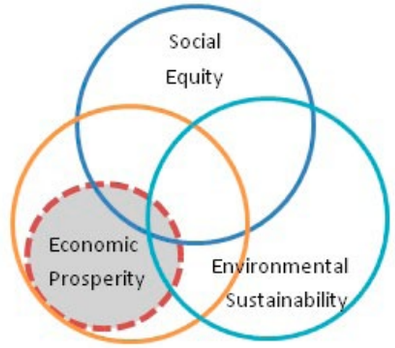



*Figure 2.2: A Nexus Approach within the prevalent Growth based Development Model*

North and South, grow ever deeper. The global economy has failed in its promise to produce and deliver basic goods in an efficient manner for an expanding population, leaving increasing numbers in abject poverty. The environmental crisis, the equity crisis, and the crisis of distributed production all have their roots in the current economic system, with implications for our culture, for our society, and for our health and well-being.

The prevalent economic model obviously needs radical rethinking in a transformation towards sustainability. Schumacher (1973) in his acclaimed thesis 'Small is Beautiful: Economics as if People Mattered' says the conventional wisdom of what is now taught as economics bypasses the poor, the very poor people for whom development is really needed. The economics of gigantism and automation is a leftover of nineteenth-century conditions and nineteenth-century thinking and it is totally incapable of solving any of the real problems of today. An entirely new system of thought is needed, a system based on attention to people, and not primarily attention to goods—(the goods will look after themselves!). It could be summed up in the phrase, "production by the masses", rather than mass production.

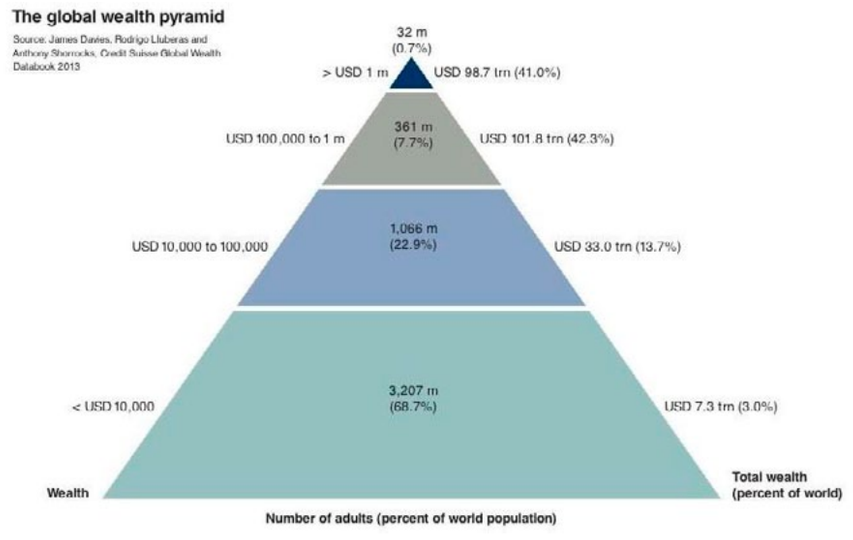



*Figure 2.3: The Global Wealth Pyramid*

Income inequity is a key factor leading to poverty and the growth based development model has not been able to ensure equity on earth. Credit Suisse (2013) has created a chart (see Figure 2.3) that shows how the wealth of the world's population is divided. 32 million people – a mass slightly larger than that of the Benelux or 0.7% of the world – have a total of 41% of all wealth on earth, or $98.700 billion in the hands. Based on the same graph 3.2 billion people – 68.7% of the world's adult people, 3% of global wealth possess or $7.300 billion. Credit Suisse also predicts that the global wealth the next five years will increase by 40% to $334.000 billion in 2018.

**Should the nexus thinking compliment climate compatible development or ecological democracy?**

The nexus approach is also widely being associated with climate compatible development. Dupar and Oates (2012) argue that 'nexus' thinking should be a complement to, but not a substitute for, climate compatible development. Climate compatible development integrates mitigation, adaptation and development approaches to maximise the benefits across all three areas. As an overall framework, climate compatible development is also high level, and needs some unpacking to guide real-life decision-making, particularly when it comes to distinguishing between integrated planning and actual (integrated) outcomes. As with 'nexus' thinking, climate compatible development approaches also need to evolve so that they can consider inter-temporal trade-offs.

However, some will argue that the approach of climate compatible development is yet rather limited in relation to the aspirations for a profound global transformation. Kothari (2009) argues that moving towards sustainable and equitable alternatives is not only about recycling and reuse, clean technologies and waste reduction but also about fundamental changes in the way we relate to nature and to each other. It requires a radical form of democracy in which each citizen has a responsible say in decision-making that is very different from current representative forms of democracy in which we vote once in five years and leave all decisions to those who come to power. There is nothing new in this concept; it has been advocated by many. But, this is not enough; it also requires that each citizen is aware of, and responsible towards, the needs of ecological sustainability, including the survival of non-human nature. Such a radical ecological democracy (RED) would consist of a number of political, economic, and social arrangements.

Kothari (2009) presents two fundamental principles that underlie the search for alternatives:

- First, ecological sustainability: Since every credible knowledge system, traditional and modern, is pointing to the fact that humanity is already well past the ecological limits of the earth, one clear principle for any alternative vision has to be ecological sustainability. This term has no easy or crystal-clear definition, especially since the term 'sustainability' is fraught with myriad interpretations. However, to put things simply, by this term I mean the continuing integrity of the ecosystems and ecological functions on which all life depends (including all hydrological, chemical, and physical processes that give us the air, water, and soil without which we cannot live). It also encompasses the continuation of biological diversity as the fulcrum of life, ensuring the security of species from human-caused extinction.

- Second, social equity: Given that one of the biggest failures of economic globalization and 'development' is in ensuring that all humans have the basics of life and are secured against deprivation of any kind, the second clear principle of any alternative vision is social equity. As in the case of ecological sustainability, this term is not possible to define in clear-cut terms. It encompasses a mix of features: equality of opportunity, full access to decision-making forums for all, equity in the distribution and enjoyment of the benefits of human endeavour (across class, caste, age, gender, and other divisions) and cultural security.



**Scenarios for Governance of a Water-Soil-Waste Nexus: The Stakeholder Mirror**

If in general a nexus approach is about sustainable management of natural resources, then a nexus approach to water, soil and waste would necessarily need to be presented with a solid justification. Compared to water and soil, waste is a different matter. There are different schools of thought on waste; while some would see waste as resources in circular economic development others argue for zero waste lifestyle approaches to prosperity. Can the nexus approach find convergence between these divergent approaches to waste management?

Braungart and McDonough, which developed the revolutionary philosophy called Cradele to Cradle, argue in favour of a completely new premise for the design and development of products based on safe and fully reusable raw materials (Cradle to Cradle 2013). Waste can become food in an endless loop. They raise three basic questions to ask to discover whether a product has been developed according to the cradle to cradle design concept; (a) Can it be eaten? (b) Is it biodegradable or can it be recycled without losing quality? (c) Can it be burnt to generate energy?

Cradle to cradle design approach argues that;

- If every consumer poses these questions when buying a product, industry will have to come up with a solution to satisfy market demand.
- If every designer poses these questions before designing a product, the trend will be set for a future full of clean, sustainable products.
- If every manufacturer ensures that their products meet these conditions, they will meet the criteria for Cradle to Cradle certification.

Is the nexus approach then considering waste as food or resources and does it attempt to zero the waste? More importantly how can the nexus approach engage all the people and stakeholders in a water, soil and waste nexus governance system? As shown in figure 4.1 a governance of water-soil-waste nexus is mirrored with similar linkages between government-people-business. The balance between the different elements is critically important in managing the nexus.

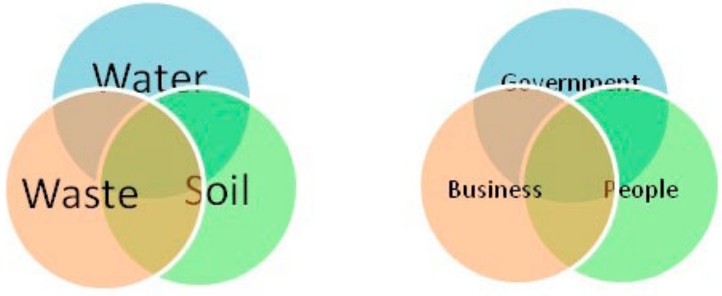



*Figure.4.1: Water-Soil-Waste Governance Nexus: Stakeholder Engagement Mirror*

The high production of waste, as shown in figure 4.2, will upset the balance of nature. Similarly, when the governance lean more towards favouring a business centred development, an imbalance in managing natural resources is most likely to take place. Controlling the business domination in governance systems, as in the dominant development model, would be critical for a nexus approach to succeed.

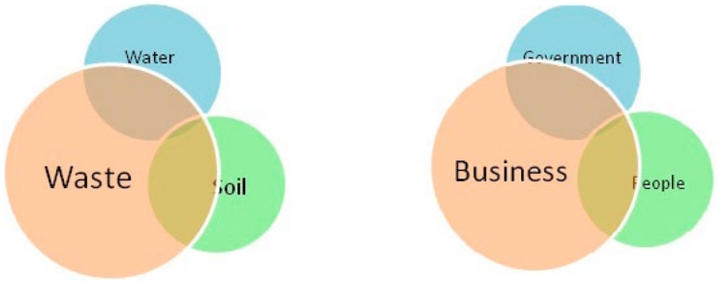
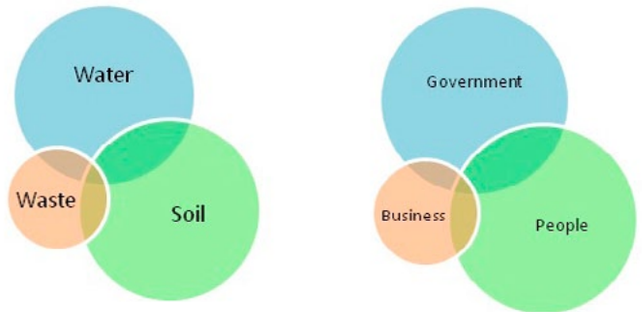



*Figure 4.2: Water-Soil-Waste Governance Nexus: Waste-Business High Influence*

The role of business, when economic profit takes central focus, in a nexus approach to resource management can be viewed from different viewpoints. Those advocating for zero growth or prosperity without growth could argue for limiting the impact of business on natural resources. Figure 4.3 would tend to present a picture that supports such arguments.




-*Figure 4.3: Water-Soil-Waste Governance Nexus: Waste-Business Low Influence*

A rights based approach would argue that proponents of modifying the current development model are a continued effort to limit the role of people or marginalise them from their own resources. Figure 4.5 would imply that despite growth through such initiatives, wellbeing of people would be very low and sustainability would be a remote possibility.

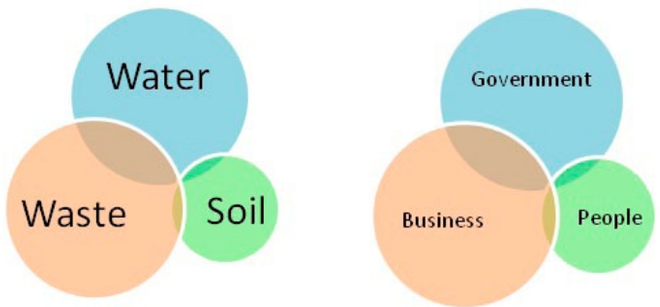



*Figure 4.5: Water-Soil-Waste Governance Nexus: Low Peoples Engagement*



Many struggles for the rights of indigenous people and marginalized local communities provide strong cases of governance or management that decouples people from their natural resources. The scenario in figure 4.6 has justification in a world order with its enormous wealth and growth continues to hold half of its population in poverty. Persistent poverty is a reality where people have been decoupled from their own resources!

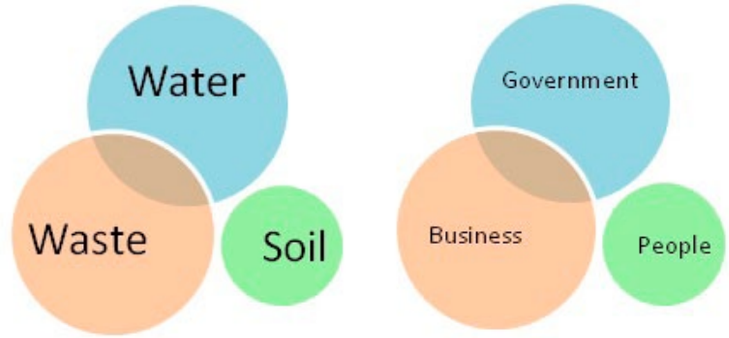



*Figure 4.6: Water-Soil-Waste Governance Nexus: Decoupling People*

**Can the Nexus engage the people in a transition to sustainability?**

De Zoysa (2009) states; "Climate change is a destiny determining phenomenon and all people need to be aware of their rights and responsibilities. But, half of the world's population remains under poverty and is being deprived of their rights towards the basic human needs. Meanwhile, the wasteful lifestyles and irresponsible behaviour of the rich and powerful continues to endanger the life of all humans on earth. A small privileged group continues to negotiate for a climate deal and they separately talk about the sustainability of the planet. By marginalising rest of the population in determining their own destinies, they have left us in destitution. A new world order is emerging, but the people are not involved in designing of it as well. A better world order needs to be created upon the mindful aspirations of the people; and should essentially be based on equitable opportunities for all to find peace, prosperity, sustainability, wellbeing and happiness."

A transformation to sustainability requires the building of new visions and scenarios. Raskin et al. (2002) in their thesis for a 'Great Transition: The Promise and Lure of the Times Ahead' argues that a transitions approach to a sustainable civilization builds on the wealth-generating features of market forces and the technological change of policy reform, but it transcends them by recognizing that market-led adaptations and government-led policy adjustments are not enough. Great transitions adds a third ingredient; a values-led shift toward an alternative global vision. Powerful additional opportunities for mending the global environment and forging more harmonious social conditions would then open. The new development paradigm would include lifestyle changes and greater social solidarity.

The nexus approach certainly needs to respond to multiple questions to qualify as strategy that can transition us to sustainability. Can a nexus approach provide practical solutions to the worlds multiple crises' and enable climate sustainability? Can a nexus approach go beyond linking a few selected aspects and try to be more holistic? Can a nexus approach engage all relevant stakeholders effectively to ensure that the outcomes are inclusive?

In the overarching goal of a global transformation, navigating a nexus approach to the sustainable management of water, soil and waste will require a dynamic engagement of the different stakeholders. Figure 5.1 is a preliminary attempt to study such a stakeholder inter-linkages model for a water-soil-waste nexus.

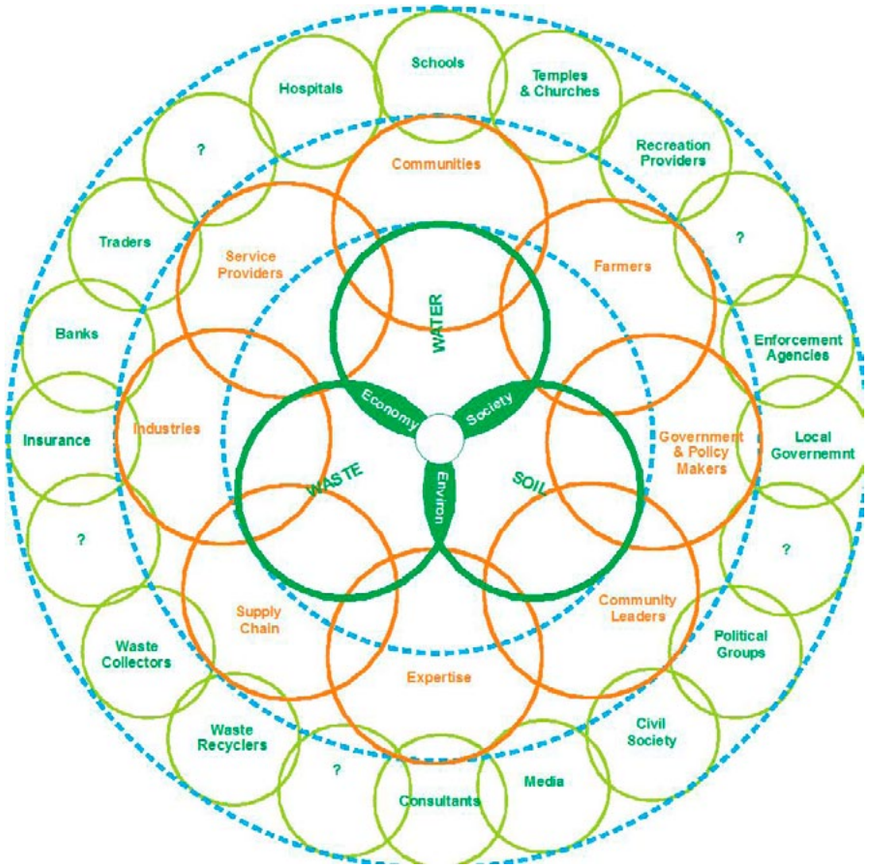



*Figure 5.1: Mapping of a Stakeholder Inter-Linkages Model for a Water-Soil-Waste Nexus*

**Conclusions and way forward**

A nexus approach to the sustainable management of water, soil and waste needs to be further analyzed in its potential contributions to a profound global transformation. The linkages between the sustainable management of water, soil and waste should be able to relate to the broader nexus between social equity, environmental sustainability and economic prosperity. As the current international programmes seeking to evolve a post 2015 agenda and sustainable development goals (SDGs), the nexus initiatives could provide strategic pathways towards finding a convergent outcome between the two processes. The efforts of a nexus approach should endeavour to create greater inclusive processes of resource governance towards sustainability. Therefore the nexus must connect the people, all stakeholders, effectively and adequately to ensure that sustainability initiatives are inclusive and equitable.

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## 8.3.2 Towards a Nexus Approach to Land, Water and Waste Treatment: Economic and Methodological Aspects

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**Abstract**

The management of land, wastewater and waste air was seldom conducted in recognition of the nexus between water, energy, waste and the food sector. Soil and land degradation are becoming critical problems around the world. Assessing the economics of land degradation using the "Total Economic Value Framework" in a nexus approach was suggested. Such a comprehensive analysis should guide and result in a holistic policy action to address land degradation. Among the methodological aspects addressed in this paper is the need for a comprehensive assessment of the energy consumption of conventional wastewater treatment systems in order to encourage and facilitate the shift to green technologies such as low-energy-demand natural systems, focusing on constructed wetlands (CWs). The sustainable management of wastewater is directly linked with the food sector, as it embodies the reuse and recovery of resources, such as the water itself and the nutrients it contains, which can then be recycled in agricultural fields for food production. The use of urine as agricultural fertilizer is highlighted, as well as the associated risks. Finally, considering that a holistic waste management methodology should take into account air quality monitoring and control techniques, biofiltration for the treatment of waste gases is featured. Additionally, the potential of its implementation in several African and the Caribbean countries is assessed. The launch of future research projects on biofiltration, aiming at assuring better life quality in these regions, is recommended.

The case studies briefly introduced here show that advancing a nexus approach to water, soil and waste management relies also on new and advanced technologies, some of which are highlighted, facilitating integrated and sustainable management. It also relies on a solid conceptual economic framework for implementation.

**Introduction**

While human population continues growing, the demand on natural resources is increasing significantly, risking the continuance of ecological systems and even the existence of all living species on earth. Thus the challenge we are facing today is how to ensure economic development, supply enough resources and achieve environmental sustainability. We need to finally recognize the environment as an entity where natural resources are interconnected and thus search for integrative management solutions.

The meaning of the NEXUS concept, initially proposed at the "Bonn 2011 conference: The Water, Energy and Food Security Nexus, Solutions for the Green Economy" refers to the necessity of a global linkage among researchers and decision makers to assure a sustainable and interconnected management of natural resources, and implement their integrated management approach, while also supporting governmental protection strategies (Hoff 2011).

The Nexus approach represents a platform for synergies across sectors, reducing negative economic, social and environmental externalities while increasing overall resource use efficiency, providing additional benefits and securing human health and well-being.

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Integrative and sustainable management of water, soil and waste are essential to maintain different natural processes and to secure food supply. Mismanagement of land and soil potentially decreases the quality and availability of water resources. Integration of the waste sector to the NEXUS approach provides an opportunity to enhance the use-efficiency of natural resources, recycle the co-products, and closes the carbon cycle as well as of plant nutrients (N, P, S, K) and water. As said by Rattan Lal in the White Book (Hülsmann and Ardakanian 2014): "Nature does not recognize waste but products after system processes".

Under this framework, the following paper provides an overview of a nexus approach for assessing land degradation effects and externalities, and proposes other options aiming at sustainable land and water management, such alternative low-energy demand technologies as constructed wetlands for wastewater treatment, recycling of human excreta as fertilizer and soil amendment, and use of bio-filters for managing odors and volatile organic compounds. These alternative technologies have been demonstrated to have a great potential on reducing environmental impacts, while assisting in food production, improving environmental and human health and increasing quality life standards. Therefore this paper is aimed to provide technical insights that can guide decision makers and researchers when building bonds in these areas.

**Economics of Land Degradation: a Nexus Approach**

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Land ecosystems provide a wide variety of services essential for human livelihoods. These ecosystem services are usually categorized into four groups: i) supporting services (e.g. nutrient cycling), ii) regulating services (e.g. climate regulation), iii) provisioning services (e.g. food), and iv) cultural services (e.g. recreation) (Millennium Ecosystem Assessment 2005, Nkonya et al. 2011). However, many of these services are not priced in markets, leading to their undervaluation and eventual degradation (von Braun et al. 2013). This has already led to land degradation on about a quarter of the global land area, negatively affecting the food security and the livelihoods of often already very poor and marginalized populations around the world (ibid.).

Causes of land degradation are highly complex and also strongly related to soil and water management, food and energy security, thus necessitating trans-disciplinary Nexus approaches for their solutions. In general, the consequences of land degradation have significant spillover effects and externalities on all spheres of economic and social life. The Economics of Land Degradation (ELD) seeks to provide an evidence based decision framework for policy actions and investments to address land degradation. The key feature of this framework is that it seeks to follow trans-disciplinary research approaches and thus, fully accounts for the direct and indirect effects of these actions. The ELD conceptual framework, developed by Nkonya et al. (2011), is presented in Figure 1. It can serve to conceptualize the Nexus approach for conducting economic research to address land degradation.

The framework considers two types of causes for land degradation: 1) proximate and 2) underlying. Proximate causes are biophysical, such as topography or climate-related, and unsustainable land management practices (Nkonya et al. 2011). The underlying causes, on the other hand, are those reasons why land is managed unsustainably (ibid.), such as insecure land tenure, population density, poverty, lack of market access, etc. The interactions between these drivers are extremely complex, leading to context-specific effects, and requiring holistic inter-disciplinary methods for their analysis (von Braun et al. 2013). The drivers of land degradation lead to differing levels of land degradation, with negative outcomes on provision of ecosystem services, human and social wellbeing, and overall economy. This requires action to address land degradation. However, the action should be based on rigorous evidence. The Nexus approach suggests three fields for action: society, economy and environment, which correspond to the three dimensions of land degradation outcomes indicted in Figure 1.

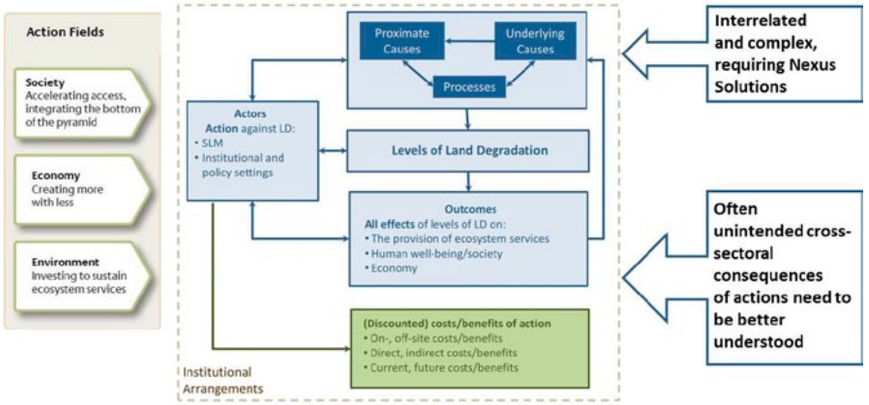


*Figure1. The Conceptual Framework for Economics of Land Degradation using a Nexus Approach; Source: modified from Nkonya et al. (2011) and Hoff (2011)*

All three action areas should take into account not only on-site but also off-site costs and benefits of action against land degradation. Moreover, in contrast to most previous economic assessments of land degradation, the ELD framework is based on Total Economic Value (TEV) framework (see Nkonya et al. 2011 for detailed description), which, in addition to direct costs of land degradation, also includes its indirect costs, i.e. the losses due to lower provision of terrestrial ecosystem services which are not traded in the markets, such as many regulating and supporting services. Another important dimension of the economic analysis of sustainable land management actions is their time aspect. It should include full accounting of current and future costs and benefits, which may necessitate making value judgments on the discount rates. The consequences of actions against land degradation are often unintended and should be better understood. The comprehensive analysis would identify institutional arrangements which promote or hinder action against land degradation, as well as the actors and key stakeholders who need to take action.

By taking on board not only market-based costs of land degradation, in terms of reduced crop yields, for example, but also the lost values of ecosystem services, negative off-site externalities, and also the time dimension of costs of land degradation, this approach can serve as a Nexus-based analytical framework to encourage sustainable and more holistic land management policy actions, which recognize and, in fact, make use of synergies among land, water, waste management, food and energy security for achieving multiple-win outcomes. The following sections of the paper provide some specific examples of such inter-connected Nexus solutions.

**Wastewater Management using Low-Energy-Demand Technologies: a Water-Energy Nexus**

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The Millennium Development Goals (MDGs), that all the member states of the United Nations have agreed to achieve by 2015, calls in goal No. 7c to reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation, and in target 7d to achieve significant improvement in the lives of slum dwellers.



Wastewater management is thus a basic development requirement, as its absence reflects directly on human health and productivity, as well as the aesthetic value of urban and rural settlements. Unfortunately, though it is a necessity rather than a luxury, it is not implemented in many places worldwide. According to the United Nations (UN-Water Factsheet on Sanitation 2013), about 35% of mankind has no access to improved sanitation, mainly due to extreme poverty or deteriorated economic conditions. Therefore, a first step towards achieving development, mainly in the growing urban centers, is the provision of sanitation, including the management of the produced wastewater either centralized or decentralized. It is only logical that high-tech and high-cost conventional wastewater treatment technologies are no solution in the foreseeable future for many parts of the world.

One of the most significant items in the running of conventional wastewater treatment technologies is the energy cost. Electricity costs are usually between 5% - 30% of the total operating costs of water and wastewater utilities around the world (IWA Water Wiki 2013). Providing this energy already poses a burden for the developed countries, while there is no sustainable access or no access at all to electric energy in some of the developing countries. This calls for a shift from conventional wastewater management technologies to green technologies that require low energy inputs as well as to involve the recycling of the energies (e.g. biogas) and other resources (e.g. water and nutrients from all waste streams).

One of the natural systems for the treatment and management of wastewater are constructed wetlands (CWs). These are engineered systems that are designed to use the natural processes of wetland vegetation, soil and the associated microbial consortia to treat various types of contaminated waters. It has been claimed that CWs are the least expensive systems to operate and maintain, mainly as a result of the use of renewable energies in CWs (e.g. sun, wind, soil, plants and animals). This implies minimum fossil fuel energy and chemical requirements towards achieving any targeted objectives of wastewater treatment (Kadlec and Wallace 2008). In this respect, these systems have an advantage over the conventional wastewater treatment systems (e.g. activated sludge systems); thus CWs may serve as an attractive alternative wherever an uninterrupted energy supply is limited or absent.

In addition, CWs are very flexible to be designed and operated at any scale, from one household to medium-sized settlements and up to bigger scales. Therefore, they are suitable to be used as a decentralized wastewater treatment alternative for scattered rural and small-scale settlements, to treat their wastewaters and thus decrease the final pollution loads to the receiving water bodies. By doing so, the integrity of these water bodies can be sustained and allow them to be available for other uses.

Furthermore, in places that face water scarcity problems, CWs can provide sufficient treatment of e.g. domestic wastewater, to a degree that complies with most standards for the reuse on irrigation. This involves the reuse of the treated wastewaters directly to irrigate crops, thus decreasing the pressure on the fresh water resources. Wastewater reuse has been implemented in some developing countries, for instance, Morocco, Tunisia, Egypt, Sudan, Namibia, India and China, for growing of vegetables, short-term crops and fish culture (Kivaisi 2001). According to Kivaisi (2001), CWs hold great potential for wastewater treatment for reuse purposes in these countries, though they are not sufficiently implemented. Since one of the most important aspects in the reuse of wastewater in food production is the pathogen and micro-pollutant contamination of the treated water, it is important to understand the degree and risks of such contamination. The limited research conducted so far suggests that CWs have high capacities to remove pathogens, however, findings were not conclusive (e.g. Weber and Legge 2008). Therefore it is very important to conduct more research on this field.

At present CWs are being used at medium- or big-scale in Europe (e.g. Czech Republic, Germany and France), North America (United States and Canada) and to a lesser extent in some developing countries for the treatment of wastewater from various contaminated domestic and industrial streams. Liu et al. (2008) reflected on the increased usage of CWs in China since the 90s, estimating these systems to be the primary technology for minimizing water shortages and pollution, and ultimately, attaining future sustainable development in China. Increased application of these systems in developing countries should be promoted. However, many research gaps remain.

Additional research following the philosophy of the nexus approach in the sectors of water, energy and food should focus on the following areas:

- A water-energy nexus approach: research is needed to elaborate on the differences of energy costs and energy requirements between conventional and natural wastewater management systems in both financial and economic cost terms. The future energy costs as well as the future energy availability may render it even more attractive to decision makers to adopt natural systems for wastewater management.
- In addition, research on the energy production and/or recovery from CWs is very limited. As an example, the plant material that is oftentimes harvested from the CWs at the end of growing seasons may serve as a biofuel input material. Optimization of energy recovery may also include the coupling of CWs with anaerobic technologies that recover biogas from wastewater and use it for the generation of electricity and thermal energy. In this way energy self-sufficiency or even a positive energy balance could be reached.
- Regarding the water-food nexus, extensive research needs to be conducted to evaluate the possibilities of reusing wastewaters from CWs for crop irrigation.

**Recycling of Resources from Wastewater: a Water-Food Nexus**
**Use of Human Urine as Fertilizer and the Potential Risks due to micropollutant residues**

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Ecological sanitation (ECOSAN) is a sanitation system that recognizes human excreta and household wastewater as a source of nutrients that can be recovered, treated if necessary and safely reused, for instance in agriculture. Human excreta have been used for crop fertilization for thousands of years in different countries. In Vietnam, the use of latrine waste as fertilizer is an old tradition (Jensen et al. 2008). Recycling of urine and faeces was introduced in the twelfth century in Japan, while in China fresh human and animal excreta have been applied to the field for thousands of years (Esrey et al. 1998).

Using human urine in agricultural fields is conceived nowadays as an alternative practice that is not only a great source of nutrients for plants and a soil amendment. It helps with reduction of fertilizer cost investment, excess use of chemical fertilizers, pollution effects from unsafe excreta disposal, and assists in protecting surface and groundwater resources. Furthermore, implementation of ecological sanitation facilities could be an alternative for the 2.5 billion people who still do not use an improved sanitation facility (WHO-UNICEF 2013).

From both feces and urine, a considerable amount of nutrients can be used. However, feces are considered much more difficult to handle hygienically and to have a greater risk for human health due to the higher pathogenic content. On the other side, urine has the highest proportion of nutrients directly available for plants, and though urine contributes less than 1% to domestic wastewater, it is responsible for about 80-90% of the nitrogen (N), 50-80% of the phosphorus (P) and 80-90% of the potassium (K) load to wastewaters (Vinnerås 2001).

Slowly, using human urine as a source of nutrients for crops has received more attention by researchers in the recent times. Several studies using urine as fertilizer, alone or supplemented with other nutrient sources (e.g. additional application of phosphorus, potassium, composted material, feces.) have demonstrated its efficiency in production of cucumber (Heinonen-Tanski et al. 2007), tomato (Pradhan et al. 2009), maize (Guzha et al. 2005; Mnkeni et al. 2008), sweet pepper (Shrestha et al. 2013) and sorghum (Germer et al. 2011) among other crops.

In general, the studies concluded that urine can perform as efficient as a mineral fertilizer or even better in some cases. Furthermore, as it is in liquid form it also improves the water supply to the crops, especially in areas where water access is scarce.



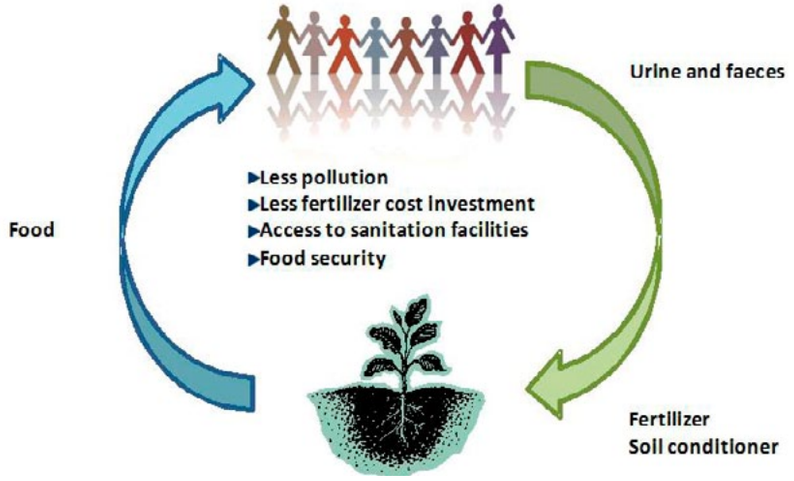


*Figure 2. The concept of Ecological Sanitation. Source: Modified from Rosemarin (2003).*

Despite all the advantages of using urine as fertilizer, this practice is commonly associated to health and environmental risks, as well as to socio-cultural issues. Urine as an excrete product can contain pathogenic microorganisms, heavy metals and metabolic residues of pharmaceuticals and hormones. Thus, accumulation of pathogens and micro-pollutants into the agricultural fields could result in a threat to human and animal health.

Schönning et al. (2002) has demonstrated that contamination with pathogens can occur in urine collected by means of diverting toilets due to a cross contamination from feces. On the other hand, Höglund et al. (2002) reported that in urine solution total coliforms, *E. coli* and clostridia were present in low concentrations while faecal streptococci were determined at concentrations up to 105/ml. However, most of the pathogens can be rapidly reduced due to the influence of temperature, low urine dilution rate and high pH. Vinerås et al. (2008) suggested that storage of urine for at least 6 months at 20°C or higher potentially reduced bacteria and viruses, resulting in a safe fertilizer for unrestricted use.

The World Health Organization (WHO) recognizes the potential of using excreta in agriculture and in 2006 has published the "Guidelines for safe use of wastewater, excreta and greywater in agriculture". This is actually a strategy of multiple barriers for health risks management associated to the use of excreta in agriculture. The multiple barriers strategy comprises measures that should be considered along the complete sanitary system, which means "from the toilet to the table".

Every measure itself potentially reduces the risks for human health. Among those practices, storage of urine is conceived as a treatment step with the purpose of hygienization before application to the field. Storage of urine in tanks or canisters is a low tech and low cost practical solution. It does not require high especial knowledge or infrastructure, so it is feasible to implement in rural as well as in urban areas (von Münch and Winker 2009).

Regarding heavy metals, normally the content in urine is low since intake is low (Winker et al. 2009), especially when compared to most chemical fertilizers (Jönsson et al. 1997). In the case of pharmaceuticals and hormones, it is believed that around 70% are excreted via urine (Lienert et al. 2007) which is the major contributor of pharmaceuticals and their metabolites detected in municipal wastewater (Winker et al. 2008). Although it is believed that the threat of human health by contamination of estrogenic compounds and pharmaceutical residues are minimal, there are some studies showing the persistence of some pharmaceuticals in soils but the evidences of their transfer to plants are not very conclusive. This probably has to do with the diversity of pharmaceutical compounds with different chemical structures, persistence purposes in the organism and

doses, and on the other side, their interaction with environmental factors (Kümmerer 2001). Two relatively recent studies show opposite results. Gottschall et al. (2012) used dewatered municipal biosolids to fertilize a wheat field before sowing. In the biosolids, over 80 pharmaceutical compounds of antibiotics, bacteriocides, beta-blockers, antidepressants, antifungals, analgesics and anticonvulsants were identified.

According to the results, some of the pharmaceuticals were detected on the wheat grain. In a more experimental approach, Herklotz et al. (2010) used Cabbage and Wisconsin fast plants in hydroponic conditions. The nutrient solution was spiked with the pharmaceuticals carbamazepine, salbutamol, sulfamethoxazole, and trimethoprim at a concentration of 232.5 µg $L^{-1}$, being higher than the one measured in reclaimed wastewater (93.6 ng $L^{-1}$, 11.4 ng $L^{-1}$, 59.2 ng $L^{-1}$, and 46 ng $L^{-1}$ respectively). With this study the authors have demonstrated that the pharmaceuticals can be taken up by cabbage and the Wisconsin fast plants. These are only two examples discussing the different factors that can influence the determination whether these kinds of micro-pollutants represent a threat for human health. Clearly, there is still a need for more research that helps to establish management measures, since the practice of use of human excreta seems to be gaining more importance, especially under the frame of the NEXUS approach.

One of the biggest challenges that reutilization of urine has to deal with is its social acceptance. Attitudes and perceptions of people are different when it is about excreta. Therefore, the success of the practice, from the collection of urine to correct application into the field or gardens, requires motivation and willingness to change habits and behaviors from all the stakeholders involved: users, maintenance staff, planners, farmers, politicians, etc (von Münch and Winker 2009).

The ECOSAN concept is particularly relevant to cities where water, space and financial resources are scarce. However, it should not be regarded as a solution only for the poor but rather available for a whole range of socio-economic conditions. Furthermore, it can be implemented at household level as well as in a larger scale (e.g neighborhoods or residential compounds). The variety of ECOSAN sanitation systems available makes it possible in most cases to find one that is culturally acceptable. While some systems are sophisticated and expensive, others are simple and low-cost (Esrey et al. 1998).

In conclusion, management of human excreta, specifically of urine, represents a waste-water-food NEXUS and its implementation could prevent further environmental pollution as well as provide benefits for agricultural practices, food security and better life quality for the communities. However, more practical research is needed in order to make this practice cleaner, safer and efficient.

**Nexus Approach for a Sustainable Waste Management: Role of Air Biofiltration in Africa and the Caribbean**

*By Johanny Arilexis Pérez Sierra* | ISWA Institute, Universität Stuttgart

An efficient management of waste in many developing countries is a real challenge to address because there is either no clear structure responsible for waste management and/or there are inadequate treatment and management techniques as well as deficient follow-up programme with insufficient financial support (Abarca Guerrero et al. 2013). As part of a holistic waste management from households and industrial processes, odors and volatile organic compounds (VOCs) play an important role since they interfere with both the health and the wellbeing of communities, and impact the atmosphere. Governments have enforced legislations aimed at protecting the environment and the life quality of inhabitants by limiting the emissions of such pollutants (Hansmann and Kroeger 2001).

VOCs can be emitted from biogenic or anthropogenic sources. The anthropogenic includes vehicles emissions and stationary emission sources, such as landfills, petrochemical industries, and solvent usage, like coating industry, iron foundries, fragrance industry, pulp and paper among others (Devinny et al. 1999; Atkinson and Arey 2003). Once emitted, VOCs are originators of pollutants capable of destroying the ozone layer (Luo et al. 2011).

Odors correspond to the characteristic of a substance or mixture of compounds, which based on their concentration, can provoke an olfactory sense when people inhale air containing them. The impact of odor is basically annoyance and nuisance, while more relevant consequences may connote headaches, nauseas, and responses as result of stress, such like: frustration, tearfulness, among others. Odors originate from natural degradation processes of organic substances and from the liquid vaporous stripping (Nadeo et al. 2013). Livestock, food processing industries, landfills and waste water treatment plants are among the typical sources of odors (Nanda et al. 2012). For these reasons, the need of waste gas treatment technologies, like biofiltration, has increased tremendously lately. Microorganisms settled on a porous medium forming a biofilm are used in this technology, for the degradation of pollutants in waste gases, as part of their metabolism (Devinny et al. 1999; Adler 2001). A filter bed can be assembled of organic or synthetic materials, which provide enough surface area and nutrients. In biofiltration, processes such as absorption, adsorption, and degradation and desorption of gaseous pollutants take place. The effectiveness of biofiltration is subject to the properties in the biofilter medium, such as porosity, density, moisture and potential of sustaining microbial populations (Devinny et al. 1999; Adler 2001). The biofiltration process can be summarized as follows: the gases flow through the biofilter media, diffuse into the biofilm and subsequently, is degraded by the microbial population. Biofilters can be constructed as open or enclosed systems, with ascending or descending gas flows (Devinny et al. 1999; Cabrera et al. 2011). This technology has been vastly and successfully employed in many developed countries (Devinny et al. 1999).

A research project was executed at the Institute of Sanitary Engineering, Water Quality and Waste Management (ISWA), University of Stuttgart, in order to determine the potential of employing biofiltration in Africa and the Caribbean (AF&CA). Up to the moment of the research there was no publication in this matter in the mentioned regions. In order for this analysis to be possible, the approach consisted of an exhaustive literature review about the state of the art of biofiltration and then, about the existence of regulations, responsible audit institutions and possible emitting sources in these regions. The availability of the biofilter materials and possible alternative local resources was also considered. Furthermore, a survey was done among some inhabitants in order to assess the awareness of the people about air quality regulations and the use of technologies to control air pollutants. In general, the most relevant stakeholders in the adoption of this technology were considered, including local government representatives, company owners, professionals in the field, students and individuals.

After the comprehensive literature review about the potential of biofiltration in AF&CA, it can be concluded that this technology has the potential to be applied frequently and successfully and could support a nexus approach for the sustainable management of waste in these regions. Parameters relevant for a nexus implementation in the field were considered, such as: existence of environmental governmental institutions, air quality regulations and emission standards, emission sources, values and claims due to malodorous substances, availability of biofilter materials, alternative local biofilter materials and possible distributing companies and suppliers of services, among others.

From the evaluated African countries: South Africa, Nigeria, Ghana and Kenya, the first two have the best conditions for an immediate establishment of biofiltration. In South Africa and Nigeria, actualized air quality policies and clear air emissions standards for VOCs were identified. However, for the case of odors the regulations are still ambiguous and very subjective. Nevertheless, it was found that Petzer and Liebennerg-Enslin (2005) already provide an integrated assessment of odor emissions and management suggestions for their control. In South Africa, the current air quality regulation was built based on the best air policies from around the world and almost everyone was considered as a stakeholder for adequate maintenance of the air quality.

In the assessed African countries there are companies that already offer services to monitor VOCs and odors. Even more, it was found that there are services of biofiltration in some of the countries. For the rest of the

assessed African countries, there is a kind of legal structure that aims at protecting the environment, however, it is still not so specific for odors and only a few have VOCs emission limits. In most of the countries there have been reported cases of complaints due to malodorous emissions from industries and waste water treatment plants. In the case of the Caribbean region, there are also institutions and regulations that promote the conservation of air quality and regulate industries from emitting certain air pollutants. Some emission limits especially for VOCs were identified in the Dominican Republic, Jamaica and Trinidad and Tobago, while in Cuba there was very limited access to this information.

For both regions, the biofilter bed materials are available at affordable prices and even some could be gathered for free. Moreover, agricultural materials (e.g. rice and coffee husk, coconut fibers, maize and sugar cane harvest leftovers, among others) can replace some of the traditional ones and serve as a local, low price biofiltration source. However, research is required to demonstrate their efficiency.

From an online survey among more than 90 people with different backgrounds from both regions, it was observed that people admit there are problems with waste and odor emissions. In general, the assessed public indicated they know there are air quality regulations and institutions that care about it. The main sources of odors mentioned from the participants were: waste waters, industry and biological solid waste. It was also evident that people do not know about the biofiltration technology.

These results give an overview of the status of air quality management in these regions and showed the relevance of the application of waste air treatment technologies, like biofiltration, that could be implemented as a pollution mitigating technique in a waste management nexus approach. It is expected that the results of this research can be useful for engineers and technicians that provide services in biofiltration and want to venture into the African and Caribbean countries. Also, it is anticipated to be the beginning of further research projects regarding the endowment of biofiltration in these countries, aimed at assuring air quality, encouraging the adoption/development of a nexus approach for the sustainable management of waste and derivate emissions, and ultimately, fostering better life conditions.

**Conclusions**

There is, so far, neither common understanding of, nor agreement upon adopting the nexus approach towards the management of water, soil and waste. However, it is important to implement such an approach in these three sectors in order to assure holistic development practices.

Based on the "Economics of Land Degradation (ELD)" framework, an overview of a potential nexus pathway to avoid land degradation was presented that considered the causes and the drivers for its deterioration and highlighted the courses of actions to be taken as well as the costs and benefits involved.

Constructed wetlands (CWs) were presented not only as a natural wastewater treatment system, but also as a response to a demand on affordable and long-lasting wastewater management techniques. The different advantages of implementing these systems included the possibility of water reuse. In addition, several recommendations were offered for the incorporation of CWs in a sustainable management of natural resources nexus framework.

The "Ecological Sanitation" (ECOSAN) system highlighted the feasibility of utilizing the nutritional content of human urine as fertilizer and considered the reduction of the dependency on water, especially in dried agricultural zones. The possible risks involved in its utilization were also discussed.

Finally, biofiltration was presented as a complementary technique part of an integrated management of waste, especially in developing countries. This is an established technique in many regions, applied mainly in wastewater treatment and composting plants, as well as in volatile organic compounds (VOCs) emitting industries. Nevertheless, it is quite a new technique in developing zones. In this document the potential of employing biofiltration in some countries of Africa and the Caribbean were discussed in order to avoid the emissions of odors and substances product of industrial processes and waste treatment sites that could cause nuiasances or degrade the ozone layer. Its role in a sustainable waste management nexus approach was considered as the key aspect.

These case studies demonstrate the potential there is in integrating different technologies and economical frameworks to secure a proper management of natural resources and also to reduce air pollutants as part of a waste management strategy. Further research and implementation is recommended aiming at assuring a nexus approach in the areas considered.

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**List of Acronyms**

| | |
|---|---|
| **CWs** | Constructed wetlands |
| **ECOSAN** | Ecological Sanitation |
| **ELD** | Economics of Land Degradation |
| **MDGs** | Millennium Development Goals |
| **TEV** | Total Economic Value |
| **VOCs** | Volatile Organic Compounds |

## 8.3.3 Water Point Mapping Initiative: The Case of Rural Water Supply in Tanzania

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**Abstract**

Water plays a key role in Tanzania's Development Vision 2025. To achieve this vision, the National Water Policy 2002 embodies effective institutionalised linkages between key water sector actors with clear roles and mandates for water policy implementation. In the current framework, Community-owned Water Supply Organizations (COWSOs) are expected to be bodies legally constituted by a community to own, manage, operate and maintain the water supply systems on behalf of the community.

Within such a framework, the Water Point Mapping System (WPMS) is one of the geo-information and communication technology tools for the management and presentation of information in a spatial context, and this enables planners, decision makers and other key partners to identify the geographic areas and communities in which to focus their efforts for maximum impact.

This paper introduces the potential of geo-information and communication technology tools for rural water supply services with direct focus on the Water Point mapping initiative in Tanzania. Furthermore, it elaborates on governance issues which need to be considered and on strategies essential to sustaining the WPMS initiative for the betterment of the intended beneficiaries of the rural water supply services. Some of the critical issues addressed in this paper for the sustainability of WPMS include the roles and responsibilities of each stakeholder, WPMS updating mechanism, capacity constraints in terms of human resources, technology, funds, and the overall system acceptance and usage.

Potential applications of WPMS beyond water may facilitate developing and adopting a nexus approach and include inter-connections with soil and land use management, systems and flux analysis, and wastewater management in developing countries.

**Introduction**

Water plays a key role in Tanzania's Development Vision (Republic of Tanzania 1999), which aims at achieving an absence of abject poverty by 2025. Its targets include the attainment of a quality of life that is socially desirable, economically viable and environmentally sustainable. Low water supply coverage impacts most severely on the poor whereby the poor make their own, often insufficient arrangements to meet their needs for basic survival.

The National Water Policy 2002 (NAWAPO 2002) embodies effective institutionalised linkages between key water sector actors, including central government, local government, External Support Agencies (ESAs), the private sector, non-government organisations (NGOs), community-based organisations (CBOs), and the communities themselves. The existing institutional and legal frameworks have established various institutions, which have clear roles and mandates for water policy implementation.

In the current framework, Community-owned Water Supply Organizations (COWSOs) established under Act No. 12 in 2009 are expected to be bodies legally constituted by a community to own, manage, operate and maintain the water supply systems on behalf of the community. These bodies may take various legal forms, such as Water Consumer Associations or Water Consumer Trusts. According to Act No. 12 of 2009, composition of COWSOs include a group of households, a village or group of villages who receive their water supply from a common source or one or more water points or a waterworks.

Within such a framework, the use of geo-information and communication technology tools has been identified as a means enabling effective information management for planning and decision-making processes. The Water Point Mapping System (WPMS) is one of the tools for the management and presentation of information in a spatial context, and this enables planners, decision makers and other key partners to identify the geographic areas and communities in which to focus their efforts for maximum impact.

This paper introduces the potential of geo-information and communication technology tools for rural water supply services with direct focus on the Water Point Mapping initiative in Tanzania. The paper highlights the intended purpose and uses of the WPMS, methodologies adopted during execution processes, the implementation status, and challenges during project execution as well as those envisaged for the future based on local situation. This paper briefly addresses governance issues which need to be considered and on strategies essential to sustaining the WPM initiative for the betterment of the intended beneficiaries of the rural water supply services. Some of the critical issues for this purpose include the roles and responsibilities of each WPMS stakeholder, the water point mapping updating mechanism, capacity constraints in terms of human resources, technology, funds, and the overall system acceptance and usage. These are the critical points for the WPMS sustainability to avoid the fate of many ICT projects which fail once donor funding stops especially in developing countries.

This paper does not detail technical issues of the WPMS initiative; rather, it addresses governance matters and why many projects fail as a result of them. Another reason to focus on governance issues is that people need water as an output no matter what technical aspects are involved. For those reasons this paper is trying to highlight some of the key issues necessary for managing WPMS in a wider context towards sustaining the WPMS as well as ensuring water availability to the community in rural areas. To achieve the intended objective, this paper recommends the immediate steps or actions needed.

The idea presented in this paper goes in line with the Bonn conference of November 2011 (Hoff 2011) that highlighted the need to advance the nexus approach to management of environmental resources - water, waste and soils. The nexus approach to environmental management is based on the search for pathways that mitigate trade-offs, identify synergies and optimize resource use. The use of WPMS within the Nexus can potentially enable decision makers to better understand trade-offs and explore synergies between (a) sectors - agriculture versus water supply (b) services - water for food production versus for drinking water, (c) surface versus groundwater, (d) freshwater versus wastewater and (e) public private and community organizations. Based on the above facts, the overall relation of this case study to the water-soil-waste nexus is to facilitate cross-fertilization of ideas on potential applications of Water Point Mapping beyond water to include inter-connections with soil and land use management, systems and flux analysis, and wastewater management in developing countries.

**Policy Framework for rural water supply in Tanzania**

Policy development for the water sector began with the first National Water Policy in 1991 and was revised in 2002 (NAWAPO 2002), thus introducing reform elements of devolution, poverty alleviation and civil service reform. Key policies such as the National Development Vision 2025 (Republic of Tanzania 1999) set the stage for the Poverty Reduction Strategy Paper (PRSP) and the Rural Development Policy (RDP), which were then supported by the Local Government and Public Sector Reforms. The comprehensive review of the PRSP led to the MKUKUTA (Mkakati wa Kukuza Uchumi na Kuondoa Umaskini) that sets operational goals and puts policy in a functional framework, which in the water sector is embodied in the National Water Sector Development Strategy (NWSDS 2006-2015, MOW 2006). The NWSDS sets out the strategy for NAWAPO implementation and in turn guides the formulation of the sub-sectoral investment

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programmes, as inputs into the Water Sector Development Programme (WSDP). The sector's strategy is incorporated into three programmes: the National Rural Water Supply and Sanitation Programme (NRWSSP), the Urban Water Supply and Sewerage Programme (UWSSP), and the Water Resources Management Programme (WRMP).

The key lesson learned from previous experience is that to achieve sustainability, water supply and sanitation facilities must be owned and managed locally by organisations that are both close to, and accountable to the consumer. NAWAPO embodies effective institutionalised linkages between key sector actors, including central government, local government, External Support Agencies (ESAs), the private sector, non-government organisations (NGOs), community-based organisations (CBOs), and the communities themselves. Under NAWAPO, the Government continues to provide the necessary technical and financial support, as well as coordination and regulation of water supply development activities. The private sector provides support to the communities in planning, design, construction and supply of materials, equipment, spare parts, and in some cases operations. In partnership with key stakeholders, the Government has adopted a Sector-wide Approach to Planning (SWAp). SWAp brings together the three sub-sectors, namely rural water supply, urban water supply and sewerage, and water resources management, under one comprehensive investment and regulatory regime (WSDP 2006 - 2025).

**Rural Water Supply Services**

The government has been the owner and operator of rural water supply systems for the past many years. This has led to a lack of commitment by communities to sustain their facilities as well as an overlap of roles and inadequate coordination. The provision of water service has previously been done without the active involvement and ownership of the beneficiaries, lack of data and information from various sources, lack of integrated databases and systems for planning and feedback. This has led to unsustainable service delivery. Operation and maintenance (O&M) of water supply schemes has not reached the level of full cost recovery, due to socio-economic conditions pertaining to the rural areas. In rare cases, schemes operate only to recover operation and maintenance costs. For large schemes, government subsidy is still granted to offset electricity bills, chemicals and salaries. For hand pump schemes, availability of spare parts at the district level is not certain because they are not fast moving items in the market and so has led to malfunctioning of some of the schemes.

With the new institutional setup, the role of the Ministry of Water is to coordinate implementation of interventions under the guidance of the National Water Policy 2002. For the purpose of policy implementation, the Government has put in place the required institutional and legal frameworks for sustainable water resources management, and water supply and sanitation services in the country. They include the National Water Sector Development Strategy (NWSDS 2006-2015), the Water Sector Development Programme (WSDP 2005-2025, Republic of Tanzania 2006), Water Resources Management Act No. 11, 2009 and Water Supply and Sanitation Act No. 12, 2009 (Republic of Tanzania 2009). The institutional and legal frameworks have established various institutions, which have clear roles and mandates for policy implementation. Community-owned Water Supply Organizations (COWSOs) established under Act No. 12 in 2009 are bodies legally constituted by the community to own, manage, operate and maintain the water supply systems on behalf of the community. These bodies may take various legal forms, such as Water Consumer Associations or Water Consumer Trusts. The composition of COWSOs under Act No. 12 in 2009 comprise a group of households, a village or group of villages who receive their water supply from a common source or one or more water points or waterworks. COWSOs are promoted through the local government framework of district and village councils. The COWSOs may contract part or all of their operation and maintenance responsibilities to private companies or individuals, or to NGOs.

Within such a framework, the use of geo-information and communication technology tools has been identified as a facilitator towards effective water sector information management for planning and decision-making processes. The WPMS is one of the alternative tools for the management and



presentation of large volumes of information in a spatial context (geo-information), and this enables planners, decision makers and other key partners to identify the geographic areas and communities in which to focus their efforts for maximum impact. This means that for any specific point on the map (identified by its x, y coordinates) detailed and accurate data of different nature can be linked in an integrated way. The implementation of WPMS is considered as a step for effective implementation of sector policies and strategies.

**Water Point Mapping System**

Water Point Mapping is a planning and monitoring tool used to locate water infrastructure and collect related information using any available technology. The information that is collected can then be used in decision making for different uses (Geodata 2013). On the other hand, the Water Point Mapping System (WPMS) is an integration of hardware, software, methodologies, data, processes and users dedicated to collecting, storing, processing and analysing water related information and giving feedback for public use. Specifically, WPMS can be used to (i) inform the planning of investments to improve water supply coverage; (ii) to allocate resources to deliver basic services where they are most needed; (iii) to promote increased investments in the sector; (iv) to determine lost investments; and (v) to measure progress and performance. Furthermore, WPMS supports local level planning and can improve accountability for water sector performance at local and national levels.

In Tanzania, based on the initiatives of the water sector stakeholders including WaterAid, SNV, Plan International, Concern Worldwide, ISF and AMREF, under the implementation by GeoData Consultants Limited, substantial administrative areas (55 out of 132 rural districts) were mapped between 2005 and 2009. The outcomes of these initial efforts were used to feed into discussions at sector review meetings, most notably the 2008 and 2009 equity reports. In order to build on the already existing experiences and benefits obtained in the pilot projects done by private sectors, especially through WaterAid exercise, the WSDP adopted the methodology in order to establish a comprehensive system that will help the ministry and other stakeholders in the country to understand the status of the water supply services in terms of coverage and functionality. The motive was a result of conflicting information on water supply coverage in rural areas provided by various sector actors including Ministry of Water, National Bureau of Statistics, and Civil Society Organizations/Non-Governmental Organizations.

The Ministry responsible for water through the Water Sector Development Programme adopted the WPM methodology by contracting GeoData Consultants Limited under a 1 year contract. The contract was signed in November 2010 to perform the undersigned assignment aimed at increasing the capacity of Local Government Authorities (LGAs) and to develop the roll out plan. In particular, the task's main objective was to develop the capacity of the potential users, operators, technical staff and decision makers to be able to use and update the water point mapping system. The contract was not completed within one year as expected due to several reasons and then extended to March 2013. The contract for the initial assignment extended on 31 October 2013.

The users of system outcomes include all organizations that have water poverty alleviation as their mandate including WSDP stakeholders. The WPMS can be used as a tool for **planning at the local level** as it provides information at the local level. In this case water point mapping results will be used for identifying and targeting the most deprived population, and therefore support proper allocation of the resources for the service.

Water Point Mapping data can be used to **analyse the durability of water points** depending on different factors such as time after construction, technology, water source type, management framework, etc. so as to help local governments and other agencies to address the sustainability challenge. The WPMS produce maps that serve as powerful tools for **advocacy,** since they provide clear messages and communicate complex information quickly and accurately. The system may be used to identify lost investments in rural water supply services because most of the water points are not durable due to many reasons. The WPMS

is seen as a tool to support **monitoring and evaluation** of the water sector delivery services and it can be used as a one stop information source for the Big Result Now initiative for planning, implementation, monitoring, and reporting ("Tanzania's Big Results Now Initiative | Africa Platform for Development Effectiveness" 2014).

The strength of water point results is that they provide a clear message on who is and who is not served in rural areas. The results can be used to highlight equity issues and schemes' functionality levels at villages and wards where poor people live. This is due to the fact that Tanzania through the Ministry of Water has been undertaking reforms towards decentralization, transferring the responsibility of services management and resource allocation to local levels. This requires adequate performance monitoring frameworks backed by accurate and reliable data at the local level. Through WSDP dialogues, WPMS is increasingly thought of as a way to collect and disseminate this information to stakeholders and public access without bureaucracy. Generally, the WPMS fits for baseline inventory, database, regular reporting, local planning and management, access functionality, equity, water quality and quantity, mapping (physical distribution of water supply infrastructure vs population), and sector planning and review.

**Adopted Methodology**

Water Point Mapping was an exercise whereby the geographical positions of all improved water points in an area were gathered in addition to management, technical and demographical information. A handheld Global Positioning System (GPS) unit was used to record the precise location and approximate altitude of all water points audited; a digital camera was used to capture photographs of each water point in order to show the status and physical conditions; and a structured questionnaire was completed to document main characteristics, such as: location, functionality, category of water supply, water quality perception, management issues, ownership and water tariff payment. All collected data was entered into a geographical information system and correlated with available demographic, administrative, and physical data. The activities planned for the execution of the WPM initiative as per Terms of Reference up to the end of October 2013 involved the following:

I. Conducting baseline survey of all developed public rural water points in the 132 LGAs of mainland Tanzania using Global Positioning System (GPS) to geo-locate each public water point.
II. Taking of geo-tagged photographs of each water point visited.
III. Collection of data on the functionality, management, technical specifications, quality and quantity of the water produced at each of the water points.
IV. Designing, developing and institutionalization of a functional web based system to produce and make public accessible maps and data relating to water point functionality and coverage.
V. Increasing the capacity of implementing agencies such as Ministry of Water (MoW), Local Government Authorities (LGAs), Regional Secretariats (RSs), Basin Water Boards, Water Laboratories, and other line Ministries in order to be able to use and update the WPM system.
VI. Launching of the system for public awareness and usage.

Consultants with support of the LGAs staff performed those activities by dividing the country into zones covering small regions. The consultants followed the standard government procedure by reporting to the Council Director who designates to District Water Engineer's office (DWEs) as the coordinating officer at the council level. From there, the first ward to be mapped was identified and one member from DWE staff was identified to lead the consultant to the Ward Executive Offices (WEOs). The Ward Executive Officer led the mapping team to the Village Executive Offices (VEOs). Other administrative processes followed based on the instructions from the village leaders. Either the VEO or a nominated representative led the team at the village to answer the survey questions of the Mapping Expert.

Components in the Water Point Mapping exercise include people (consultants, LGA staff, water point beneficiaries, etc.), Global Positioning System (GPS), computer, camera, Internet connection, base maps (shape-files), software, and survey questionnaires.



**WPM Implementation Status**

A baseline survey of the developed public rural water points in the 132 Local Government Authorities in Tanzania Mainland was completed by mapping a total of 74,250 water points nation-wide. Although it seems water points were completed for 132 LGAs, it means that all public or improved community water points were collected across Tanzania Mainland and uploaded into the system based on the existing shape files for administrative boundaries (wards, districts and regions). But, once new shape files are released by the NBS or Ministry of Lands, the updating will be effected so that the physical location of the water points will also be based on the new shape file.

Geo-location and labelling (geo-tagged) of these 74,250 improved public water points were achieved using a Global Positioning System. Labelling water points physically was considered as an important feature for monitoring campaigns by outsiders such as Ministry of Water, Prime Minister's Office Regional Administration and Local Government (PMORALG), Regional Secretariats, Civil Society Organizations, Non-Governmental Organizations, Development Partners and other key stakeholders. Using GPS, the mapping of water points along with the collection of data on the functionality, management, technical specifications, quality and quantity of the water were completed at each of the water points based on the approved questionnaire. Designing, developing, and testing the web based WPMS to produce and make public accessible maps and data relating to water point functionality and coverage has been completed although enhancements are ongoing based on new demands, changing business processes and emerging technologies for updating.

Training for system administrators, system users, and trainers has been done at the national level. Although basic training for the users commenced, the capacity of the sub sector to use the system in sustainable basis is critical. The capacity building needed involve not only training on how to use system but also making government staff use the system for daily or routine planning and monitoring aspects. This means acceptance is a prerequisite for system users and decision makers at all levels. This will enable smooth transition and update process in a sustainable basis to ensure that people get water in a sustainable manner.

Water Point Mapping simplifies monitoring of the distribution and status of water points as well as informing investment planning to improve water supply coverage. The information is transparent for all stakeholders including the public at large. The WPMS addresses the issues of transparency in service delivery and distribution of resources, accountability for both government and public, and citizen participation to improve water service delivery in rural areas.

The WPMS website is operational, offering different possibilities for the public to view the water point data for the whole of Tanzania and to execute little reports for some administrative units in the form of maps, tables, graphs and photographs. It is an objective tool for registered users from the state water management that can allow for targeted planning of water scheme improvements. Every public user has access to the general information about the distribution of water points. There are some groups for registered users that use advanced functionalities of this web application (e.g. WPM System

Administrators on national level, WPM data editors at national and local levels, WPM technical reporters at various regional levels, WPM summary reporters at national and/or basin level). The rural water supply service coverage and other related information can now be accessed through https://wpm.maji.go.tz. The design of the WPMS considered both Swahili as an official or local communication language and English as a third party language.

The WPMS analysis results indicate that as of December 2012 Tanzania has 74,250 improved community water points in rural areas. Out of these, 45,754 water points (about 62%) are functioning while 28,496 water points (about 38%) are not functioning. The updating of the system is intended to change the status as a result of new water points.

Key factors that led to the success of the water point mapping efforts were based on joining forces and sharing experience with all stakeholders involved in the water sector - from government and non-

governmental organizations to the private sector - to come up with a concrete proposal on how to support local level planning and improve accountability for water sector performance at local and national levels.

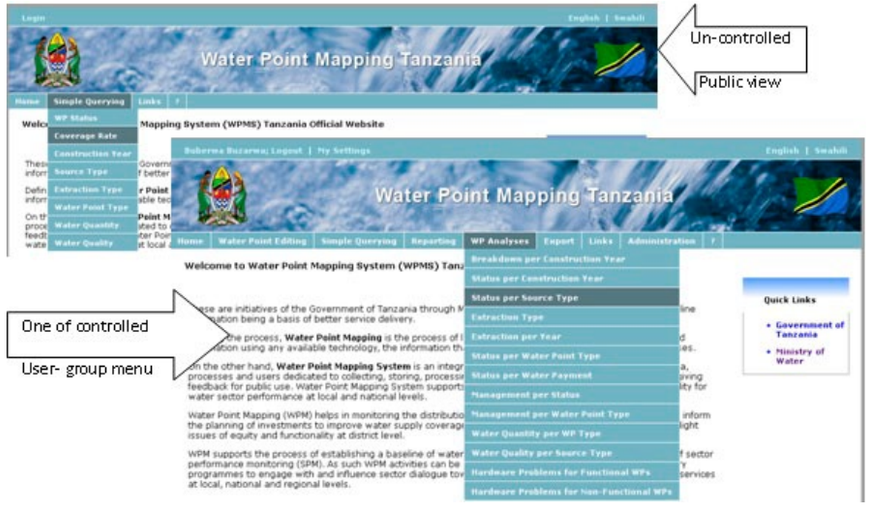


*Figure 1: Uncontrolled and controlled public view and user group menu respectively.*

**WPMS Implementation Challenges**

Although the Water Point Mapping System has been installed and the contract ends 30 October 2013, there are still pending challenges that have been experienced during field work and that are envisaged for future sustainability of the system. Most of the systems are functional when there is donor support and sudden death once support stopped due to lack of resources, but the critical reason is due to ignorance or resistance to change.

The water point's data updating mechanism is still a challenge. It has been recommended to update the data through community owned water supply organizations (COWSOs) who will be informing the district water engineers regarding the functionality status of the water facility within their community. The District water engineer will be responsible for updating data into the WPMS. Some of the stakeholders are un-happy with this methodology for the reason that the district water engineer may provide information that favour his/her interest such as the highest functionality of water points. The big issue here is the *lack of incentives and trust to report on functionality.*

Technological challenge is another barrier in the sense that there is no t*ested semi-automatic or fully automatic updating mechanism through cellular network and system sensor technologies based on the local situation*. With this technology we must consider carefully on the local situations in terms of the kind of technology best fit for rural areas where there is no cellular network coverage. After system installation, there are several options emerging for updating the water point functionality, although they are all still under very initial development stages. The availability of automated technologies may be supplementing the manual updating mechanism through COWSOs or LGAs who may not have incentives for updating water point functionality status.

Acceptance of the WPMS as a planning and monitoring tool is another challenge faced during the project's implementation period. All stakeholders, namely politicians, managers, donors, users and service beneficiaries, must be involved to address this challenge. The acceptance involves streamlining the system within the planning process, updating and sustainable usage. Acceptance also includes enforcement



of the WPMS into government machinery. Acceptance provides better opportunities for mobilization and availability of enough resources for smooth sustainability of the system including avoiding untimely disbursement of allocated funds as experienced during the start-up of the project. This has prevented project activities from being completed timely.

Although COWSOs are considered as potential for WPM updating as the direct beneficiaries of the water points, the reality indicates that despite the available governing laws for COWSOs registration, there is still a lack of stipulated standard procedure for COWSOs registration. This is because there are many uncoordinated stakeholders engaging with COWSOs registration. COWSOs registration should be done in an agreed standard and coordinated manner. The issue of Validation and Inquiry Process (VIP) possess conflicting ideas or understanding by various stakeholders (government, CSOs, etc.), and therefore they should both agree on the way VIP can be taken care in a more transparent manner.

User requirements specification was limited to rural water supply based on the data collection template used in the pilot projects done by SNV, WaterAid, etc. The requirements specification and validation did not cover sector wide requirements, and as a result, these requirements emerged at the end of the project.

WPM Infrastructure is another challenge in terms of technology, development and users. For example, reliable connectivity and internet bandwidth issues for hosting and access of the system is a barrier. Future upgrades to the WPMS in line with technology developments, increasing user demands and change of business processes will have to be addressed at this stage. This is because the WPM initiative in Tanzania has been done through WSDP funding. Stakeholders must think of the sustainability once donor funding stops. Stakeholders (Government, CSOs, NGOs, DPs, Research Institutions, Private sectors, user communities) need to think strategically on the WPMS sustainability. WPMS sustainability does not consider only data but also the overall system perspectives, in terms of water point infrastructure, people, technology and other resources, that make water flows and feedback accessible so that remedy actions are taken timely in case water stops to flow.

In most cases, the potential of maps or spatial information remains underexploited in Tanzania and the water sector in particular. According to a study developed by WaterAid (WaterAid 2010), the use of this tool for better planning at the district level was still low despite the acknowledgment of its potential usefulness.

**WPMS Governance**

Governance for the WPMS is important because it determines how government, individuals and a society manage, use and allocate resources and distribute rural water supply services aiming for the poor majority using the WPMS as an enabler. WPMS facilitates interaction and dialogue among key players, both formal and informal, for setting standards and objectives and for resolving disputes over water supply services for the poor. WPMS governance in Tanzania will be executed based on the existing policy framework and structures with regard to rural water supply services. The overall institutional structures and mechanisms for the sustainability of the WPMS will be based on the Water Policy 2002 through the existing WSDP implementation structures because this is an integrated system in terms of applications and users. The proposed roles and responsibilities of the key stakeholders for WPMS are summarized in table 1 below.

Table 1: Roles and Responsibilities of the key stakeholders in Water Point Mapping System in Tanzania

| Roles | Responsibilities |
|---|---|
| Ministry of Water (MoW) | • The lead Agency & Project advocate.<br>• Issue policies, guideline, and standards on Water Point Mapping System and Rural Water Supply and Sanitation.<br>• Mobilize adequate resources for project implementation.<br>• Provide capacities to users at all levels for using WPMS. |

| Roles | Responsibilities |
|---|---|
| Ministry of Water (MoW) | • Coordinate capacity building to Community-owned Water Supply Organizations through Local Government Authorities for updating the water points.<br>• To establish standard procedures for registration of Community Owned Water Supply Organizations.<br>• Update all shape files after obtaining from National Bureau of Statistics and Ministry of Lands.<br>• System upgrade and administration in line with changing requirements and technologies.<br>• Water Point Mapping System Quality Assurance (SQA). |
| Technical Team (MoW + Development Partners, etc.) | • Provide advice to harmonize concepts and strategies for Water Point Mapping system sustainability.<br>• Review and advise on MoW strategic plans on WPMS.<br>• Support for mobilization of resources for WPMS capacity building.<br>• Facilitate exchange of experience- and lessons-based best practices.<br>• Analyse WPMS guidelines based on the National Water Policy 2002.<br>• Monitor and evaluate the implementation of WPMS policy measures and standards including to provide a platform for improved networking. |
| Prime Minister's Office, Regional Administration and Local Government (PMORALG) | • Collaborate with MoW to ensure WPM system is smoothly institutionalized by Local Government Authorities as a planning & monitoring tool for rural water supply services.<br>• Support for provision of necessary ICT infrastructure for WPMS. |
| Development Partners (DP's) | • Support in mobilization of project resources for investment and operating costs.<br>• Support in providing technical assistance to the project for sustainability issues. |
| Regional Secretariats | • Coordinate all water development projects in the region including construction of water points.<br>• Monitor the use of the WPM system by LGAs as a tool for planning and resource allocation. |
| Basin Water Boards/ Water Labs | • Collaborate with Local Government Authorities (LGAs) in WPMS updating.<br>• Monitoring of water resource at LGAs and villages (such as schemes, dams, wells, etc.).<br>• Approve, issue, enforce and revoke water rights and discharge permits.<br>• Enforce water sources protection and pollution control measures.<br>• Educate stakeholders i.e. LGAs and communities on Water Resource Management & Water Quality regulations and ensure compliance.<br>• Advice the LGAs on water quality management issues. |
| Local Government Authorities (District Water Office - DWE) | • Regular updating of functionality status into the WPM system for existing and new Water Point installations.<br>• Using the WPM system for routine planning, monitoring & advocacy.<br>• Use the water point maps and results for the equity allocation of resources for water projects in the wards and specific villages or locations.<br>• Coordinate COWSOs registration and capacity building.<br>• Routine monitoring of the functionality status of the water project at lower levels (wards, villages, etc.). |
| Village Executive Officer (VEO) | • Daily or weekly monitoring of the functionality status of water points and water supply services with collaboration with COWSO or Village Water Committee or Boards.<br>• Prepare plans and budgets for maintenance and repair of water infrastructure in collaboration with VWC or COWSOs.<br>• Support VWC or COWSOs on major or minor repairs of the water points.<br>• Keep copies of registers for water points in the village. |



| Roles | Responsibilities |
|---|---|
| Village Executive Officer (VEO) | • Report income and expenditure to the Village Committees on regular or annual basis.<br>• Report any non-functional water points to DWE for any technical support. |
| Community Owned Water Supply Organizations (COWSOs)<br><br>- Part I - | • Regular update on water point status to VEO and DWE.<br>• Manage water points and collection of revenues.<br>• Manage minor or major repairs of the water points.<br>• Keep registers for water points in the area of jurisdiction.<br>• Appoint water point representative for day to day operations and updates.<br>• Allocate funds for repairs and new construction of the water points or infrastructure including installation of sensor systems for real time updating. |
| Community Owned Water Supply Organizations (COWSOs)<br><br>- Part II - | • Inform communities or beneficiaries of the income and expenditure on a regular basis.<br>• Keeping contact with DWE on a weekly or monthly basis. |
| Communities | • Pay for water supply services to ensure sustainability in terms of water point repairs and pay for upgrade of sensor systems for real time updating.<br>• Contribute to new water points and installation of sensor systems.<br>• Manage water resources and water points.<br>• Get feedback on income and expenditures on a regular basis. |
| Contractors & Consultants | • Construction of new water points.<br>• Fill out the water point data collection form during and after installation and submit to DWE and copied to COWSOs, VWC or VEO. |
| Research and Academic Institutions (Local/Foreign) | • Research and putting into practice automated and cheap technologies best fit for water point mapping updates based on the local situation.<br>• Research and putting into practice best practices for WPMS sustainability issues.<br>• Research and putting into practice technologies best fit for water supply services in rural areas where poor community live. |
| Private Sectors | • Provide technologies for easy WPMS updating and information dissemination to user communities or beneficiaries.<br>• Collaborate with government in data management system in order to avoid bureaucracy through rapid response.<br>• System hosting and management services. |

**Options for Updating Water Point Mapping System**

Updating the WPMS is a critical issue in order to ensure that the system is efficiently, effectively and reliably used. Three options have already been tested for updating the water point mapping baseline information:

I. Updating through mobile phone.
II. Updating through LGA staff/ DWEs office.
III. Updating through Community Owned Water Supply Organizations.

Geodata noted that several initiatives have been invested in testing the above methodologies including Maji Matone Programme which tested option one (i) above while use of local government staff to update the data tested option (ii) above in Iringa region as a pilot phase before starting water points data collection countrywide. Option (i) and (ii) failed due to lack of incentives for updating as well as change of attitudes for both the public and government staff (Geodata 2013).

A report by Geodata indicated that option three (iii) has been tested in Muleba and Magu district by the consultants through support of the Embassy of the Kingdom of Netherlands (EKN) under the supervision of SNV - Netherlands Development Organisation. Consultants' recommendation is that there is a promising future in using option three i.e., COWSOs for the water point updating because they are direct beneficiaries of the water supply services.

The issue of updating is yet to be concluded but the Ministry of Water proposes the short term and long term solution as follows:

**a) Short Term Solution for updating**

- COWSOs/VWC/VEO to update water point status reporting to DWE by filling forms. The incentive for COWSOs to participate in updating water point data is to get government support in repairing water points for the continuity of the water supply services to community as direct beneficiaries.
- DWE will be responsible for data verification and submitting to MoW for the existing and new water points.
- MoW will be responsible for data uploading into the system.
- MoW will also be responsible for software upgrades, and also updating shape files after obtaining them from National Bureau of Statistics or Ministry of Lands.
- For system and data quality assurance, MoW through Regional Secretariats shall be responsible for routine verification of the water point's status reporting.
- Water quality data to be updated by water quality staff from laboratories in regions, zones or basin water boards.

**b) Long Term Solution for updating**

- COWSOs or Village Water Committees (VWCs) to submit water point status to DWE. COWSO or VWC may appoint a water point representative for the day to day monitoring functionality of the water point and provide status to COWSO or VWC who are responsible to submit status to DWE.
- DWE to verify and upload water point status into the system for the existing and new water points.
- MoW to upgrade software and update shapefiles after obtaining them from NBS or MoLHSD.
- For data quality assurance, Regional Secretariats shall be responsible for routine verification of the water point status reporting from LGAs.
- In future, the water point functionality status updating in a real time basis shall be supplemented by any automated technology such as using sensor system either based on cellular coverage, telemetry, etc. depending on the research outputs and best practices. Therefore, researchers or academic institutions need to provide any tested technology for real time updating of the water point functionality.
- Water quality data to be updated by water quality staff from laboratories in regions, zones or basin water boards.
- Any option best fit for rural areas.

**Next Step**

The sustainability of the WPMS needs systematic planning based on its potentiality. In order to achieve this intention, the following issues are recommended for further scrutiny so as to develop a detailed strategy and plan for the next step. Major issues include among others the following:

a) Completing WPMS training to all potential users including LGAs, RS water offices, Basin Water Boards, Water Quality Laboratories, etc. Training must be done not only to water engineers but also directors, planners and politicians at LGAs. This will enable smooth transition into system usage for the planning and monitoring process.



b) Enhancement and up-scaling of the WPMS to incorporate water quality issues and other parameters for the overall sector performance support with Big Result Now (BRN) initiative and Open Government Partnership in Tanzania. This can be achieved through after sales Service Level Agreement.

c) Field testing of updating technology that can be used to map the status of water points. This is to look into influences for lack of incentives to report and **lack of trust in government agencies. Also, include pilot** testing available technologies (if any) for real time updating water point's functionality through sensor system technology based on cellular coverage, telemetry, and many others.

d) Putting into practice a long term solution or approach for WPM updating **through COWSO's, etc., but also looking at governance issues under COWSOs and capacity building to COWSOs, in terms of standards, guidelines and training on WPM & VIP issues.** Alternatively, perform field test "planning clinics" methodology that involves government, private IT companies and COWSOs to streamline methodology using Open Data Kit updating technology, etc.

e) Engaging key custodians and partners involved in the preparation and updating of the shape-files for the administrative boundaries (wards, districts, and regions). Look at the harmonization issues of the spatial datasets at all levels to bridge the gap between NBS and Ministry of Lands.

f) Capacity building for the research on easy-to-use technology and policy issues related to Water Point Mapping sustainability. This can be done through WDMI.

g) Use WPM results for addressing governance issues for the sector. This can be used as a basis for enhancing technology know-how on the updating mechanisms, which are more reliable, but at reduced cost to the consumer or almost at no cost. This also includes identification of a standardized methodology to address governance issues and technical know-how for Water Point Mapping System sustainability based on pilot experiments in different parts of the country.

h) Institutionalize WPMS as a monitoring tool for rural water supply projects (putting into practice "acceptance & change management strategy").

**Conclusion**

The Ministry of Water in Tanzania has noted the potential of geo-information and Communication technology tools for planning, management and decision making towards effective services delivery. More efforts are needed to address the issue of capacity of sustaining WPMS in a wider context. The Ministry of Water recommends the adoption of a nexus approach in planning for the sustainability of the WPMS in Tanzania. The reasons behind and the economic incentives needed to foster a nexus approach in this context include (i) strengthening the policy actor and capacity development institutions such as Water Development and Management Institute (WDMI) and disseminating knowledge and understanding to water beneficiaries or communities, (ii) through its integrated and wider approach for sustainable management of water, the nexus approach will enable lessons learnt from Ministry of Water to connect and disseminate knowledge throughout the world as a collaborative approach in developing new innovations for water point's functionality through real time technologies like sensor systems.

The use of a nexus approach in the WPMS initiative is not intended to replace the existing institutional framework and structures but to facilitate cross-fertilization of ideas on potential applications of Water Point Mapping beyond water to include inter-connections with soil and land use management, systems and flux analysis, and wastewater management in developing countries.

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## 8.4 Towards Nexus Approach: Case Studies at Local and National Levels

### 8.4.1 Towards Nexus Approach: Case Studies on Integrated Management of Water, Soil and Waste from China, Ethiopia, Iraq, Mexico, Serbia and South Asia

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**Abstract**

Securing water, food and energy supply is a global concern, in particular given the challenges of increasing demand in developing countries while water and soil resources are in decline. Promotion of sustainable development world-wide facilitates resource security, but there are several challenges to be faced, often pertaining to integrated management of water, soil and waste. This paper represents a compilation of selected case studies dealing with particular aspects of integrated resources management in four different continents. The cases represent practical applications of a nexus approach to the sustainable management of water, soil and waste, with main focus on water management.

The case study in Serbia takes advantage of the current restructuring of the energy sector, which is focused on renewable energy potentials, and analyses the potential for energy recovery from wastewater and organic material flows via anaerobic digestion and biogas utilisation. The case study on Mexico explains how the integrated assessment and management of water in urban areas, by means of Material Flow Analysis, can support the goals of soil protection, food security and also avoid public health problems. The vicious circle of land degradation and food insecurity is addressed in the case study from Ethiopia which discusses how the smart utilisation of water and waste could help to alleviate the problem of land degradation in that country. The section about the Himalayan ecosystem reviews the trapped potential and policies that need to be implemented in order to synergize land, energy and water management schemes to face the growing needs of the population. A case study on Iraq provides recommendations for climate change adaptation including institutional and social dimensions based on the comparative assessment of five different locations in Seattle (USA), Odense (Denmark), Tehran (Iran), Khulna (Bangladesh) and Melbourne (Australia). The final case study on China discusses how to balance the various ecosystem services with respect to soil, water and land use management. It highlights the importance of a nexus approach in developing adaptive management strategies for harmonising soil management and water supply security in the dry regions of China.

The case studies showcase the connections between water resources, soil, energy and climate. The general conclusion drawn from all case studies points out that integrative approaches recognizing and dealing with root causes are essential to ensure water supply and food security in the future.

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**Introduction**

Our world is changing due to both natural and anthropogenic causes. The changes, noticeable at the local, regional, and even global scale, have enormous impacts on living species, ecosystems, urban systems (including cities), energy sources and land use. As a consequence, negative effects can be observed on the available water and soil resources which are primarily attributable to human activities rather than natural causes.

No doubt, water is our most precious resource, yet we face threatening crises in the availability of water for people and all living species on our planet. There are many factors affecting the availability of water resources on our planet, out of which population growth, climate change, land use changes and energy consumption can be considered as a key factors. The heritage of these four factors will not only be less available water per capita, but also more degraded water quality especially for people in the developing countries.

Water, soil and food production are closely interconnected given that all agricultural activities and livestock farming require large amounts of (fertile) soil and (clean) water for their activities. The food processing industries are also important water consumers. Therefore, any negative trend in water management would also impact the food security. Additionally, the uncontrolled generation and disposal of wastewater and solid waste from cities and from industrial areas play an important role in the problematic: while being a pollution source for soil and water bodies, it is also a potential source of raw materials and energy.

Unless we find better ways to protect our water and soil resources and of managing the wastewater and solid waste the future looks dreadful for billions on earth. With this motivation, many approaches for an integrated management of water, soil and waste have risen in the past. Examples of such approaches start with the management of the water demand for all stakeholders and users in a region and go on with the reuse of treated wastewater in the agriculture, industry and even in the urban areas. The generation of energy by co-incineration of solid waste or by biogas production from wastewater sludge is a further example of integrated management of waste in the energy sector. The construction of multi-purpose dams for a balance in energy generation and water supply for agricultural and urban uses is another example of the integration of energy and food demand criteria in the management of water resources. Thus the integrated management of water, soil and waste aims at building synergies across sectors and at optimizing the efficiency in the use of resources and automatically implicates securing water, food and energy for its use in the future.

The Bonn2011 Nexus Conference has opened and expanded the global discussion on the importance of interlinking water, energy and food security. The new approach, called "Nexus Approach", moves towards interdisciplinary solutions of looping water, energy and food sectors in order to optimize resource use and to stimulate green economy growth (Hoff 2011). The three pillars of sustainable development - social, economic and environmental - are also the cornerstones to applying a nexus approach. There are six “Nexus Opportunity Areas” which call for: increasing policy coherence, accelerating access (to human rights), creating more with less, minimizing waste, valuing natural infrastructure and consumer influence mobilization (BMU, BMZ 2012). The implementation of these opportunities requires the right policies, strategies, incentives, research and capacity building.

This paper is a contribution of scholars supported by the scholarship programme “International Postgraduate Studies in Water Technologies” (IPSWaT), organized and supported by the German Federal Ministry of Education and Research (BMBF). IPSWaT brings together young professionals from all over the world who work in high quality research projects mainly related to the water sector but also interlinked with diverse global challenges such as biodiversity depletion, energy efficiency, land use management and climate change. The present paper represents a selection of case studies from six scholars where water management issues have been dealt within the context of Nexus approach.



**Possibilities of Practical Implantation of a Nexus Approach in Serbia**

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In January 2014 the Council of the European Union began negotiations with the government of the Republic of Serbia on Serbia's accession in the European Union. Such a situation obliges the Serbian Government to promptly align its laws with the EU standards. With the adoption of EU regulations, many changes are expected in the environmental field, particularly in wastewater, waste and energy sectors.

By 2012, the sewer system served ca. 60% of the total households in Serbia (SORS 2013). This fact is quite defeating, considering that in most of the European cities more than 95% of the population is connected to wastewater collecting systems. Out of 310,000 Mm³ annually discharged wastewater in Serbia, 41% is discharged into the Danube River, out of which 94% is not treated (SORS 2013). The situation in rural areas is difficult to describe properly due to non-existing databases. However, in most of the cases wastewater is collected in septic tanks and eventually drained into groundwater. Additional pressure on the receiving waters originates from the agricultural sector where it is estimated that the majority of pollution is coming from 130 farms and 1.2 million animals predominantly located in the autonomous province of Vojvodina (WHO 2009).

The situation concerning the waste management sector in Serbia is not much better. In 2010 a new Strategy for Waste Management for the period 2010-2019 was adopted and is based on European Union waste management hierarchy. Like the first version from 2003, the strategy foresees waste disposal as a last option. Despite the strategies, out of ca. 2.6 Mil. t of municipal solid waste (MSW) produced annually, around 70% is collected and ultimately disposed of at 164 landfills, 3 sanitary landfills and over 3,500 dumping sites (EEA 2011). Consequently, ca. 90% of existing landfills (without counting dumping sites) have been causing severe effects on the ground water quality (Rakijaš 2012). When taking into consideration the fact that 80% of drinking water sources emerges from groundwater in Serbia, the significance of the situation becomes clear.

Nowadays, most of the Serbian decision makers perceive wastewater and waste management projects as prerequisite, but also as an expensive investment project. Here, questions concerning the end users affordability and energy demand of the technical solutions as well as expected increase of energy price are of utmost concern. Serbia, as a transition country definitely, does not have the capacities for large-scale investments in the required infrastructure of the mentioned sectors. Thus a new nexus-oriented approach of interlinking water, waste and energy sector provides a good opportunity for further sectorial improvement.

In 2011, the Nexus conference in Bonn initiated a global debate on the importance of interlinked water, energy and food security. Nexus aims to bring economic benefits through more efficient utilization of resources, productivity gains and reduced waste (BMU, BMZ 2012). This is a particular challenge in today’s Serbian economic climate, but might be seen as an opportunity for prosperity. The achievement of a Nexus approach in Serbia would require transition from the main-stream economy system (unlimited energy and material input, unlimited waste generation) towards steady state economy system (maximised resource efficiency, diminished resource input and waste generation). Here sectors of wastewater and waste management could be re-organised to work in synergy with each other while being in the “symbiosis” with the energy sector (providing resource for energy generation and accepting energy for operation).

Wastewater is a carrier of significant amounts of material (e.g. nutrients) and energy (e.g. thermal and chemically bounded energy) flows which can be utilized. MSW consists of ca. 50-70% of organic fraction which can be considered as additional potentials of generating regional added value in the form of energy. By doing so, other sectors could benefit, for example, agriculture (from recycled water and sludge as a fertilizer) and industry (recycled water and energy). On this long transition towards sustainability guided by a Nexus approach, Serbia would have to solve many economical, technical, legal and institutional challenges (Figure 1).

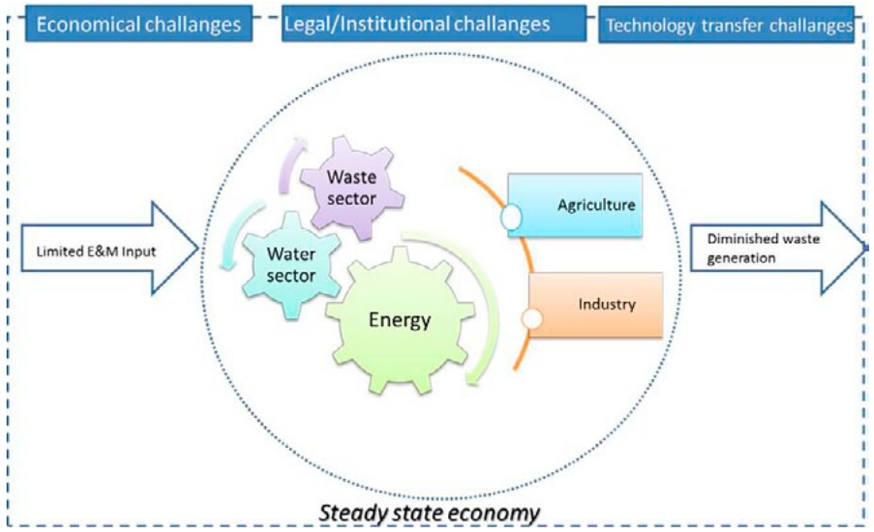


*Figure 1. Challenges and pathway towards a Nexus approach*

In order to demonstrate and to check possibility of applying a nexus approach of interlinking water-waste-energy management sector in Serbia, the city of Cacak was selected as a case study. The city of Cacak (114,809 inhabitants, 636 km²) is located in Central Serbia and represents one of the most common types of Serbian cities. Like many municipalities in Serbia, Cacak has been facing problems to reorganise the wastewater and waste management sector in accordance with environmental, economic and social principles of sustainability. The City of Cacak annually extracts ca. 11.5 Mil.m³ water. Losses are estimated to be 40% (City of Cacak 2011). Generated wastewater is evacuated with a 300 km long mixed-type sewage system serving 50% of mainly urban population and then discharged into West Morava River, effluent of the Danube River, without any treatment (City of Cacak 2010).

Due to the non-existing data, energy demand of the water use cycle (drinking water demand and wastewater treatment) was estimated in accordance to Cornel et al. (2011), considering low and high energy demand scenarios (Table 1).

Table 1. Estimated energy demand of the water use cycle in the city of Cacak, estimated according to Cornel et al. (2011)

| | Volume | Low energy demand | | High energy demand | |
|---|---|---|---|---|---|
| | ($m^3$/a)[a] | (kWh/$m^3$)[b] | (kWh/a) | (kWh/$m^3$) | (kWh/a) |
| **Fresh water intake** | 11,455,143 | 0.21 | 2,405,580 | 0.4 | 4,582,057 |
| **Water loss** | 4,238,403 | | | | |
| **Preparation and distribution** | 7,216,740 | 0.06 | 433,004 | 0.17 | 1,226,846 |
| **Wastewater collection and treatment** | 6,134,229 | 0.39 | 2,392,349 | 0.83 | 5,091,410 |
| **Wastewater discharge** | 6,134,229 | 0.11 | 647,756 | 0.11 | 674,765 |
| **Total estimated energy demand** | | | 5,905,699 | | 11,575,078 |

[a](City of Cacak 2011); [b](Cornel et al. 2011)



Inhabitants of the city generate 29,000 t/a of MSW, out of which organic part (OMSW) accounts for 65%. Since the beginning of 2012, the collected MSW has been disposed of at the newly build regional landfill, which is located 64 km away from the city.

For a defined case study an energy balance analysis was performed in order to check to which extent the energy demand of the entire water use cycle can be subsided by the energy produced from the locally available "waste flows". The idea is that the future wastewater treatment facility in the city of Cacak, besides its primary role of wastewater treatment, should also serve as energy generation centre by introduction co-digestion process of sewage sludge and OMSW.

Table 2 represents available material flows considered for the co-digestion and energy balance of the proposed solution. Based on the provided data showing that 50% of the inhabitants are connected to the sewer system and the industrial water consumption, capacity of the wastewater treatment (current conditions) was estimated to 65,215 p.e. (population equivalents).

The amount of sludge after dewatering process (gravity thickening assumed) is estimated to:

- Primary sludge 37 m³/day (calculated with 40 g/Cap*d primary sludge generation and DM 4% in fresh primary sludge and DM 7% after dewatering)
- Excess sludge 98 m³/day (calculated with 30.2 g/Cap*d excess sludge generation and DM 0.7% in fresh excess sludge and DM 2% after dewatering (DWA 2006)).

Thus, total amount of thickened sewage sludge available for the process of anaerobic digestion would be 49,545 m³/a. As a co-substrate, an OMSW amount of 18,850 t/a is available for the process of co-digestion. This would result in a total mixed substrate amount of 68,395 t/a. This amount of substrate has the potential to generate 2,015,680 m³ of biogas annually. The amount of slurry (output of the biogas rector) would account for 43,157 m³/a.

Table 2. Material flows considered for the co-digestion and their energetic potentials

| MATERIAL | UNIT | VALUE |
|---|---|---|
| **OMSW** | t/a | 18,850 |
| **DM OMSW (DM= 45%)** [a,c] | t DM/a | 8,483 |
| **oDM OMSW (oD.M=60%)** [a,c] | t oDM/a | 5,090 |
| **Biogas yield from OMSW** [a] | $m^3$/kg oDM | 0.30 |
| **Annual biogas yield from OMSW** | $m^3$/a | 1,526,850 |
| **Energy content biogas from OMSW** [a] | kWh/$m^3$ | 6 |
| **Annual energy yield from OMSW** | kWh/a | 9,161,100 |
| **DM Primary Sludge (DM Flow Mass= 40 g/Cap*d)** [b] | t DM/a | 952 |
| **oDM Primary sludge (oDM= 67%)** [b] | t oDM/a | 638 |
| **DM Excess sludge (DM Flow Mass= 30.2 g/Cap*d)** [b] | t DM/a | 719 |
| **oDM Excess sludge (oDM=70%)** [b] | t oDM/a | 503 |
| **Biogas yield from Sewage Sludge** [d] | $m^3$/kg oDM | 0.40 |
| **Annual biogas yield from sewage sludge** | $m^3$/a | 488,830 |
| **Energy content biogas from sewage sludge** | kWh/$m^3$ | 7 |
| **Annual energy yield from sewage sludge** | kWh/a | 3,177,395 |
| **Total Annual Energy Yield** | kWh/a | 12,338,495 |
| **CHP efficiency** electrical [c] | % | 0.40 |
| **Gross Electricity production** | kWh/a | 4,935,389 |

| | | |
|---|---|---|
| **Electricity used by the reactor (10%)** [c] | kWh/a | 493,540 |
| **Net electricity** | kWh/a | 4,441,858 |
| **CHP efficiency** thermal [c] | % | 0.45 |
| **Gross heat production** | kWh/a | 5,552,323 |
| **Thermal energy used for the reactor (35%)** [c] | kWh/a | 1,943,313 |
| **Net thermal energy** | kWh/a | 3,609,010 |
| **Total install capacity** | MW | 1.3 |
| **CO2 emission savings (0.8 kg CO2/kWh)** [c] | t/a | 8,390 |

*[a](DWA 2002); [b](DWA 2003); [c](BMELV 2010); [d](DWA 2006)*

The estimates show that generated biogas is sufficient to produce ca. 12,300 MWh annually (net energy of 4,441 MWhel/a and 3,609 MWhth/a). This means that the electrical energy produced would be enough to cover the entire wastewater treatment energy demand in the case of the least energy demanding technology, or ca. 75% in the case that the advanced technology is applied. If one considers the energy demand of the entire water usage cycle (drinking water and wastewater management) then the generated electrical energy would cover 75% of the minimum or ca. 40% of the maximum estimated energy demand. Additional benefits of such solution are: 3,609 MWhth/a generated heat and 43,157 $m^3$/a slurry which could be potentially used as a soil conditioner or for energy generation (e.g. incineration) Finally, the proposed solution would result in CO2 emission reduction of 8.390t/a (BMELV 2010).

Serbia needs a new approach in order to cope with the arising environmental, social and economic challenges. The Nexus approach may provide a suitable framework because of its holistic and future orientated principle. Concerning the case study of Cacak, a first evaluation of possibilities to activate regional potentials was analysed, focussing on flows which are traditionally referred to as unwanted (waste) products. The idea behind this evaluation is to prove to decision makers that wastewater and waste treatment projects should not be seen as expensive infrastructural projects, but rather as an opportunity for regional energy generation.

**Potential Nexus Applications to the Integrated Evaluation of Urban Water Systems in Mexican Context**

*By Gabriela Espinosa-Gutiérrez* | Institute of Wastewater Management and Water Protection. Hamburg University of Technology

The water management in Mexico currently faces several challenges. Two topics of concern are the availability and the quality of water resources. The average yearly water availability per capita ($m^3 \cdot hab \cdot year^{-1}$) has decreased by 77% between years 1950 and 2010 due to the population growth. Projections for year 2030 count with a further reduction of the availability. Furthermore, the distribution of the available water varies largely throughout the country, ranging from 164 $m^3$ per person each year in the driest regions of the country to 23,385 $m^3$ in the humid regions. The problem is aggravated by the seasonal character of the precipitation and consequent recharge of the renewable water sources since almost 70% of the yearly precipitation takes place from June to September (Comisión Nacional del Agua 2012, 28-32).

The quality of the available water is also of concern. Until 2003, Mexico was using an integrated index of water quality (índice de calidad del agua, ICA) which grouped 18 different physical and chemical parameters in a weighted manner. According to this index, in 2003 53% of all monitored superficial water bodies presented some degree of pollution, 23% presented a moderate degree of pollution and 11% was highly polluted (Secretaría de Medio Ambiente y Recursos Naturales 2005, 322-325). In 2009 it was determined that 21 water basins in the country were highly polluted regarding one or several water quality indicators. Simultaneously, 31% of the monitored superficial water bodies showed some level of pollution in terms of chemical oxygen demand (COD), 15% presented some level of pollution in terms of biological oxygen demand (BOD), and 7.5% presented pollution due to Suspended Solids (TSS) (Comisión Nacional del Agua 2011, 36-39).

The fact that the water is not equally distributed in the country and that the available water might be polluted represents a threat for the food production of today and in the future since the growing of crops require a secure source of water to ensure the necessary quantity and quality of products. Furthermore, untreated wastewater flows of cities might directly pollute the soils and reach the aquifers, threatening the health of the population.

The Mexican Water Agenda 2030 was created to establish strategies to counteract these problems and to meet international sustainability standards in water management issues. It includes as two of its main goals the improvement of water use efficiency (to ensure future availability) and avoiding further pollution of the water bodies (to protect its quality). To fulfil these goals in a sustainable manner, an integrated assessment and management of water in the cities is indispensable, given that cities represent an important pollution source for the water bodies. Conventional assessment approaches, however, are not carried out in an integrative manner.

To provide for an integrated evaluation of urban Water and Wastewater Management Systems (WWMS) in the context of Mexican middle sized cities and thus to contribute with a better understanding of the water and contaminant flows, a case study was carried out for the city of Tepic, located in the eastern part of Mexico. The goal was to depict all the water consumption processes as well as the pollution sources and paths in one integrated model in order to evaluate the inputs and outputs of the city and recognize as well the potential threats for the soil and water bodies. A representation of the created model and the included processes can be seen in Figure 2. The flows of drinking water, wastewater and rain water were included in the model as well as its Nitrogen and Phosphorus content to account for pollution sources in the city. Three scenarios were calculated representing the years 2007, 2011 and 2030.

Material Flow Analysis (MFA) was used to evaluate the scenarios. This methodology helps to assess a system's relevant flows and stocks in quantitative terms and it reduces the complexity of the system as far as possible while still guaranteeing a basis for sound decision making (Brunner and Rechberger 2004, 28). The MFA methodology has been used in the past as a tool for the integral evaluation of material flows in different contexts and at different geographic locations (see Bao et al. 2010, Meinzinger 2010, Belevi 2002 for some references). However, the practical application of MFA for the evaluation of urban water management in Mexico remains largely unexplored.

For the MFA work of this case study, data was obtained from measurements on site and from consultation of local experts. The data obtained included the groundwater abstraction volumes of all users, wastewater discharge volumes of industrial and non-industrial users, hydraulic capacities at the wastewater treatment plants and precipitation (rain), as well as nutrient concentrations in the flows and flow distribution coefficients in the processes. This information was complemented with literature values to construct a model of the city representing the water and nutrient flows. Through the balancing procedures of the MFA, it was possible to calculate the inflows and outflows of the city and its different paths. The potential application of such knowledge in a Nexus approach is promising.

From the input side, for example, it can be appreciated how much water in total is needed by the city for its population and for its productive activities under real conditions. Additionally, projections of the potential groundwater recharge from water leaks and rain water in the city are obtained. This is useful to make improved approximations of the aquifer exhaustion in the region and the rivalry between the city's and the agriculture's water needs. This research included the nutrient input as an internal supply process, however, an expanded model could include the amount of food (nutrients) required by the city from the agriculture and thus help to calculate the future needs of the city.

For the output side, the amount of untreated wastewater leaving the city as direct discharge or polluted rain sewer outflow is obtained. The total amount of Nitrogen and Phosphorus contained in such flows is also calculated. This information is required to assess the impact that the city has on the river quality. It is important as the same river may act as a water supplier for downstream agriculture and settlements and it may provide for groundwater recharge to a certain extent. The exfiltration of wastewater from the sewer to the soil is also an important flow requiring attention, as this can directly affect the groundwater quality and it represents a direct threat to the health of people using this water.

The integrated assessment renders information about internal processes that can and should be improved in order to achieve a better control of the city's exports. An example is the flow of untreated wastewater from the sanitary sewer towards the rain sewer; this flow pollutes the collected rain water which is only slightly polluted and it is then directly discharged to the river without treatment. On the other hand, there is also a direct input of rain water into the sanitary sewer increasing the transported volumes of wastewater and diluting the pollutants. As a consequence, the capacity of the treatment facilities is exceeded and the amount of pollutants in the direct discharge is increased. Furthermore, this flow increases the risk of sewer pipelines collapsing and of wastewater overflowing residential areas, threatening the health of the inhabitants.

The model is therefore useful in the realistic assessment of the water inputs and outputs of the city in terms of volumes as well as nutrient loads. Water sources, paths and destinations were recognized as well as the interactions between the different consumption, pollution and transport processes of the city. Furthermore, the model created in this research allows comparisons to be made before-and-after situations as well as the modelling of several solutions and its impacts on the city before decisions are taken. With this information, city planners and stakeholders are in a better position of implementing successful strategies to increase efficiency in water use and to avoid further pollution of the water bodies and therefore to contribute positively to water, and also food security.

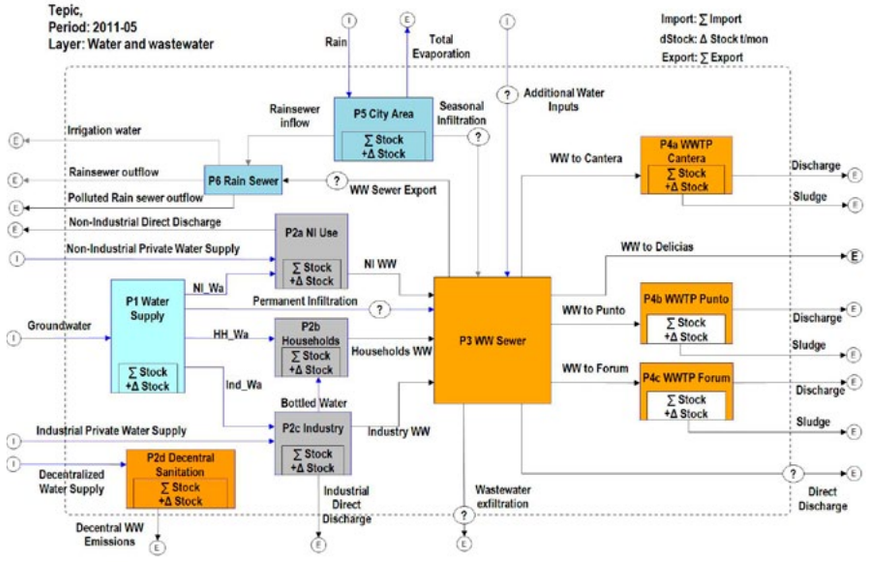


*Figure 2. Model of the city of Tepic representing the water, wastewater and rain flows*
*Abbreviations: E –Export, HH –Household, I –Import, Ind –Industrial, NI –Non Industrial, Wa – Drinking water, WW – Wastewater, WWTP –Wastewater treatment plant.*



**Land degradation in Ethiopia and its connection with management of water and waste**

*By Yohannis B. Tadesse* | Institute of River & Coastal Engineering. Hamburg University of Technology

Land degradation is one of the serious environmental problems in Ethiopia. While the term land degradation covers a wide range of issues, soil erosion, soil nutrient depletion and deforestation are most prominent in Ethiopia (Desta et al. 2000). Erosion costs Ethiopia an estimated soil loss of 137 ton/ha per year across the country (ATA 2013). Depletion of key soil nutrients such as nitrogen, potassium, phosphorus, organic matter, boron, and copper from arable lands is high (Smaling 1993, ATA 2013, Selassie and Belay 2013). The country has seen its forest shrink from about 40% coverage to almost nothing in less than a century (Bishaw 2001). Given that the country's economy relies heavily on agriculture – about 46% of the GDP, 85% of the employment and 90% of the country's export (Government of Ethiopia 2012), the land degradation problem needs to be addressed urgently to prevent further loss and rehabilitate already degraded sites.

The sources of land gradation in Ethiopia are complex and in general one type of land degradation can be cause for another. For example, soil erosion results in soil nutrient depletion, and deforestation causes the land to be exposed to erosive forces such as water and wind. While deforestation can be the result of natural factors such as landslides and wild fires, it is mainly caused by human activities such as agriculture, logging, clearing of forests for wood fuel, urbanization, mining, infrastructure development, etc (Allen and Barnes 1985). In the Ethiopian context, forests are cleared mainly to reclaim land for subsistence farming, wood fuel and construction material. It is exacerbated by rapid population increase.

Besides deforestation, the major factors that cause and/or facilitate soil erosion are low vegetation cover, terrain, rainfall characteristics, farming methods and practices, soil types, over grazing, extended use of sloping areas for grazing and farming, etc. (Bishaw 2001). Soil nutrient depletion is the decrease of soil nutrients crucial for plant growth such as organic matter, nitrogen, phosphorus, potassium and other, below the level needed for plant growth. The direct causes of nutrient depletion are mainly loss of topsoil by erosion, nutrient mining by crops, decrease or absence of fallow periods, unbalanced crop and livestock production. In Ethiopia, however, use of crop residue and cattle dung for household energy is worsening the problem of soil nutrient depletion. While the causes of land degradation previously mentioned are generally the direct causes, many researchers argue otherwise, underlining that inappropriate government land policies, dynamic land tenure systems, mismanagement of crop lands, negative impacts of technical change and poor institutions are the root causes of land degradation (Taddese 2001, Amede et al. 2001, Ananda and Herath 2003).

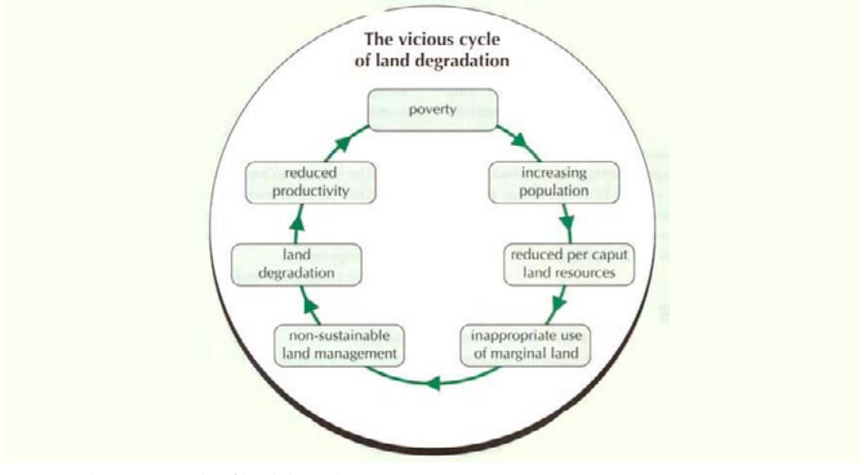


*Figure 3. The vicious cycle of land degradation (FAO 1995)*

Different solutions for the land degradation problem in Ethiopia that range from technical to institutional approaches have been proposed. Technical solutions such as improving the organic content of soil with legume cover crops, crop residue management, tree planting, alley cropping, etc. have been proposed as a solution to the land degradation problem (Amede et al. 2001 and Bishaw 2001). On the other hand, Ananda and Herath (2003) suggest that recognizing institutional and environmental dynamics and strengthening institutions are crucial to alleviating the problem.

Both the technical and institutional solutions have to be accompanied with approaches that strengthen the livelihood security of the farmers if they are to result in a lasting solution. This is particularly important in the Ethiopian context since the land degradation problem has resulted in vicious cycle of land degradation (see Figure 3) in which the farmers are unable to invest in their land. This triggers further land degradation and in return causes the farmers to become even poorer.

The problem of land degradation in Ethiopia has to be seen in a nexus way with the management of water and soil. In the process, reducing the entire reliance of the farmers on land resource for their livelihood should be sought. To achieve this, the utilization of water and waste resources can be intensified. The following section highlights how the wise management and utilization of water resources and waste can help alleviate the problem of land degradation.

*Addressing land degradation via a nexus approach*

Desperation has led to the major causes of land degradation in the Ethiopian context as highlighted above. Question of survival (Lal 2013) has led communities to farm marginal lands, over graze, use forests for wood fuel, construction wood, use animal dung for fuel, etc. Prudent planning and utilization of the country's water resources can strengthen the livelihood security of these communities. Irrigation and hydropower generation are key water utilizations that can reduce the problem of land degradation.

In Ethiopia, crop is harvested mainly once a year per plot of farm due to the rain-fed nature of the country's agriculture and availability of rainfall mainly during single season of the year. With the population increasing, more land needs to be under cultivation to secure food in this manner, requiring clearing of forests for crop production, farming of marginal lands, avoiding of fallow, etc. However, irrigation can be employed to produce crop about three times a year, enabling production of more food from a given piece of land. This, in turn, reduces soil nutrient depletion on other sites: less land under farm means more forest for wood fuel and construction wood; so plant residue and animal dung, that otherwise are used as energy source, would be available to maintain the soil nutrient. Moreover, greater harvests each year would enable farmers to have the resources to invest on their land.

Ethiopia is endowed with high hydropower potential. However, only about 5% of the hydropower potential is utilized so far (Derbew 2013). The utilization of the country's vast hydropower potential has to be intensified to replace the widespread use of biomass among urban and rural population with hydropower generated electricity. A lot of plant residues, forest and animal dung, which are currently used as energy sources by about 90% of the population (Derbew 2013), can be saved. This would have an enormous impact on soil nutrient and thereby on agricultural productivity.

Urbanization in Ethiopia is growing at a fast rate. This has resulted in huge waste management problems in cities and towns. Generally, much of the waste comes from households, consisting mainly of organic waste from food leftovers. For example, 70% of Addis Ababa's solid waste is organic (Fekade 2009). One can expect even a higher ratio of organic component of solid waste in other parts of the country. The leftovers from food have a lot of nutrients taken up from the soil during their production. For sustainable management of soil nutrient, these nutrients need to be replenished in one way or another. Methods to convert waste into useful components are already available. Organic waste can be easily decomposed into bio-gas and compost. Compost is very useful in improving the organic content of soil. Bio-gas, on the other hand, can be used as energy source for household cooking and lighting. While the compost directly helps to improve the soil nutrient, the bio-gas is indirectly useful in alleviating land degradation problem since it reduces the need for plant residue, wood fuel and animal dung as energy sources.

Land is a critical resource, particularly in developing countries such as Ethiopia since much of the livelihood relies on agriculture. Therefore, sustainable management of land is imperative for any development effort the country is making. The management of land resources is highly interlinked with management of water resources and waste. To combat problem of deforestation, soil erosion and soil nutrient depletion in Ethiopia, smart utilisation of the country's water resources for irrigation and hydropower generation is necessary. In addition, continuous productive land needs the replenishment of the nutrients taken up by crops or animals back into the soil.

**Opportunities for the water, energy and food security nexus in South Asia**

*By Shobana Srinivasan* | Institute of Wastewater Management and Water Protection. Hamburg. University of Technology

South Asia falls under the category of critically water stressed regions in the world. Due to rapid industrial growth, the demand for water is increasing in urban regions, which decreases the amount of water available for agriculture. Also, several parts of this region experience erratic monsoon patterns making them heavily reliant on surface and ground water resources for irrigation. Approximately 70 – 80 % of India's agriculture is dependent on groundwater (Narayanamoorthy 2007, 349-362). There has been poor water management and over exploitation of groundwater for agriculture resulting in declining water tables. High electricity demand for agriculture competes with growing industrial needs. South Asian countries are ultimately dependent on each other and on external water resources coming from the Himalayas and water security is under threat. This can be seen based on the share of external renewable water resources in some countries of South Asia (Table 3).

Table 3. External Renewable Water Sources in Some South Asian Countries: (Chellaney 2011)

| Country | External (million $m^3$) | Total (million $m^3$) | External Dependency Ratio (%) |
|---|---|---|---|
| Bangladesh | 1,105,644 | 1,210,644 | 91.30 |
| India | 647,220 | 1,907,760 | 33.40 |
| Nepal | 12,000 | 210,200 | 5.70 |
| Pakistan | 170,300 | 225,300 | 75.59 |

The Indus-Ganges-Brahmaputra Plains which is the agricultural zone of this region is dependent on water supply from the Himalayan glaciers. But according to the report by IPCC (2007), climate change would take its toll on fresh water availability, hence limiting crop productivity and food security in the future. Shortage of energy for agriculture adds to the problem. All South Asian nations are in the development phase depending widely on conventional energy sources like coal and gas although there is room for development in the renewable energy sector. The prices of oil and gas imported are increasing steadily and the supply remains unreliable. Measures taken to decrease the demand-supply gap in energy could boost the economic growth in these regions (Koch 2012). The rural population in the South Asian countries lack access to proper electricity making them dependent on bio fuels like Jatropha and biomass for agricultural residues and cow dung for fulfilling domestic needs. Hence, there is a progressive decrease in soil fertility due to lack of natural fertilizers and competition for energy crops. This limits the expansion of food crops, which needs to be intensified in order to supply food for the enormous population. As food, water and energy security are related to each other, developing sustainable approaches in any direction will have

a positive impact on the other two. For instance, sustainable agriculture can lead to lesser consumption of water and energy, maintenance of water quality and prevention of soil degradation. Integrated water resources management can contribute to reduction in energy consumption and mitigate water scarcity. Furthermore, policies framed in any one of these sectors will have a strong influence on the other sectors as well. Therefore, having a better understanding of the linkages between food, energy and water will help formulate better policies for adapting to future needs (Rasul 2012, 3).

To develop and implement a nexus approach to enhanced food, water and energy security, the Indian sub-continent needs to take into consideration the ecosystem services provided by the Himalayas. The resources from this mountain range have been indispensable for the development of the plains downstream. The Himalayan glaciers have around 12,000km³ of fresh water locked in ice masses supplying water to three major river systems in South Asia (IPCC 2007). Since most of this water is used up for irrigation, food production in the plains of the rivers Ganges, Brahmaputra and Indus are completely dependent on surface and ground water sources arising indirectly from the Himalayas. The Himalayan vegetation, its water sheds and its aquifers are responsible for the supply of ground water. Managing the forest, soil and aquatic ecosystem in the ranges will ensure reduced run off, prevent heavy floods and increase the infiltration of water to recharge the aquifers. Also, the Himalayas have huge potential for renewable sources of energy like hydropower, wind and geothermal power. The total estimated hydropower potential in South Asia sums up to 500 GW (Vaidya 2012, 11-19). Only about 7 % of this potential has been realized so far. Developing low impact hydro power plants can not only reduce the regions power demand but also decrease its reliance on fossil fuels and mitigate the impacts of micro climate changes due to greenhouse emissions in the Himalayas. There is also a huge and promising geothermal capacity stored in the valleys and hot springs amidst the vast mountain range. The Geological Survey of India recognizes about 10,000 MWe power from geothermal sources of which 5,000 MWt comes from the Himalayan hot spots (Chandresekharam 2005, 24-29). Although the geothermal potential of Nepal is unknown, the hot springs generate revenue to the government via tourism.

Apart from providing water and energy to South Asia, the Himalayas influence the micro climate of the region by ensuring monsoon circulation. The Himalayas have a wide range of fauna and flora of which many plants have medicinal value and serve as food for the mass populations. Many fruits and vegetable harvested in this region are circulated all over south Asia and the rest of the world.

This ecosystem has to be protected from degradation and negative influences. Destruction of this ecosystem in any form will shift the balance maintained leading to crucial loss in any of the services provided to the plains. Therefore, all the South Asian countries must consider steps to sustain and protect the Himalayan ecosystem in order to build a sustainable future for water, energy and food supply. This measure will also enhance the lives of people living in the mountain region and promote sustainable agriculture, optimum water usage and renewable energy supply downstream. Key features concerning Himalayan ecosystem management that have to be included in the future policies are:

- Conserving the soil quality and water infiltration capacity by afforestation of degraded lands and preservation of existing forests. Development of soil quality can bring about improved water retention capacity ensuring prolonged ground water supply and protection from floods and landslides.
- Promotion of hybrid solar and wind energy systems which supply electricity and energy supply to the rural population in the Himalayas reducing their dependence on fire wood and biomass for cooking .The crop residues and extra biomass produces can be used to enhanced soil quality via composting techniques.
- Production of energy crops in barren lands to prevent its competition with food crops.
- Conservation of wetlands, lakes, aquifers and permafrost regions.
- Monitoring and maintenance of water quality upstream, especially in pilgrimages to ensure lesser pollutant load downstream.
- Promotion of environmentally sound infrastructure for water supply, hydro and geothermal power plants and irrigation downstream to reduce run off rates and prevent damages due to floods (Rasul 2012, 7).
- Development of eco-tourism as a means of sustainable development of the mountain region.
- Providing incentives for the mountain communities to preserve and manage the wide ecosystem and creating awareness by implementing schemes like rain water harvesting, wood gas production, eco sanitation, renewable energy supply and organic farming.

These steps, if included in nexus development policies can definitely put the resources available to optimum usage guaranteeing water, energy and food security in South Asia. The International Centre for Integrated Mountain Development (ICIMOD) has been working in the Himalayan region monitoring the climate change adaptation measures, resource management and collaborating with countries of South Asia to enable policy reforms. More research has to be done to reveal the full benefits of the water-food-energy nexus in order to be viewed as one and addressed in an integrated manner.

**Climate Change adaptation and Storm Water Management in Al Hillah, IRAQ Nexus Approach**

*By Firas Al Janabi* | Institute of Hydrology and Meteorology & Institute for Urban Water Management, Dresden University of Technology

The observed increases in temperature along the last century will continue at even higher rates, which will significantly affect the water cycle. Climate change projections indicate that the intensity and frequency of extreme rainfall will increase over many areas of the world in the 21st century. Urban drainage systems are vital infrastructure in urban settlements whose main objective is flood protection. These systems are designed with historical precipitation data assumed not to change, and in general, have very long lifetimes. The aforementioned increases in extreme rainfall represent a challenge for the design and management of such systems, which has encouraged a significant amount of research about the potential consequences and possible adaptation measures. However, these studies have mainly focused on the most direct impacts, such as damages to infrastructure, leaving the social and institutional dimensions of climate change out of the discussion.

Adaptive capacity is defined (IPCC 2007) as "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences". The determinant factors of adaptive capacity can be grouped into three dimensions; the awareness, the ability and the action dimensions. The first deals with the role of knowledge in adaptive capacity; the second is related to the potential to design and implement adaptation measures in terms of technology and infrastructure; and the third is also related to adaption solutions, but in terms of economic resources available and the effectiveness of institutions, (EEA 2012).

Assessing all dimensions of adaptive capacity is not an easy task, which is exacerbated by the poor information available. It is carried in terms of knowledge about climate change and perception of the risks, related to the urban drainage systems. Even though this is not sufficient to assess adaptive capacity as a whole, which requires further analysis, it is a first step.

The objective of this work is to provide recommendations for climate change adaptation in the city of Al Hillah (Iraq) including institutional and social dimensions. Al Hillah city is the capital city of Babylon province – Iraq (Figure 4). It is located on the Al Hillah River near the Euphrates River in central Iraq, close to the ruins of Babylon. Roughly 97 km south of Baghdad, the city is on the flood plain between the Tigris to the east and the Euphrates to the west. Mean elevation of the area is about 30 m.a.s.l., augmenting very gradually southward (USNRL 2009).

Since the required data for working out the recommendations for climate change adaptation were largely lacking for Al Hillah, the approach taken was to merge information from the review of five cities from different regions of the world. The main criteria for the selection of the cities were the amount and quality of the

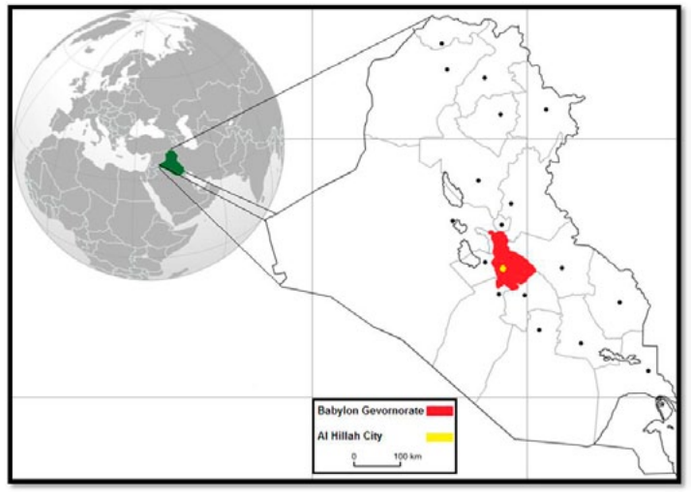


*Figure 4. Location of Al Hillah City., Iraq*

information available in terms of climate data and urban water data, also the variety of the climate (covering climate change projections, impact assessment and adaptations to climate change while taking into account the social and institutional dimension of climate change, with a focus on the storm water system); it was also important to cover a wide range of regions and climates, resulting in different boundary conditions. The cities selected, and the main reason for their selection, are given in the following Table 4. See Figure 5 for the geographic location of the studied cities, including the City of Al Hillah.

**Table 4. Selected cities, main criteria for the selection and type of data/information considered to be used in a case study of the city of Al Hillah, Iraq**

| City | Criteria for the selection | Data type |
|---|---|---|
| Seattle | Adaptation plan(structural and non-structural measures) | Urban drainage data from the city of Seattle |
| Odense | Adaptation implemented - economic assessment | Adaptation reports data |
| Tehran | Quick improvement of the urban water system | Urban drainage data |
| Khulna | High vulnerability of Bangladesh. Social aspects considered. | Urban drained data from the Asian Development Bank |
| Melbourne | Developed adaptation plan (social aspects considered) | Urban drainage data |

Table 5 provides a brief, general description of the selected cities, along with their main characteristics including geography, topography, population and importance within their country. It can be seen that most of the selected cities are located in coastal areas except the city of Tehran. Most of the reliable studies are focused on coastal cities (e.g. New York, Amsterdam, Ho Chi Minh), probably because they are more aware of the vulnerability of drainage systems and the consequences.



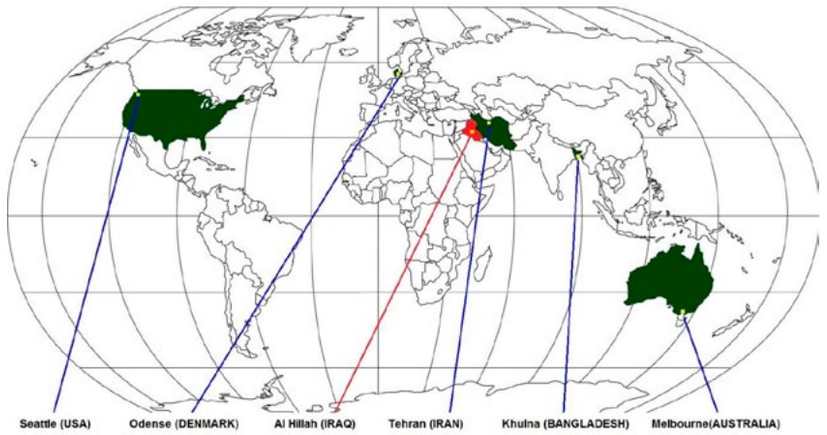


*Figure 5: Approximate geographical location of selected cities. Table 5 provides a brief, General*

**Table 5. General description of the selected cities and of Al Hillah**

| Study cases | Seattle | Odense | Tehran | Khulna | Melbourne | Al Hillah |
|---|---|---|---|---|---|---|
| Country | U.S.A. | Denmark | Iran | Bangladesh | Australia | Iraq |
| Area ($km^2$) | 370 | 305 | 686[7] | 45.65 | 37.6[8] | 64 |
| Population | 600.000 | 170.000 | 8.244.535 | 1.000.000 | 100.000[2] | 500.000 |
| Elevation (m.a.s.l.) | 56 | 13 | 1.200 | 2 | 32 | 33 |
| Latitude / Longitude | 47°37'N / 122°21'W | 55°22'N / 10°23'E | 35°42'N / 51°25'E | 22°49'N / 89°34'E | 37°49'S / 144°58'E | 32°29'N / 44°28'E |
| Brief description of topography | Located in an isthmus between a sound and a lake. It is a hilly city. | Located by an estuary in the Funen island, with small valley formations1 | Southern part is flat, with high mountains to the north and east. | Deltaic plain, with smooth slopes (flat), located near the coast.[10] | Located by a bay, very flat. Mountains to the east of the metropolitan a area. | Very flat alluvial plains. It's characterized by low elevation and poor natural drainage. |

*[7](City of Tehran 2013); [8](City of Melbourne 2009); [9](Fryd 2010) [10](Asian Development Bank 2010)*
*Source: Online entries in wikipedia.org for each city. Other sources indicated as footnote.*

There are some similarities between the catchments studied, but also significant discrepancies. For example, the area analysed in the city of Tehran is much larger than the entire city of Khulna. Despite the fact that much of the city of Tehran is flat (southern part), the catchment analysed is in the northern part, near the Alborz Mountain, characterized by steep slopes as well as receiving more precipitation than other areas of the country. The rest of the catchments studied, especially the city of Khulna, are relatively flat.

*Climate projections for Al Hillah*

For the Babylon governorate, whose capital city is Al Hillah, three stochastic weather generators have been used to produce future climate projection at a daily resolution. The performance of three different WGs was assessed by comparing the synthetic climate data produced by them with the observed data from eight climate stations across the governorate. The WGs used were the GEM6, ClimGen and LARS-

WG, with the latter resulting as the best performer. The site climate change scenarios were produced using the LARS-WG scenarios tool forced with Five GCM's, the B1, A1B and A2 emission scenarios and for two different periods of time, 2046-2065 and 2080-2099 (Figure 6 and Figure 7).

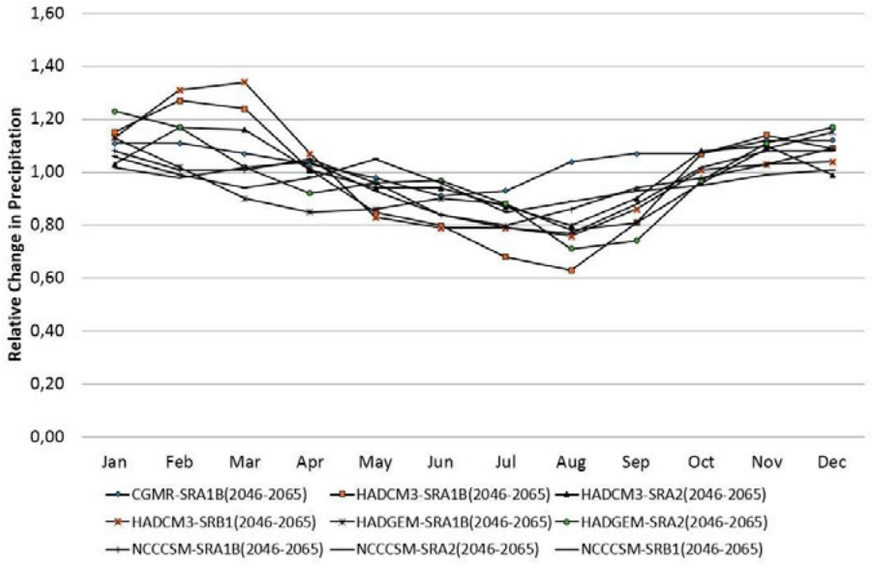


*Figure 6. Relative projected changes in precipitation in Babylon region 2046-2065 according to results derived from LARS-weather generator*

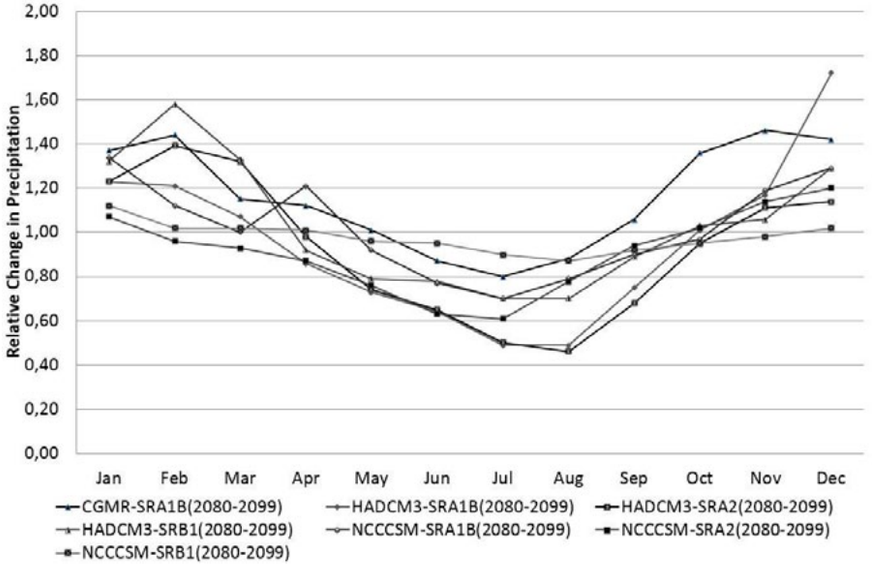


*Figure 7. Relative projected changes in precipitation in Babylon region 2080-2099 according to results derived from LARS-weather generator*



Despite the differences in the outcomes due to the different GCM's and emission scenarios used, the results in general suggest an increase in average temperature and a decrease in precipitation totals. In the winter period, December to March, a positive relative change indicates an increase in precipitation (Figure 7). However, less precipitation occurring as rainfall is expected in winter due to the increase in temperature, but then more extreme rainfall events are expected. Rainfall in summer will become even scarcer, and droughts are expected to become more frequent and prolonged.

The coverage of urban drainage system in the urban areas in the Babylon governorate is relatively low, and according to Al Meini (AWC 2010), its development is constrained due to technical, institutional and economic factors. These are essential dimensions of adaptive capacity, which indicate the ability of a system, in this case the city, to adjust to a changing climate. These gaps in adaptive capacity and the necessity to improve the current drainage system are similar conditions to those present in the city of Khulna, which were overcome to a certain extent by cooperation with international institutions.

*Recommendations for climate change adaptation*

Thus, following the approach of Khulna can be an option for the city of Al Hillah in order to improve the adaptive capacity of all stakeholders, and extend the urban drainage system of the city to reach a higher coverage. This adaptation measure is an important step considering the focus of this study, as it will improve equity in the city, the key factor in the social dimension of climate change.

The case of Tehran may not work properly as a recommendation for Al Hillah city because of the future urban water systems design ideas. While the city of Al Hillah needs covered pipe systems to solve the main problems of the floods in the districts, Tehran uses open channel systems as a part of the urban drainage system.

Adaptation to climate change is a long process that should be started as soon as possible. The focus should be placed first on non-structural measures such as enhancing adaptive capacity of institutions and stakeholders, development pro-adaptation policy and legislation, and increasing research and studies on the topic.

It is important to create a working group dedicated to climate change adaptation on the urban water sector (e.g. as done in Odense and Seattle), where stakeholders from different disciplines and governmental agencies collaborate, which in return will help to increase awareness at all governmental levels. Personnel from the urban water management institutions should play key roles within the group.

In this context it is also important to develop guidelines for adaptation at high governmental scales to be used at regional and local scales. The guidelines developed in Denmark can be a very good example. They establish a minimum level of service, one of the main questions to address in adaptation (Willems 2012), and indicate the steps to follow for the selection of appropriate adaptation measures, ensuring equity among all municipalities, one of the main aspects of the social dimension of climate change.

Among the considered cities, Odense, and in general Denmark, had the most complete adaptation strategies, so it seems advisable to keep on reviewing their advances, as they seem to be rather compromised and on the right track. However, the boundary conditions, from climate to socio-economic characteristics are completely different, and many of the measures implemented in one city may not be effective in the other. For structural measures it may be more interesting to follow the advances in the city of Melbourne, and in general Australia, as some of the boundary conditions are similar. They are likely to serve as the basis for an adaptation plan not only in Al Hillah city, but also at a larger scale; for example, the country as a whole or even the region if the urban drainage systems is found to have similar boundary conditions.

**Nexus Approaches to Soil, Water and Land-use Management in China**

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The Loess Plateau in NW China is one of the most fragile and erodible areas on the earth with a commonly reported erosion rate ranging from 20,000 to 30,000 t km² y-1 (Xu et al. 2004). For controlling soil erosion at the Loess Plateau, large-scale vegetation restoration (e.g., afforestation) and building of terraces and check-dams (sediment-trapping dam) have been implemented over the past 50 years. All of these measures are considered effective and beneficial for enhancing soil infiltration, increasing water use efficiency, alleviating flash floods, enlarging carbon sequestration and supplying timber. Nevertheless, several researchers have found wide-range implementation of land use modification without considering potential side-effects could raise problems; for instance, afforestation could reduce water yield (Zhang et al. 2008) and increase the severity of water shortage (Cao et al. 2009), and cause conflicts between decreasing arable land resource and increasing population (Chen et al. 2007). In addition, predicted changes in climate may enhance existing water shortages. Thus, adaptive innovative management strategies are necessary for mitigating water use conflicts and ensuring regional sustainable development. A key step towards such strategies is to improve our quantitative understanding of response of water resources components (e.g., precipitation, evapotranspiration, runoff) to different land cover / form and climate change across different scales.

In terms of scale, land use and climate may have varied roles in controlling water yield. Specifically, climate impact may occur at large scales and is likely to be unitary in both small and large catchments, thus consistent in a region. In contrast, land management change is a typical local phenomenon and its effect significantly decreases with increasing spatial scale (Bloeschl et al. 2007). Yet, whether there is any dependency between catchment size and the hydrological response to changes in land management and climate has rarely been studied in a systematic way. So far, only the impact of afforestation / reforestation on water fluxes has been widely addressed within a number of conservation measures. Other soil conservation practices, such as constructions of level terrace and check-dams, have been seldom discussed. The difficulties are, on one hand, a lack of spatially explicit data on soil conservation; on the other hand, there are still difficulties to integrate terrace into hydrological models. For these reasons, the use of distributed and process-based models for assessing changes in water fluxes at the catchment scale is hampered. To overcome these shortcomings, decision supporting tools (e.g., statistical models) using available, yet limited, datasets to quantify the hydrological responses to changes in land cover and climate must be developed.

Given the context, this study addresses the following research questions:

- What kind of different roles do various soil conservation measures play in controlling water yield?
- To what extent does land use and climate change contribute to water yield reduction across different scales?
- Is it possible to develop an empirical tool to assess the impact of various land management strategies on water yield?

To answer the research questions, the impacts of land cover / form and climate change over the past five decades have been investigated in small and large catchments of Jing River (Gansu province, NW China) as a case. Jinghe, as a secondary tributary of the middle reaches of the Yellow River, covers a drainage area of 3,082 m² and is characterized by arid and semi-arid transitional climate.

In a small watershed (19 km²), using statistical analysis approaches, the trends and variations in annual streamflow (Q), precipitation (P), potential evapotranspiration (PET) and climatic water balance (CWB) were examined for the last 50 years. The results detected a statistically significant decreasing trend in annual Q, while no statistically significant trend was identified for P, PET and CWB. Furthermore, an abrupt streamflow reduction due to massive land use change was identified around 1980. Using this year, the runoff record was divided into two periods: initial period and transient period. Subsequently, the contributions of land use and climate change to water yield reduction were quantified. Our results provided evidence that land cover / form change and precipitation variability are the major factors reducing runoff



at the small catchment scale; specifically, 74% of runoff reduction may be attributed to land-use change, while climate takes responsibility of 26%. Among all of the soil conservation measures, afforestation and terrace construction appear as the cause for considerable reduction in water yield. The runoff coefficients of forested and terraced land are only 1.6% and ≈0. With respect to climatic parameters, precipitation appears as the decisive factor in controlling runoff. Moreover, a good correlation between the ratio of runoff to precipitation and the percentage area of various land use types was found.

Nevertheless, the contribution of land use and climate change on water yield may vary from small to large scales. To analyze this relation, a meta-analysis using catchment sizes ranging from 10 to 1,000,000 km² on the Loess Plateau was conducted. The results indicate that the change rate of runoff due to land use and climate change depends on catchment size (Figure 8). As a local phenomenon, the effect of land use decreases rapidly with increasing catchment scale, and finally subsided at about 6, 000 km², while the impact from climate remains at a steady rate on large scale (> 6,000 km²). After investigating the relationship between climatic factors, land use and runoff on large scale (upstream of Jinghe, 3,080 km²), normalized CWB, namely (P-PET)/PET, was found to be another decisive factor in addition to precipitation affecting runoff, which describes the evaporative demand of the atmosphere.

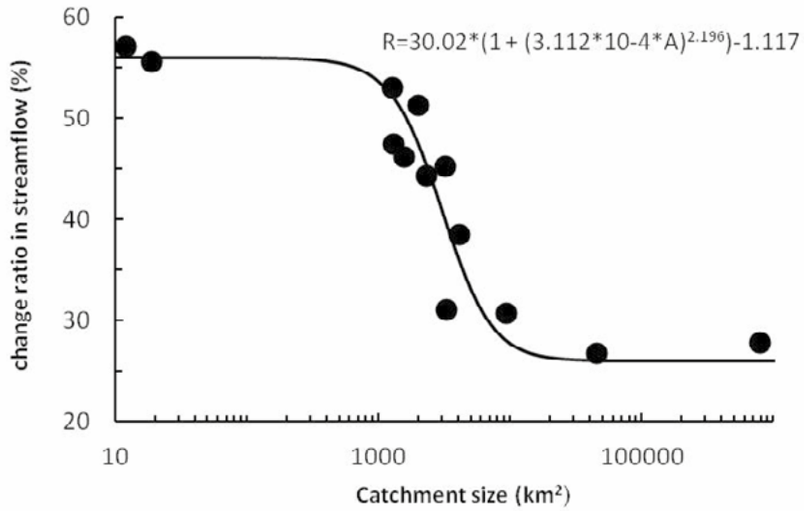


*Figure 8: Dependency between catchment size and change rate in streamflow in the Loess Plateau region (Zhang et al. 2014)*

So far, water (precipitation) and energy (PET) availability are recognized as the key factors driving evapotranspiration rates (Budyko 1958) and statistical models were constructed for estimating evapotranspiration. But the disadvantage of such models is that they could not reflect the impact of changes in land management strategies on runoff due to incapability of integrating land-use factors into the model. Thus, from the view of water resources management, an approach that can adequately depict the relationship between land-use pattern, climate variability, and water yield is required.

On the basis of the relationship among land use, climate and runoff in small watershed (Zhang et al. 2014), a new statistical approach that incorporates temporal changes in land cover / form and climatic parameters for predicting annual and long-term runoff was derived. This model describes runoff as an integrated output of a complex interaction between available water and energy, type of land use and catchment properties. This approach proved to have higher predictive ability than other models in reproducing runoff. The main advantage of this approach is that it directly links the effects of climate, catchment characteristics and different land use / management form to variations in runoff (Figure 9). Here, the dryness index (PET/P)

indicates the annual variability in climate. Our analysis implied that large-scale afforestation and terrace causes a significant decline in runoff. If we consider the dryness index as an indicator for various climate conditions in sub-catchments, we can see that expanding afforestation may cause more significant runoff reduction in relatively more humid sub-catchments than in the relatively drier sub-catchments in terms of absolute quantity. But in terms of percentage, it is probably more critical for drier sub-catchments, due to their more limited water availability. This may have severe consequences for water resources management and sustainable development in this region, especially in dry areas (high dryness index), which already suffer from severe water shortage. In these areas, it appears to be more appropriate and feasible to establish grassland rather than closed forest stands for preventing soil erosion. A compromise may be to have a reduced number of trees on grassland. This may be an effective contribution to mitigate and/or control the adverse effects of extensive soil conservation measures on runoff.

Our results show that implementation of project for ecosystem restoration requires careful consideration of side-effects and evidence-based planning. In this context, a nexus approach to soil and water resources management is useful in developing adaptive management strategies for harmonizing soil management and water supply security in the dry land region of China.

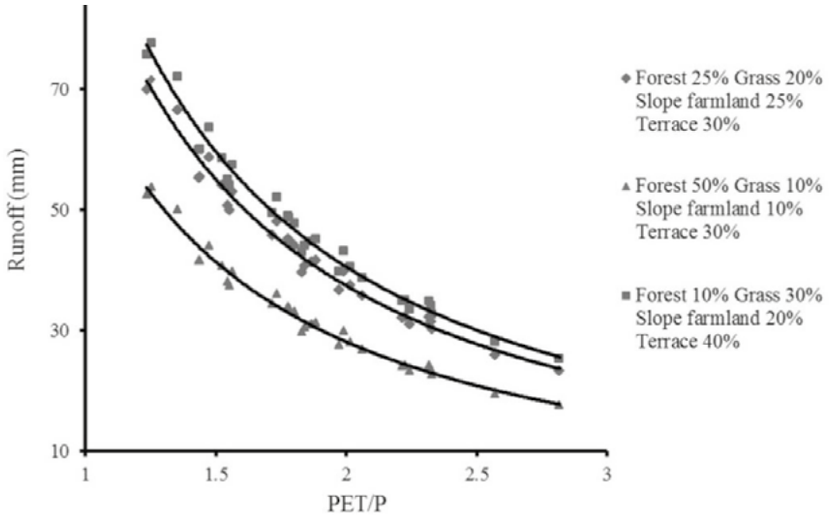


*Figure 9: The variation of annual runoff against index of dryness (PET/P) under different land use (percentage in areal cover) (in submission)*

**Conclusions**

Proper management of water resources is a demanding task, calling for good governance at the local, regional and global levels. Furthermore, it requires linkage between policies and institutions of other sectors such as waste, energy and food productions. Population growth, climate change and unsuitable land use management have been additionally affecting water management, especially in developing countries.

Within six case studies, specific problems in the water sector in different continents were outlined. While the addressed issues related to water resources are different and vary due to the various contexts from country to country, they all show that water management strategies or solutions to water related problems cannot stand on their own. Water resources are affected and constrained by many other factors such as land and waste management, as well as climate chan ge. Moreover, they are inter-connected and interact in a complex way.



Therefore, we need to focus on integrative approaches of linking different sectors which offer sustainable solutions and adaptive strategies to ensure water supply and food security in the future. The solution depends on recognizing the root causes of the problems and dealing with them instead of only mitigating the consequences. For this purpose, improved monitoring, modeling and forecasting technologies can be a key success factor in providing decision makers and stakeholders with more precise and accurate information. In this context, nexus approaches that are developed under various frameworks would be useful tools for developing adaptive solutions and measures, ultimately, ensuring the sustainable development.

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**List of Acronyms**

| | |
|---|---|
| **ATA** | Ethiopian Agricultural Transformation Agency |
| **AWC** | Arab Water Council |
| **BMELV** | German Federal Ministry of Foof, Agriculture and Consumer Protection |
| **BMU** | German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety |
| **BMZ** | German Federal Ministry for Economic Cooperation and Development |
| **BOD** | Biochemical Oxygen Demand |
| **CNA** | Comisión Nacional del Agua (Mexican National Water Commission) |
| **COD** | Chemical Oxygen Demand |
| **CWB** | Climatic water balance |
| **DWA** | German Association for Water, Wastewater and Waste |
| **EEA** | European Energy Agency |
| **GCM** | Global Climate Model |
| **GRS** | Government of the Republic of Serbia |
| **ICA** | Indice de Calidad del Agua (Water Quality Index) |
| **ILRI** | International Livestock Research Institute |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **MFA** | Material Flow Analysis |
| **MSW** | Municipal Solid Waste Management |
| **PET** | Potential evapotranspiration |
| **SEMARNA**T | Secretaría de Medio Ambiente y Recourses Naturals (Mexican Ministry for the Environment and Natural Resources) |
| **SORS** | Statistical office of the Republic of Serbia |
| **TSS** | Total Suspended Solids |
| **USNRL** | U.S. Naval Research Laboratory Marine Meteorology Division |
| **WG** | Weather Generator |
| **WHO** | World Health Organisation |
| **WWMS** | Water and Wastewater Management Systems |



## 8.4.2 African Development Bank's Experience Following Nexus Approach – Case Studies in Integrated Watershed Management to achieve Food Security and Sustainable Natural Resources Management from the Republic of Cape Verde, Burundi and Gambia

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**Abstract**

This paper looks into AfDB's experience in integrated watershed management to achieve inclusive green growth, sustainable development and food security objectives by adopting nexus approaches in Africa. The population growth, food insecurity, poor water and natural resources management have been some of persisting challenges faced by the African Continent. The African Development Bank (AfDB) and other development partners are involved in the efforts to overcome these challenges faced in achieving poverty eradication, food security, drought resilience and fight against desertification, and climate change through affective integrated watershed planning and management involving stakeholders' at all levels. The outcome of these interventions provided the local population skills to help themselves manage in a better way the indigenous natural resources. Such moves are known to contribute well to economic growth and better life of the humanity and work force in these areas. AfDB came forward to provide financial support besides its role in imparting knowledge, learning and skills development programs. For better understanding of the nexus approach, efforts have been made by the AfDB to introduce the issues concerned followed by three case studies undertaken in the Republic of Cape Verde, Burundi and Gambia. The AfDB experience under three case studies showed that to achieve inclusive and green growth objectives in sustainable natural resources management, the Nexus Approach in soil, water and waste should focus on communities based integrated watershed planning and management equally supported by the relevant rural development interventions.

**Introduction**

Water, soil, and waste systems are interconnected and efforts have been made to introduce and develop nexus approaches in an environment-friendly and integrated manner to ensure sustainable management of water, soil, and waste, thereby enhancing food security for an ever-growing population (Aller et al. 1991, Kirkeby et al. 2006). The term Nexus is commonly used to define how and where these systems intersect. Because actions related to one system can impact one or all of the other systems, it became a necessity to adopt a nexus approach. At the core of the Nexus approach is a strong understanding of the interdependencies among these systems, as exemplified for water, soil and waste (Lal 2012, 2013). Obviously the Nexus approach will require an integrated approach to be adopted by involving all kinds of stakeholders' including: the individuals, businesses and government. To advance the goal of integrated planning, policy and management, it is important to increase awareness about how these three systems intersect, and that is why greater coordination of the multi-stakeholders' is necessary (Kirkeby et al. 2006, Wieder and Kelman 1993). In continuation of the research work at AfDB on water-soil-waste nexus, three case studies conducted in Africa are presented in this paper.

The case studies successfully demonstrated the significance of multi-stakeholders' driven nexus approach with multi-faceted dimensions of water resources development to achieve food security and to meet human development objectives. It is noteworthy that such a water system includes the water cycle and the major interacting elements namely: the physical, biological and biogeochemical, and the human components (Turner et al. 2004).

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Any change in the said components will cascade throughout the whole system. Therefore, it is well needed to include the learning process and interaction with the society to be ready to understand and know the changes occurring around. There is a consistent need to know and observe conditions acting as indicators, which might be for example: depleting water level, population growth, water quality, and existing management. The environmental conditions, water flow, water for agriculture, level of nutrients in water, all such factor count in developing economic crops. On the other side knowledge about water for irrigation, water pollution, concept of waste disposal and good management system are the basic requirements in developmental processes for national and in global context (Paul and Steinbrecher 2013). AfDB took a lead in providing funds as well as transferring skills to facilitate the implementation and success of Nexus approaches.

It has been well documented that during the second half of 20th century, adoption of input-responsive varieties enhanced food production. However, even bigger challenges lie ahead because of the growing societal demands. Just for essence, the global population of 7.2 billion in 2013 is expected to reach 9.2 billion by the year 2050 and stabilize at 10 billion by 2100. The growing and increasingly affluent population, with preference towards more and more meat-based diet, is likely to jeopardize the finite, fragile, and dwindling soil and water resources which are already under great stress in densely populated countries of Asia, Africa and elsewhere (Worldometers 2011, UN 2013).

Economic growth and increase in gross domestic product also lead to generation of waste or by-products, along with contamination and eutrophication of water resources. International trade in food/feed products also involves transfer of virtual water, which is a serious issue when water-scarce countries export virtual water to water-endowed countries. The problem is confounded by the present and future climate change driven by the growing energy demands of the carbon civilization. Thus, adaptation to climate change represents both a threat as well as an opportunity for sustainable development. Adaptive strategies must be sustainable socially and environmentally to advance the Millennium Development Goals, while buffering agro-ecosystems against extreme climate events (e.g., pedologic, agronomic, and ecologic drought) add further to research needs. Thus, recognizing and addressing the water-soil-waste nexus to be an important issue in achieving climate-strategic agriculture. Sustainable intensification of agro-ecosystems, producing more per unit consumption of essential resources, must consider judicious management of hydrological as well as biogeochemical cycles (Gan et al. 2013, Gulati et al. 2013).

**The African Development Bank's Experience on Implementing the Nexus Approach**

Under its 'Ten Year Strategy' (2013-2022), Agricultural Sector Strategy (2008-2014), and the integrated water resource management, the AfDB is committed to invest in integrated watershed based rural development projects. The Bank has been supporting adaptive and integrated, multi-stakeholders' driven collaborative strategies that are sustainable, socially and environmentally and advance the Millennium Development Goals, while buffering agro-ecosystems against extreme climate events. Thus, recognizing and addressing the water-soil-waste nexus approach which is important to achieve climate-strategic agriculture.

In the following case studies attempts have been made to support the implementation of a Nexus approach in African countries and inform about the role of AfDB in providing resources, skills, information. AfDB is also playing its role to bring new concepts and joint work options with water scientists around the world.

**Case Study-1 Cap-Verde: Restoring Watersheds**

The Republic of Cape Verde is an archipelago of 10 volcanic islands (nine of which are inhabited), situated at about 500 km off the coast of Senegal in the Atlantic Ocean. Only a tenth of the land is arable. The climate is arid and the rainfall pattern is unpredictable and variable. The environment of the country is characterized by: (i) extreme fragility of the ecosystems related to the lack of water and erosion due to steep slopes, irregular and torrential rains and violent winds; (ii) unsuitability of crops to soils and miss use of ground water, (iii) lack of water harnessing and retention of infrastructure. The low infiltration and retention of surface water have resulted in insufficient underground water. Improper farming practices such as bush clearing, weeding, and cropping on steep slopes contribute to the degradation of soils. It is in this particular environmental context that Cape Verde requested AfDB support to restore the watersheds, to ecologically rehabilitate more agricultural lands and to retain more water for both agriculture and household use.

The main project deliverables were: (i) construction of 20 dams, 22 wells, 4 underground culverts; 950 ha of vegetated corridors and 90 km from raised platforms; (ii) planting 1,733 ha degraded lands; (iii) planting of 88,700 woody trees and 467,600 fruit trees, (iv) improvement of 349 hectares of pastureland, (v) construction of 11 km of piped water supply; construction of 40 water reservoirs and 109 dams to control torrential flows; (vi) rehabilitation of 7 km of irrigation canals; (vii) development of 200 ha of irrigated crops; (viii) construction of 200 production units and 200 family breeding water tanks, (ix) awareness campaign reaching 20,000 inhabitants in community organization; (x) training of 270 people in technical and vocational training, 1,300 people in soil conservation techniques, and 450 people in new techniques/farming practices as well as conservation and processing of agricultural produce; and, (xi) establishment of a micro-credit scheme.

The case study-1 Cap-Verde project report (AfDB 2002) showed that the project was successful in meeting its objective to rehabilitate and restore fragile ecosystems, to gain more arable lands and to retain more water for agricultural and households purposes. All these factors have positively contributed to improve the communities' well-being. The vast majority of the projects' targets were achieved, with some targets surpassed. Although extensive research and measures have not yet been carried out, however, field visits well demonstrated the success in ecological recovery of several degraded areas, land erosion control and plantation.

*Photo 1, 2: The landscape of aridity and denudation of Cap-Verde before (left) and during (right) the project phase to add terraces, provide cover, soil and water conservation and add nutrition to the soil. (Photo Courtesy to Bamba DIOP, KITANE SOULEYE and Jean Louis KROMER at the AfDB)*

**Case Study-2 Burundi: Integrated Watershed Management Project**

The forest resources of Burundi were seriously degraded during the last 10 years long socio-political crisis in the country. In the war-torn country, more than 30,000 ha of woodlots and 10,000 ha of natural forests had been destroyed, reducing the country's forest cover rate from 8% to 5%. The overexploitation of arable lands by overgrazing, tilling of steep slopes and the phenomena of erosion in various forms led to massive degradation of natural resources (soils, forests) of the over-populated country. Furthermore, during the war, the country lost many of its managerial staff and much infrastructure, and its achievements in the area of resource protection and restoration of vegetation cover. The absence of urgent interventions seriously affected the few remaining resources and heightened the phenomenon of erosion of watersheds, thus causing frequent landslides, significant losses of farmlands and soil fertility. Furthermore, bush fires became rampant with the search for new arable lands and new pastures. It was agreed to support projects to reduce the sufferings of people and to restore the natural resources.

The Watershed Management Project focused on four components, namely: (i) capacity building, (ii) conservation and improvement of resources, (iii) improvement of agro-silvo-pastoral production and (iv) management of the project (AfDB 2012).

The implementation of the Watershed Management Project and the environmental protection activities led the project to organize major training and sensitization actions concerning all stakeholders involved in the process. The project built capacities of officials of the Department of Forestry as well as those of the local population for better management of State and community plantations and sustainable management of family farms. With the technical support of the Provincial Agriculture and Livestock Delegations and the Regional Forestry Inspectorates, the project set up vast programs of sensitization of smallholders to improved farming techniques, water and soil conservation techniques and plantation management. In addition, the project organized training courses for mixed farmers on the improvement of pastures and the production of fodder. All these actions benefited thousands of people. The project financed the creation of 15,000 ha State plantations to protect the bare hillsides against erosion. It has also financed, at the request of the population, the creation of 1,800 ha of community woodlots. The production of the seedlings for the various plantations was undertaken by producer groups and associations, in particular those of women.

All the plantations of the project have been mapped for woodlot development and management needs. The community plantations are today covered by management contracts between the forest authorities and the local communities. The project financed the construction of 600,000 linear meters of erosion control works (contour bunds, erosion control hedges, stone-works, vegetated ditches, etc.) on the slopes and farmland threatened by erosion.

*Photo 3: Plantation to recover slopes and to add cover, soil and water conservation and add nutrition to the soil (Photo Courtesy to Bamba DIOP, KITANE SOULEYE and Jean Louis KROMER of AfDB.*

Approximately 50 km of old tracks in a state of degradation have been rehabilitated and 100 km of new tracks opened in the new plantations. About 250 km of tracks and fire-breaks have been opened or maintained throughout the project. These activities were implemented using labor-intensive works reducing rural unemployment.

To diversify the sources of income and satisfy the population's food needs, the project promoted income-generating activities such as bee-keeping, market gardening and fruit-growing. The project contributed to the creation of 3,750 ha of private plantations to satisfy the population's forest product needs. During the five years project, 145 ha of hedgerows and the sowing of 3,000 ha multi-purpose fodder species enabled to improve 5,800 ha of natural pastures in the project area. These activities reduced soil degradation along cattle tracks, increased the availability of fodder for cattle and reduced livestock pressure on woodlots to improve soil fertility and production systems.



**Case Study-3: Sustainable Land Management Project in Gambia**

Land degradation in Gambia is a critical problem, which is adversely affecting the structure and functional integrity of the country's watershed and the ecosystems. Upland watershed ecosystems have degraded largely due to: overgrazing, soil erosion and intensive cultivation. The results of intense pressure on land resources, high population growth and recurrent droughts disrupted the developmental approaches. Lowland ecosystems and riverine wetlands are threatened by erosion, siltation and sedimentation resulting from upland degradation. Declining rainfall over the last 40 years has increased aridity in the uplands and acidity/salinity of soils in the lowlands. The reduced flow of the Gambia River cause salt water intrusion into the 'river basin'. This degradation is manifested in the following ways: (i) loss of the natural productivity of land; (ii) loss of native biological diversity and resilience; (iii) increased emission of carbon dioxide and reduced carbon sequestration; and (iv) degradation of watershed function, including destabilization of sediment storage and release. Progressive degradation of these ecosystems has resulted in increased food insecurity and ever decreasing access to natural resources across the country.


*Photo 4: Project activity signboard under the Sustainable Land Management Project (SLMP) Gambia. Showing Soil and water conservation activities and forestation at Penyem Village (Photo Taken in June 2013 by Sheikh J. Ahmed)*

The case study (AfDB 2010) demonstrated that the area was seriously affected since the 'Sahelian drought' in the mid-1970s. The reduced rainfall resulted in various forms of land degradation in the lowlands, leading farmers to abandon lowland rice fields. Problems included: sea water intrusion into formerly productive rice fields, water shortage in upland valleys (and part of the lowlands) and flood plains increase in demand for rice. Besides other approaches to improve the condition, AfDB project team is promoting use of agricultural residue to restore soil fertility and also the enhancement or soil fertility management by biomass production via afforestation and use of nitrogen fixing trees.

**Conclusions and Recommendations**

The AfDB' experience of the three case studies shows that:

1. It is important to increase awareness about the nexus approach in soil, water and waste among the communities and the organizations using green and inclusive growth models.

2. The Nexus Approach is helpful in achieving food security and effective watershed planning.

3. Multi-Stakeholders' driven and community based watershed planning and management has proved to be the best way to achieve outcome of the Nexus Approach in soil, water and waste.

4. The Nexus Approach needs to consider integrated and inclusive approaches by involving all kinds of stakeholders' including: citizens, MDBs, donors, trained individuals, researchers, academic institutions, NGOs, ENGOs, businesses and all the levels of the governments.

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## 8.4.3 Sustainable Land Management: Advancing the Nexus Approach on the Ground – Some Practical Policy-Relevant Recommendations

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**Introduction**

Land degradation, including soil degradation, represent a critical challenge to sustainable development in all countries and globally. As such, the sustainable management of land and its soil component will underpin the achievement of many of the envisaged sustainable development goals (SDGs), including food, water, climate security, and governance, to be reflected in the post-2015 development agenda. This is so due to the fragile interdependence and interconnections between resource management and associated shocks (be it deforestation drought, floods, poor harvest, loss of topsoil, etc.). A suggested approach that aims at embedding targets on soil, water and waste within the SDGs will meet the level of ambition envisaged in many international events and conferences, from Rio 1992, through Rio+20 and beyond; and will also set the scenario for the mobilization of necessary resources to implement a nexus approach to a sustainable natural resource management. Practical indicators based on existing global datasets are also envisaged to support implementation of these targets at the local and national levels and to measure progress in reversing the current trends in ecosystem degradation as well as scaling up their sustainable use and restoration. Monitoring and reporting will be vital for affected countries in demonstrating to cooperation partners and donors the consequences and extent of the impacts of their actions on the ground, in which benefits derived from land and watershed management be accounted for at the maximum level possible (livelihoods, resilience) for a much broad justification of the need to undertake long term sustainable investments in degraded ecosystems.

Integrated approaches to natural resource management, such as sustainable land management (SLM) and integrated water resource management (IWRM) provide practical cost-effective options to improve resource use efficiencies while minimizing unsustainable exploitation and environmental degradation. In some cases, a nexus approach which recognizes the inter-linkages and feedback loops among natural resources has been an integral part of land stewardship since the agricultural revolution. Today, many smallholder farmers across the world sustainably manage their soil, water and waste either out of necessity or for the benefit of future generations, or both. The on-farm recycling of water and waste is an important key to self-sufficiency and sustainability which decouples productivity from expensive and toxic inputs such as energy and agro-chemicals. Local and national policies that incentivize these actions are welcome. There is however the other side of the coin. In many countries around the world there are still in place pro-land degradation policies, including subsidies on fertilizers, pesticides, credits favoring unsustainable practices and operations, etc., based on narrowly defined economic benefits without considerations of the global nature (including the nexus) of SLM and IWRM benefits for the landscape, ecosystem and their local populations.

**SLM embodies the nexus approach**

The demand for food, water and energy is expected to increase significantly in the coming decades. Consequently, there is an urgent need to do one or the other: either we increase agricultural productivity and water use efficiencies while at the same reducing and recycling waste in the production-distribution-consumption chain; or we recognize that in the near future (if not today) we are to be facing increased social and political conflicts, including south - north migration, more climate change impacts, lower

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biodiversity benefits (even beyond the point-of-no return thresholds) and therefore more pressure on the way international cooperation and global financial schemes are set in place. Most current natural resource management practices tend to reduce long-term productivity and contribute to the degradation and loss of important ecosystem services. With regard to soils, organic matter is being significantly depleted resulting in a lower retention capacity for water and nutrients, and thus long-term declines in fertility and productivity. Furthermore, degraded soils require more water which compromises local groundwater recharge and downstream reservoir storage.

The common practice of identifying only private economic benefits is part of the narrow focus on few provisioning services that target at output maximization for the global market and farm revenue; in many cases these have led to unsustainable agricultural practices which are generally associated with industrial monocultures. In fact, some non-market SLM practices have been eliminated, to the cost of community resilience and in favor to market-only approaches. A nexus approach accounts for these externalities also counting with those not included in standard economic analysis scenarios and seeks to reduce tradeoffs and build synergies among different sectors (e.g. water, energy, food) as well as natural resources (e.g. soil/land, water, nutrients) and climate adaptation and regulation (e.g. through carbon sequestration). Once the benefits of these externalities are accounted for in common sustainable agricultural practices in terms of biodiversity and the associated ecosystem services are fully captured in decision-making, integrated soil, water and waste management clearly becomes not only sustainable but also cost-effective and economically and financially profitable.

Like the ecosystem or landscape approach, SLM is a systemic conceptual framework for maintaining healthy and productive land while protecting biodiversity and enhancing the delivery of important ecosystem services. At the farm level, SLM promotes the use of less non-renewable resource inputs by prioritizing soil and water conservation, crop diversification and rotation, integrated pest management and green manure, and the recycling of water, waste and other on-farm inputs.

There are however many positive trends as SLM is gaining track in policy relevant recommendations of many international agencies and countries. As indicated by FAO (2013) we started by using the SLM definition of the UN Earth Summit 1992 as *"the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions"*. WOCAT (World Overview of Conservation Approaches and Technologies) and the UNCCD use a SLM definition that highlights the provisioning, regulating and cultural services of SLM: "practices that reduce soil and land degradation whether it is caused by physical (winds, runoffs, soil sealing, etc.) or chemical (nutrient leaching, loss of organic matter, etc.) factors. If sustainably managed, the soil will ensure the provisioning of land ecosystem services" (Gabathuler et al. 2009). TerrAfrica (2014) have defined SLM as *"the adoption of land use systems that, through appropriate management practices, enables land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources"* (see also FAO 2013).

As FAO reports, SLM implementation is based on four common principles:

- It is land-user-driven and fosters participatory approaches;
- It is a framework for integrated use of the ecosystem's natural resources;
- It has a strong governance approach: multi-level and multi-stakeholder involvement; and
- Its implementation targets policy and institutional support at the local level, including incentive mechanisms for SLM adoption and income generation.

As such, SLM fully embodies the nexus approach as it encompasses well-established principles of sustainability such as soil and water conservation, integrated natural resources and ecosystem management, etc.



**Scaling up the nexus approach**

Although the nexus approach is gaining increasing attention in the global policy arena as reflected not only in the Dresden Nexus Conference of 2015 but also in the previous initiatives held in Bonn (2011 and 2014) and in Chapel Hill (2014) most examples of successful implementation can primarily be found at relatively small scale, either at the community or farm level. Scaling up the nexus approach remains a challenge for a number of reasons including the lack of multi-sectoral (institutional, educational) coordination and the associated structures to govern decision-making in dynamic production landscapes with diverse stakeholders. One policy strategy which attempts to encourage the nexus approach at larger spatial scales has been the "payments for watershed services" which emphasizes and supports the linkages between soil and water at the bio-regional level. It explicitly recognizes that sustainable agricultural production depends on the regulating services provided by healthy and intact ecosystems in the wider landscape. Challenges here include trans-boundary ecosystems as well.

Another policy relevant option for scaling up the nexus approach is the "demonstration effect" or "additive effect" whereby the benefits of SLM are expanded to the broader local community, neighbors, sustainable agricultural producers, market distributors, which are often inter-linked through regional cooperatives or associations. Ultimately, the prospect of scaling up integrated soil, water and waste management will depend on a paradigm shift in the current production-distribution-consumption behavior staring from small farmers and agri-business to the actors - private and public - engaged in food production for the global market. Motivating schemes for the important role of local authorities and national governments in supporting this shift need to be in place; this can be done by fostering local / territorial governance mechanisms that effectively facilitate coordination among different stakeholders, recognizing the roles played and accounting for their competing interests, of men and women; and of public and private organizations in the broadest sense.

**Conclusion**

The current global trend of loss of land productivity, including in the drylands, mostly through desertification, land degradation and drought, has a disproportionate impact on different social sectors of the economy: private and public sectors, men women and children who bear in different levels the burden of food production and collecting water. Much still needs to be done to address land and soil degradation if the significant challenge it presents to sustainable development will be overcome.

Promising developments over the last few decades point to significant land recovery and improvements under the auspices of local communities. For instance, farmer-managed natural regeneration and agroforestry techniques, such as planting of "fertilizer trees" on agricultural and grazing lands, have already been adopted in many regions. Such techniques have contributed to improved livelihoods and increased productivity of millions of hectares of land across Africa. In many cases, local communities are at the forefront of these innovations.

A major scaling-up of the broad associated benefits of these SLM systems should be fostered and pursued everywhere not only for increased sustainable investment on land / ecosystem restoration but also for environmental and social (sometimes non-market related) impacts; by improving awareness at all levels, enacting public policies and strengthening institutions, and harnessing the potential of civil society and the private sector. Thus sustainable management of land and soil is indeed a building block for sustainable development and as such, it is an important tool for underpinning the achievement of many of the envisaged SDGs and plays a central role in the implementation of the post-2015 development agenda.

**Case studies from Africa**

In the following section a small sample of case studies from Africa show the application of the nexus approach on the ground (for more details: Liniger et al. 2011). Many of these SLM practices have been

successful at the local or farm level while some have had produced regional implications as a result of farmer to farmer extension as well as government planning and external incentive mechanisms.

*Composting in Burkina Faso*

Since 1988, over 5,000 families in Boulgou Province of Burkina Faso have adopted simple pit composting technology without any external incentives. Pit composting helps to reduce water requirement in drier areas and at the same time reduces labor inputs. The total area of manured fields is approximately 200 km² with some pastoralists using compost in their gardens. The adoption of pit composting practices has spread from farmer to farmer while adjacent pastoralists have started to systematically collect manure for sale due to increased demand for manure in composting.

The high water retaining capacity of the compost is significantly more important than the additional nutrients which only become available in subsequent years. The modest quantity of compost applied is not enough to replace the nutrients extracted by the crops in the long-term thus small amounts of nitrogen and phosphorous fertilizer are needed along with crop rotation. During the dry season, after harvest, fields are grazed by cattle of the nomadic pastoral Peuhl, who also herd the agriculturalists' livestock. The net transfer of organic matter (manure) to the fields from adjacent areas requires improved management of the surrounding vegetation to avoiding overgrazing.

*Rainwater harvesting in the Sahel*

Rainwater harvesting (RWH) techniques must be profitable for land users and local communities, and must be simple, inexpensive and easily manageable. Incentives for the construction of macro-catchments, small dams and roof catchments might be needed since they often require high up-front investments. The greater the maintenance needs the less chance that land users and local communities will adopt the RWH techniques. In general, adoption rates in Africa remain low. Farmers hesitate to invest time and money in RWH without the security of land tenure and limited access to local markets where they can sell surpluses. However, some RWH technologies like zaï have been widely adopted with (and in some areas, without) external support.

In Africa's Sahel region, a dry area covering the southern edge of the Sahara desert that stretches from Senegal's Atlantic coast to the Ethiopian highlands, farmers are using innovative planting methods to reverse years of degradation. Beginning in the 1980's farmers in Burkina Faso and Niger began planting their crops in zai pits. The zia pits, that are dug into the ground in rows and filled with organic material, are especially convenient because farmers can start making them during the dry season. These pits can retain water for long periods of time, while increasing soil fertility. Farmers in the Sahel also constructed stone structures that helped to capture water runoff and retain organic material in the soil. Together these innovations are helping return this once barren land into thriving farmland.

*Agroforestry in West Africa*

Agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately integrated with agricultural crops and/or livestock for a variety of benefits and services. The integration can be either in a spatial mixture (e.g. crops with trees) or in a temporal sequence (e.g. improved fallows, rotation). Agroforestry ranges from very simple and sparse to very complex and dense systems. It embraces a wide range of practices such as alley cropping, farming with trees on contours, or perimeter fencing with trees, multi-storey cropping, relay cropping, intercropping, multiple cropping, bush and tree fallows, parkland systems, home-gardens, etc.

Both ecological and social factors are simultaneously important in motivating land users to grow trees on their farms. Land users as observed do accept yield losses provided the new intervention results in a clear return on investment. In the traditional parklands of West Africa, dense shading by shea nut trees (*Vitellaria paradoxa*) and néré (*Parkia biglobosa*), which reduce millet yield by 50–80% are used because of the high economic returns from marketable tree products. Markets for multipurpose tree products are crucial for the adoption of agroforestry on a scale to have meaningful economic, social and environmental impacts. Land tenure reforms and established systems of payment for ecosystems services will encourage land ownership, stimulate the development of agroforestry plantations, and provide incentives for establishing tree nurseries at the village level.

On the vast denuded plains of Pays Kabyé in northern Togo, barriers of leguminous trees (*e.g. Cassia siamea or spectabilis;* a medium sized tree growing between 10-20 m tall; *Albizzia procera*, *Leucaena leucocephala*) and shrubs (*Cajanus cajan, Erythrina variegate*) have been established between fields cultivated with annual crops such as maize. The shelterbelts provide a good micro-climate and protect the crops against wind erosion, soil moisture loss through evaporation and physical damage to crops. The denser the shelterbelts, the better the windbreaking effect, but the higher the competition with crops for nutrients, light and water. Frequent pruning helps to avoid too much competition while providing fuelwood. When leguminous tree species are used, soil properties can be improved through nitrogen fixation and the provision of organic matter.

*Farmer Managed Natural Regeneration in Niger*

Farmer Managed Natural Regeneration (FMNR) is the systematic regeneration of living and sprouting stumps of indigenous vegetation which used to be slashed and burned in traditional field preparation. The naturally occurring seedlings and/or sprouts are managed and protected by local farmers. Most suitable are species with deep roots that do not compete with crops and have good growth performance even during poor rainy seasons. In Niger, the three most valuable species, as perceived by land users, are *Faidherbia albida, Piliostigma* reticulatum and *Guiera senegalensis*.

FMNR technology was first implemented in the Maradi region of Niger in the early 1980's and its spread throughout the region has been largely spontaneous, with minimal external assistance. The area covered today by trees from FMNR is estimated to be more than 50,000 km² in Niger.

In response to the scarce presence of live tree stumps, seeds of indigenous species are broadcast but with reduced short term benefits and high mortality rates. There is also the challenge of overcoming cultural norms and values which uphold that 'a good farmer is a clean farmer' (i.e. no trees). In addition, land (including trees) is often treated as common property during the dry season resulting in over-exploitation. It is thus critical to create sense of ownership of trees that encourages communities to develop rules that respect property and encourage long-term sustainable use.

*Integrated Crop-Livestock Management in Africa*

In Integrated Crop-Livestock Management (ICLM) crops and livestock interact to create synergies, making optimal use of resources. The waste products of one component serve as a resource for the other: manure from livestock is used to enhance crop production (improve soil fertility), whilst crop residues and by-products (grass weeds and processing waste) are supplementary feed for the animals. Grass and prunings from agroforestry trees grown on contour conservation barriers, as well as nitrogen-fixing legumes grown under conservation agriculture systems, are further potential sources of fodder.

Livestock are integral to most African cropping systems: they provide traction and transport, as well as meat, milk and hides. Improvements to the livestock component of integrated systems include upgraded intensive pastures through shifting night enclosures (kraals/bomas), fodder planting/hay making, and stall feeding ('cut-and-carry'; 'zero grazing') in the more humid areas. Various factors influence the type and effectiveness of crop-livestock interactions, including socio-economic parameters (access to land, labor and capital) and ecological conditions (temperature and rainfall). Integrated crop-livestock systems are common in semi-arid

and sub-humid (and humid) areas as well as in tropical/temperate highlands. Given the growing demand for livestock products, the sub-humid areas are predicted to the best potential to provide most of this increase.

Skillful organization and management of animals and the land is needed. Rules and regulations have to be followed by all concerned, particularly with regard to exclusion of areas from grazing and in terms of animal health and nutrition. Specific skills can be taught, but much must be learnt through experience. In semi-arid regions the transition in crop and livestock production from the current relatively extensive, low input/output production to more intensive, higher input/output production presents numerous challenges:

- participation of community right from the beginning, during planning to implementation, to ensure ownership;
- availability of land and consensus of the community where the system can be introduced or applied;
- secure land use rights and tenure;
- need for training and capacity building in use of technology and its benefits;
- need for training and support in animal husbandry; and
- requires change in mindset from 'focus on parts' towards 'the whole system'.

*Equitable Payments for Watershed Services in Tanzania*

Equitable Payments for Watershed Services (EPWS) is a programme using Payments for Ecosystem Services (PES) to improve rural livelihoods. Incentive mechanisms are used to reward upstream landowners for maintaining a beneficial land use or for adapting a particular land use practice which affects the availability and/or quality of downstream water resources. The EPWS approach has enormous potential to advance a new conservation revolution based on a compensation mechanism encouraging and financing conservation efforts as well as improving the livelihoods of the rural poor.

In Tanzania, a payment mechanism has been established to compensate farmers for delivering watershed services (in form of freshwater) through implementation of SLM. Compensation payments – paid in cash and through material support – are made first to establish land use changes, and thereafter for service delivery and maintenance. They are mainly covered through international donors (DANIDA) and 'buyers' from the private sector, investing in watershed management.

EPWS aims to spread SLM technologies to communities, to raise awareness of the benefits of SLM and to improve land productivity. Farmer groups are formed to lead the implementation of SLM. The approach includes supervision, support and training of farmers to ensure appropriate implementation of SLM and efficient soil erosion control. Methods include demonstration plots and farmer-to-farmer extension. Capacity building to farmers (on gender mainstreaming, good governance and relevant laws and policies) and monitoring of hydrological and livelihood status are important components of the approach. Efforts to ensure good women integration resulted in a relatively high proportion within the farmer groups (>35%).
This PES approach is very new in the country and there is little expertise within the government – which therefore needs to take deliberate efforts to groom experts through seminars and courses on PES mechanisms and its operationalization. The EPWS team consisting of staff from CARE International and WWF as well as short term workers is always involving government staff in various enabling activities to foster successful EPWS schemes.

*Climate smart agriculture in Kenya*

In keeping with the Strategy for Revitalizing Agriculture (SRA) of Kenya 2010-2015 and Kenya's vision 2030, national and international partners have teamed up to address these challenges by strengthening the capacities of smallholders to manage land and water resources in vulnerable agro-ecological zones. The Kenya Agricultural Carbon Project, implemented by the NGO Vi Agroforestry, is demonstrating the many potential benefits of "climate-smart" agriculture. It involves an integrated approach to agricultural land management, including recycling of residues, composting, cover crops, and land rehabilitation, and also operationalizes the principles of a multi-functional production system through agro-forestry techniques.
The aim of the project is to create a mosaic of partners working together to leverage investment as a key component of the management of natural resources and the adaptation strategies. About 12,000 households are expected to benefit by strengthening adaptation to climate change risks in the selected watersheds and districts. Further actions are required in some key areas such as access to financial services and markets, in addition to acquisition of equipment for building water source schemes, at community scale, better fodder and tree species for improved soil fertility, crop diversification and livestock feed resources.

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## 8.4.4 Nonpoint Source Water Pollution Management in South Korea in the context of Water, Soil and Waste Nexus Approach

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**Abstract**

Water pollutants from nonpoint sources such as urban areas, roads and farmland comprise a great variety of substances and may contribute significantly to the overall pollution of water bodies. This implies that waste, soil and water sectors are interconnected in terms of material fluxes in nonpoint water pollution and that a nexus approach, considering the interconnectedness, can lead to more effective, sustainable and comprehensive solutions for this pollution. In South Korea, nonpoint sources account for 68.3% of organic matter load to four major rivers and are projected to increase their share continuously due to a growing number of development projects. To manage nonpoint source pollution, the government of South Korea introduced the first Nonpoint Water Pollution Management Programme in 2004 and implemented the second Programme in 2012, reflecting limitations in the process of the first Programme. The second Programme consists of tailor-made measures for urban/suburban areas, rural areas, rivers and forestry and cross-cutting measures on research & development and education. This study analysed the second Programme in terms of adoption of a nexus approach to managing water-soil-waste and identified mutual benefits among relevant sectors. For example, the second Programme includes ecological wetland and low impact development (LID) practices in water-soil nexus terms, expanding green manure crop in soil-waste nexus terms and biogas production using livestock manure in waste-water nexus terms, respectively. These measures were identified to deliver additional benefits such as efficient use of resources, enhancing biodiversity and tackling climate change. Moreover, the programme demonstrates that nexus approach policies require research and education on inter-sectoral material flux, policy design and governance. In conclusion, the South Korea's case shows that a water-soil-waste nexus approach can improve resource efficiency and can contribute to mutual benefits among relevant sectors in sustainable development policies.

**Introduction**

Water pollution sources can be classified into point and nonpoint sources (Wolfe 2001). Unlike point source pollution, which is confined to industrial sources or sewage treatment plants, nonpoint source (NPS) pollution results from the inflow of a variety of pollutants from urban area, roads, farmland, mountains, and construction sites where pollutants are delivered by rainfall runoff or atmosphere deposition (U.S. Environmental Protection Agency (EPA) 2014; Wolfe 2001, Figure 1).

NPS pollution comes in various forms and is mainly due to the run-off from (EPA 2014):

- Urban and suburban areas: sediments, nutrients and heavy materials from paved surfaces in construction buildings, earth surfaces and industrial areas or combined sewer overflows
- Road areas: pollutants or car exhaust gases accumulated on roads
- Agricultural Operations: pesticides such as herbicides and insecticides from agricultural lands, fertilizers, compost, livestock manure or soil from farmland into water bodies
- Forestry and mining operations: soil efflux from deforestation, residuals of logging and mining or other harmful chemicals
- Others: agricultural activities or parking lot construction in the vicinity of rivers

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Due to this wide range of substances from various resources, NPS requires to be addressed by an integrated approach, since facilities and regulations against point source pollution work less for NPS pollution. Given the features of NPS pollution, the flow of nonpoint sources involves waste, soil and water, the linkage of which needs to be considered to devise counter-measures.


*Figure 1: Nonpoint sources of water pollution (source: Bakker 1998)*

NPS pollution demonstrates that the water, soil and waste sectors are closely interconnected in terms of material fluxes. The measures to manage NPS pollution can be more effective, when based on material flux analysis integrating interconnected sectors via innovative (modelling) tools. For example, biogas production using livestock manure (i.e. waste sector) in rural area can deter excessive nutrient accumulation in soil sector and eutrophication in water sector. In this regard, a nexus approach to the management of water, soil and waste - identified as a platform which combines related disciplines and sectors, considering interconnectedness of resources and their sustainable use (Herath 2013) – would deal with NPS pollution in a more effective, sustainable and comprehensive manner.

This report introduces Korea's current status of NPS pollution and the relevant management programme; a nexus approach connecting water, soil and waste; and the approach's advantages. It also suggests the directions for developing a nexus approach by sharing Korean cases, specifically, in terms of knowledge, capacity building and governance.

**Nonpoint Source Water Pollution in South Korea**

Korea has higher intensity of rainfall caused by climate change and increasing areas with paved surfaces through urbanization. This results in aggravated water circulation and increased water levels and discharge in the rivers due to the reinforced rainfall runoff. As a result, more NPS pollutants end up in rivers and lakes, resulting in growing water pollution, algal blooms and fish kills (ROK 2012).

In 2010 the load of organic matter, expressed as Biological Oxygen Demand (BOD) amounted to 1,640 ton BOD/day for the four major rivers of Korea (i.e. Han, Geum, Nakdong and Yeongsan rivers). The load of Phosphorus, the major nutrient causing eutrophication was 97.8 ton TP/day. NPS represented 1,119 ton BOD/day (68.3%) and 57.6 ton TP/day (58.9%). The share of BOD is expected to increase to 72% of the total discharge by 2020 due mainly to the growing number of development projects and the ensuing increase in paved surfaces.

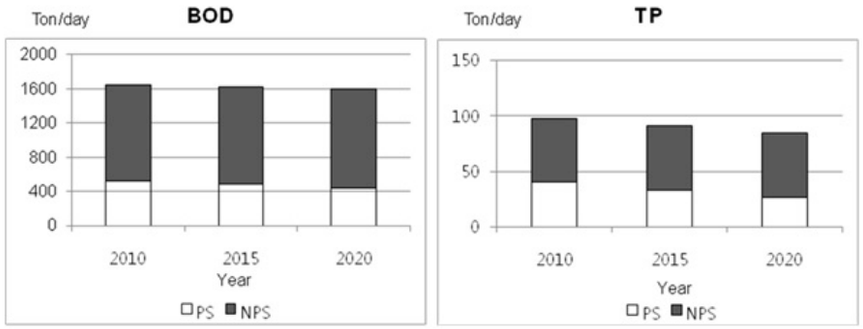


*Figure 2: BOD and T-P load projection from water point source (PS) and nonpoint source (NPS) to Korea four major rivers (source: ROK 2012)*

Data of 2010 revealed that among nonpoint sources, BOD and TP mostly originated from urban areas, roads and agricultural lands (BOD: 63.5%; TP: 57.5%), followed by livestock facilities (BOD: 28.4%; TP: 38.1%).

**Nonpoint Source Water Pollution Management Programme in South Korea**

Korea initiated the First National Nonpoint Source Pollution Management Programme in 2004. The First Nonpoint Water Pollution Management Programme identified and implemented 34 tasks with the participation of 7 government departments, including the Ministry of Environment, the Ministry of Agriculture, Food and Rural Affairs, and the Ministry of Land, Infrastructure and Transport etc. One of the key measures was a mandatory report system for nonpoint sources in construction work to effectively manage the pollutants. Another step was to designate areas where nonpoint sources could severely affect the use of rivers, lakes and marshes as special management areas. Environmental impact assessments on development projects were required to include measures to address nonpoint sources. Along with these steps, a pilot programme was run, in which the central government gave financial support for local governments when they installed artificial wetlands or reservoirs to control the inflow of nonpoint sources. Educational programmes were carried out to encourage farmers to use pesticides and fertilizers in an environmentally friendly way and to prevent soil erosion.

The First NPS pollution management programme was implemented for 8 years until 2011, and in the following year the Second programme was announced. In the process of executing the first measures, limitations were identified and reflected in the second one. The Second National NPS Pollution Management Programme was put in place from 2012 onwards. Below an introduction and summarization of this Second Programme will be given, outlining the advancements compared to the first programme (ROK 2012).

**Urban and suburban areas**

The sustainability of the WPMS needs systematic planning based on its potentiality. In order to achieve this intention, the following issues are recommended for further scrutiny so as to develop a detailed strategy and plan for the next step. Major issues include among others the following:

1) Limitations of the first programme

   Due to higher density and increasing paved surfaces it was difficult to manage NPS pollution in urban and suburban areas. Three limiting factors towards a sustainable NPS pollution management system were identified in the first programme. First, the management practice was focused on treatment-after-pollution. However it was shown that there is an increasing need to apply low impact development (LID)[2] techniques to prevent pollution rather than treating it.

   A second limitation became obvious during the initial stage of rainfall events, when combined sewer overflows discharge highly concentrated pollutants, which deteriorate the water quality. Underfunded local governments had been passive in installing combined sewer overflows treatment facilities.

   A third limiting factor was the generally low level of awareness with regard to nonpoint source management. This was e.g. observed among local municipalities and construction contractors, although there were needs for the frequent cleaning up of road dusts or pollutants and the prevention of soil efflux from construction sites.

2) Main features of the second Programme
   The main objectives of the second programme respond to the limiting factors of the first programme:

   (a) To disseminate LID principles and practices, urban planning laws will be revised to ensure that LID techniques will be considered in development projects. LID technique guidelines will be developed, and incentives will be provided to contractors.

   (b) To prevent the direct inflow of combined sewer overflows into rivers, reservoirs for rainwater and sewage will be installed more widespread, and combined sewer overflows treatment facilities will be added in the existing sewage treatment plants.

   (c) To clean up pavements more frequently, local governments will increase their budgets for street vacuum cleaners and devise effective cleaning guidelines. The "Guidelines for Green Road Project" will be complemented.

**Rural areas**

1) Limitations of the first programme

   Related to NPS pollutants in rural areas, similar to NPS pollutants in urban and suburban areas (see above), missing awareness among the stakeholders could be observed as one important limitation factor with respect a sustainable pollution management. In rural areas cultivators need to control the soil effluxes from cropland. However, there had been limited efforts because the stakeholders were not fully aware of what causes NPS pollution, what impacts might result from it and how to manage the pollutants.

   The compost or fertilizer made from livestock manure, when overused in farmlands, can make their way into rivers in rainfall events. The exact location an origin of the pollution will be difficult to identify. Still, many farmers use livestock waste which is not fully composed as fertilizer for agricultural land. The first programme put in place the treatment facilities of livestock manure, though small-scale livestock farms cared less about using the facilities and placed untreated animal excrements in their farmland.

2) Main features of the second programme

   (a) Agreements with farmers in water source management areas will be introduced to incentivize them to install nonpoint source control systems and cultivate their crops in an environmentally friendly way. Policies will be introduced to compensate potential losses against the previous revenues for farmers in the agreements.

[2] LID (Low Impact Development): LID is the land development approach to control rainwater to soak into the ground rather than moving rainwater offsite through a conveyance system. LID integrates various measures into the development including constructed green spaces, native landscaping, bioretention and infiltrations techniques (EPA 2013).

(b) The seeds of green manure crops will be offered for free to promote the cultivation of them on idle farmland during the winter season. It can reduce the use of chemical fertilizers.

(c) Vegetative filter systems and ecological wetlands will be more established according to the origins of nonpoint sources such as livestock farms or croplands whose soil is highly vulnerable to erosion.

(d) More treatment plants will be established to convert livestock manure into biogases for energy sources. Standards for the re-use of animal excrements as fertilizers will be enhanced. Nutrient content in farmland and regional water pollution levels will be taken into consideration in devising up livestock manure treatment guidelines.

**Rivers, abandoned mines and forestry**

1) Limitations of the first programme

To reduce the use of areas adjacent to rivers as parking lots, roads or agricultural lands, additional measures were needed. The poor management of small-scale mines led to the efflux of soil and harmful chemicals. Tailings and leachate from abandoned mines continuously drained into rivers. Small twigs and other by-products of logging activities were rarely collected or used and contribute, left in place, to an enrichment of nutrients in soil and water ecosystems if carried away by runoff water to rivers.

2) Main features of the second Programme

(a) To block the use of river basins in advance as parking or agricultural areas, the government and local municipalities will make a purchase of the regions and convert them into ecological wetlands or eco-belts.

(b) More abandoned mines will be subjected to environmental impact assessments of land and water pollution. Pollution prevention projects will be continued to stop the loss of mine tailings and rocky wastes from regions with a high potential of contamination.

(c All of the logging byproducts will be collected and their use as biomass (fuels or pellets) or industrial feedstock (boards or chips) will be promoted through new guidelines. To this end more relevant specialists and treatment facilities are needed.

**Research & Development and education sectors**

1) Limitations of the first programme

There were not enough basic survey data, including NPS loads by pollution channels from NPS to water bodies. Research and demonstration cases were in short supply in terms of the designing and installing green infrastructure suitable for Korean NPS pollution and its effects on abating pollutants.

In some areas with large-scale NPS pollution, relevant authorities, residents and civic groups had a consultative body, while local governance was not in place in most areas and therefore could not discern causes of NPS pollution. Public awareness needed to be enhanced so that residents, farmers and relevant operators understand the need for practical ways of nonpoint source management and related incentives.

2) Main features of the second Programme

(a) To raise the effectiveness of NPS pollution management policies long-term monitoring on the generation and characteristics of nonpoint sources by current land use or soil cover will be conducted. Moreover, the values for the unit loads of nonpoint source pollutants will be revised, to obtain a more precise image of NPS pollutant flows in the environment.

(b) Models will be developed to predict rainfall, nonpoint source loads and water quality impacts. These models will reflect regional characteristics by using the geographical information system (GIS). They can be used to show which regions are notably vulnerable to nonpoint source pollution. In addition, modelling can provide the data basis for vulnerability mapping.

(c) Eco-friendly nonpoint source mitigation systems suitable for Korean environment will be developed and installed. More investment will be made in technology development suitable for Korea's nonpoint sources with the focus on the sectors with low levels of technology such as agriculture.

(d) Policy governance will actively engage with 8 government departments participating in the Second Programme. In regions where water quality is heavily affected by nonpoint sources, campaigns and incentives will be put in place to establish NPS governance led by local municipalities, residents and developers.

(e) Education programmes will be developed for developers, farmers and urban residents, respectively. This will continuously raise awareness of NPS pollution management.

**Common areas**

Main features of the second programme

(a) Recommendation guidelines for permeability area ratio by river basin or development project will be presented to prevent floods as well as drying of city streams..

(b) The following institutional scheme will be studied: A certain amount of extra charges will be imposed to the developers whose development projects increase paved surfaces, while charges will be exempted for them when they implement measures to reduce rainfall runoff.

**Major Features of the Programme in terms of water, soil and waste nexus**

Global changes, including climate change, the loss of biodiversity and depleting resources require more integrated policy and decision making processes to achieve sustainability. For example, with respect to nonpoint source management, there should be changes in land use practices of urban planning and farming. When livestock manure is reused, land and water pollution will simultaneously be prevented. Ecological wetlands for the prevention of NPS pollution have a series of positive effects such as the prevention of floods, water pollution and soil erosion and the preservation of biodiversity.

Policy or decision making processes in one sector should consider their ripple effects in other sectors. By doing so, common measures addressing shared issues can be identified. This will increase the possibility of enhancing synergy effects, tackling externalities with efficient use of resources and sharing mutual benefits among relevant sectors (Hoff 2011).
The following introduces the major features of Korean NPS management measures in the perspective of a water-soil-waste nexus.

*Water-Soil (Land) nexus*

Material flow analyses show that a significant amount of water pollution is caused by nonpoint sources depending on land use practices. The 2010 data showed that in Korea, nonpoint sources represented 68.3%

of the organic matter carried into the water bodies, 64.5% of which came from urban development and the use of roads and farmland (ROK 2012). Therefore, the appropriate control of nonpoint sources generated by land use practices is imperative to elevate the quality of water bodies such as river, lakes and marshes.

Korea's Second Management Programme for Nonpoint Source Pollution Management follows the water-soil nexus approach by the integration of natural resource management and governance as is the case with the application of LID techniques, the creation of ecological wetlands in the vicinity of farmland or livestock farms and eco-belts in river basins. Expanding the application of the LID techniques means encouraging eco-friendly land use from the planning stage. LID practices have several positive effects: a) to prevent the inflow of nonpoint source pollutants into aquatic ecosystems by stemming rainfall at its initial stage from rapidly going into water bodies; b) to induce rainfall to permeate the ground to maintain enough amount of ground water; and c) to prevent floods which occur more frequently because of climate change. On top of this, constructing green spaces, which are one of the LID techniques, also have an effect of protecting biodiversity. Establishing eco-belts in state-purchased river basins has the same positive impacts as LID practices: controlling water pollution, keeping natural hydro-cycles, preventing floods, and protecting biodiversity.

To sum up, the water-soil nexus is of great importance for the reduction of nonpoint source pollutants. A further adaption to the nexus approach of water, soil and waste could make Korea's "Nonpoint Source Water Pollution Management Programme" more sustainable.

*Soil (Land)-Waste nexus*

With respect to NPS management, the soil-waste material flow mainly results from the excessive use of chemical fertilizers and agricultural chemicals; the use of livestock waste as fertilizers; and mineral tailings and harmful chemicals in mines. Through the soil-water material flow, waste or pollutants in land will ultimately arrive in the aquatic ecosystems, causing water pollution.

Main policy items relating to the soil-waste nexus incorporated in the Second NPS Management Programme are:

- promoting the cultivation of green manure crops;
- tougher standards for the use of livestock waste as fertilizers;
- preventing the loss of mineral tailings.

In particular, green manure crops help decrease the use of chemical fertilizers and synthetic pesticides and herbicides and make soil less vulnerable to erosion by improving soil fertility. The crops also contribute to creating eco-friendly landscapes and serve as honey plants. Using fertilizers made from livestock waste can reduce the application of chemical ones and elevate soil fertility. Therefore, the NPS management polices relating to the soil-waste nexus have ancillary effects of promoting resource recycling and preserving the environment as well as the prevention of water pollution.

*Waste-Water nexus*

With respect to NPS management, the waste-water material flow mainly results from the treatment of livestock manure and logging by-products. In 2010 livestock waste represented 28.4% of BOD nonpoint sources in Korea (ROK 2012). Main policy items are making use of livestock waste as energy sources or fertilizers and forestry by-products as biomass or industrial feedstock. Converting livestock manure to biogases and using forestry as biomass are also representative policies to reduce greenhouse gases by supplying renewable energies. Using industrial feedstock made of forestry by-products helps enhance resource efficiency. Therefore, the NPS management polices relating to the waste-water nexus seek to prevent water pollution, promote resource recycling and reduce greenhouse gases.



**Knowledge, capacity building and governance for the nexus approach**

The Korean government incorporates future research and development tasks into the NPS management plan. The tasks will help close the knowledge gaps in the water-soil-waste nexus approach. The R&D tasks are a) to collect long-term monitoring data on how the current land use practices or soil covers determine material flows; b) to develop a system based on GIS and water-soil material flow modelling research reflecting changing rainfall patterns by climate change and regional land use practices; and c) to analyze the impacts of policies within each areas of water, soil and waste on the water-soil-waste nexus. When policies create synergetic and mutually beneficial effects among areas, they need to be further developed.

In terms of capacity building, pollution source-specific educational programmes need to be developed. For example, programmes for livestock farmers provide information that the proper treatment of livestock manure has positive impacts on extensive issues such as the prevention of water and land pollution and the promotion of resource recycling and eco-friendly agriculture.

In terms of governance, NPS management programmes involve not only several government departments but also local governments, farmers, urban dwellers and development contractors. This means the successful management of NPS depends on well-functioning governance in diverse forms by stage and region. To facilitate the governance structures, incentives are needed.

**Conclusion**

The NPS programme of Korea confirms that the nexus approach can help come up with policies that are resource-efficient and mutual beneficial, ultimately responding to global changes and achieving sustainable development. In addition, the nexus approach needs nexus knowledge, data and indicators based on the analysis of other engaged sectors, relevant spatial and temporal scale, planning horizons (Hoff 2011).

Korean examples help understand how the water-soil-waste nexus approach can be applied in NPS management programmes. The reported management measures address various aspects, namely the water-soil, soil-waste and waste-water nexus and have ancillary effects such as preserving biodiversity and responding to climate change. However, more research is needed to identify each policy's influence on other sectors, synergies generated and how policies contribute to sustainable development.

There is a need as well to continuously research into the potential effects on each sector of various policy tools in finance, governance, awareness, capacity building, technology development and innovation.

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## 8.4.5 The Sanitation Story of Himachal Pradesh, India

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**Why Sanitation?**

A survey carried out by the British Medical Journal in 2006 showed that an overwhelming majority of the medical fraternity recognize sanitation as the most significant event responsible for reducing disease burden since 1840. The squalid wretchedness so vividly reflected in Dickens' view of industrializing Britain in the 19th century had to be banished before the scourge of water borne and infectious disease could be tamed in the developed world of today. On the one hand, this underlines the key difference between the developed and the developing world of today. On the other hand, it highlights how little has been achieved in sanitation in the post World War II era.

The nexus between water and sanitation although mentioned in all discussion is seldom consciously articulated by policy in the right order of priority. Sanitation has always been the poor cousin when compared with drinking water, in terms of the attention and financial support it has received even though the two are always clubbed together as part of the same sector. This is both a reflection of the relatively lower importance given to sanitation by donors and governments and even more, the limited priority attached to sanitation by those in need of it. As a result, the world remains off track to meet the sanitation MDG target. The key culprit for this is India. Against the global open defecation rate of 15%, in India over 50% of its 1.2 billion population continue to defecate in the open every day. However, even in this dismal scenario, there are beacons of hope. Himachal Pradesh, one of India's smaller states with 6.7 million people and a predominantly rural population has shown tremendous improvement in recent years. This case study documents the policy and process which brought about the change and the challenges that remain.

**The Context: A History of Non Achievement**

Till the United Nations declared the 1980s as the Water and Sanitation decade, little attention was paid to sanitation by India's centralized planning framework. Some infrastructure schemes in urban areas were the only signs of concern for sanitation in over 30 years. In 1986, a Central Rural Sanitation Programme (CRSP) was launched to subsidize toilets for poor rural households. From a level of 1% toilet coverage of rural households in 1981, the census of 1991 showed this had gone up to 9%. The limited success of this endeavour gradually brought about the realization that behaviour change is critical to avoid a landscape of defunct toilets. In 1999, the CRSP was overhauled and a new Total Sanitation Campaign (TSC) was launched. This programme reduced the emphasis on household subsidy and incorporated the need to raise awareness and emphasize the benefits of toilet usage.

"The new TSC made little headway. An implementation machinery used to pushing toilets with high subsidies, simply threw up its hands in the new low subsidy regime. Some states sought to counter this with their own subsidy schemes. Most allowed the whole rural sanitation programme to lapse into a state of hibernation" (Sanan 2011). Rural sanitation was becalmed in the doldrums. The occasional surge induced by a state subsidy scheme was only a storm in a teacup, and the ripples settled soon enough leaving sanitation in much the same place.

"In 2003, rural sanitation in Himachal Pradesh was part of this zone of indifference that most of India fell under. It had been through the cycle of diligently implementing toilet construction under the CRSP for many years and then for four years between 1994 and 1998 it ran its own state subsidy scheme that saw

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construction of about four hundred thousand toilets in rural areas. The resultant picture was similar to that in the various other states which had ventured down this path. Many toilets were built on paper and most others were only the visible shell, the superstructure, functioning as additional storage space in a corner of the yard. Usage as toilets was negligible. After the state scheme stopped and the TSC began in 1999, the districts prepared the obligatory project proposals for funding under the TSC. A few desultory workshops, some posters printed, slogans painted on the occasional wall, the futility of pushing toilets with even smaller subsidies than earlier realized, and the official machinery quickly forgot about rural sanitation" (Sanan 2011). With the Public Accounts Committee of the state legislature actively probing responsibility for wastage of funds under the earlier state subsidy scheme, there was even more reason to forget toilets as far as possible.

**A policy to Target Collective Behaviour Change**

At this stage a change in policy was initiated both in India and Himachal Pradesh. But the change at Central and State level took different directions. The Centre scaled up individual household subsidies to successively higher levels even as it instituted a reward for fully sanitized villages. Himachal decided to pursue a different path, inspired by a new approach to sanitation which has come to be known as Community Led Total Sanitation (CLTS).

"CLTS is rooted in the understanding that sanitation requires behaviour change not merely at the individual level but at the level of the collective. This is because even if many households learn to use toilets, open defecation by others places the entire community at risk. Favourable public health outcomes are secured only when the entire community adopts improved sanitation behaviour, the area is totally free of open defecation and excreta is safely and hygienically confined. This is only possible when behaviour change of the entire collective leads to collective action. The essence of CLTS is to trigger collective behaviour change and empower communities to take action to end open defecation and improve sanitation practices" (Sanan and Moulik 2007).

The two approaches have demonstrated visibly different results. In India as a whole, toilet coverage amongst rural households has grown from 22% in the 2001 dicennial census to 31% in the 2011 census. In Himachal Pradesh, it has increased from 28% to 67% in the same period and a survey in January, 2013 shows this to be at a level of 84% (Government of Himachal Pradesh 2013). Not only this, the central award for fully sanitized communities called the Nirmal Gram Puruskar (NGP) covers only above 10% of rural local bodies in all of India while in Himachal this is expected to cover 50% of all rural local bodies in 2013 (Government of Himachal Pradesh 2013). More important, surveys show that in the country as a whole, NGP awardees continue to exhibit significant presence of open defecation and only a negligible number are actually Open Defecation Free (ODF) (TARU 2008). In Himachal Pradesh, on the other hand, a 2010 survey shows open defecation in NGP awardees is only about 2% and an overwhelming 57% are completely ODF (IDS 2011).

**Knowledge of New Approach**

The CLTS approach was pioneered in Bangladesh in the year 2000 by an Indian development consultant named Kamal Kar (Kar 2003). Using techniques borrowed from participatory rural appraisal (PRA), communities were triggered by feelings of disgust to end the practice of open defecation. The key to success was community resolve and action to change collective behaviour. Policies which shift the focus from behaviour to toilets or convey that the community is not one collective entity in facing this problem or that the problem is to be addressed by outside intervention, defeat CLTS. Bringing CLTS to a subsidy ridden environment like India where the focus has always been on toilets with external financing for one part of the community, was a tall order. An exposure visit to Bangladesh, facilitated by the Water and Sanitation Programme South Asia (WSP-SA) brought knowledge of CLTS to some of India's policy makers. Goaded by a solitary champion, the state of Maharashtra introduced a no subsidy CLTS approach in pilot districts in 2003. Thereafter, policy makers in Himachal Pradesh also learnt of the approach from WSP and began the process of building an environment in favour of the new approach.



**Introducing CLTS: First Step**

The first step was a brainstorming workshop at Barog in district Solan of the state to usher in the new approach to rural sanitation and try and draw the first supporters to the cause. The workshop held in late 2003 was a relatively low key affair. Participants, other than WSP representatives numbered only around 20. District officials responsible for rural sanitation among their various charges and non-governmental organizations (NGOs) who had shown willingness to be part of mass campaigns in the state in the past (such as the literacy campaign of the 1990s), were the main participants.

Eleven of the twelve districts in the state were represented and six NGOs working in different districts. Based on its experience in Maharashtra, WSP had conceived a workshop format that led sequentially through analysis of the existing situation, introduction to new approaches, group work on key issues and identification of a way forward. Participants discussed the development of the total sanitation campaign in the state (basically its dismal progress!), the issues encountered during implementation and based on inputs on other approaches took part in group work which identified key CLTS principles as the way forward.

The district presentations brought out the despondent state of affairs in rural sanitation in the state. Seven districts had already secured funding under TSC but even on a toilet count basis progress was minimal. There was no firm data on actual coverage and usage but plenty of anecdotal evidence to show that open defecation was rampant and use of subsidized toilets extremely low. The new idea of doing away with subsides was well received and the work of laying down principles for a comprehensive new rural sanitation strategy and preparatory steps in this direction proceeded smoothly. The main debates at Barog were not so much about rural sanitation or the issue of state subsidy for the poor that bedevils most discussion on the subject when CLTS is proposed, but about the role of the World Bank! One of the NGOs present, the Himachal Pradesh Gram Vigyan Samiti (HPGVS – literally Himachal Pradesh Knowledge and Science Committee) was born during the massive literacy campaigns of the early 1990s. It was greatly influenced by the left oriented People's Science Congress of Kerala, that inspired the mass literacy movement in India through its work in that state. The suspicion of the World Bank's 'neo liberal agenda' and its pro privatization stance led to interesting questions. 'Why is this institution showing an interest in rural sanitation? In what manner would its ideology end up impacting the new strategy?' The fears were allayed when it was clarified that WSP has no lending agenda, that the new approach being discussed had not evolved through a World Bank project and that strategy development and finalization was in the state's hands.

Workshop participants agreed that the negative perceptions about toilets have to be overcome by locating appropriate triggers to mobilize the community around the need to end the practice of open defecation. The existing sanitation delivery mechanism lacked the capacity to facilitate a new approach and NGOs would have to be brought in as support organizations. A menu of technology options is a must to enable informed choice by households. Individual household subsidy should be replaced by community incentives for Gram Panchayats (GPs - bottom most tier of rural local bodies, with an average 1500 odd inhabitants in Himachal Pradesh) based on achievement. GPs should be encouraged to manage drainage and solid waste management by utilizing their own funds.

**Next Steps to implementing CLTS**

"In late 2003, WSP commissioned a rapid assessment of the sanitation situation which confirmed expectations. Effective toilet coverage was about 28%, and rural sanitation did not appear in any listing of local priorities. In January 2004, WSP facilitated an exposure visit to Maharashtra for key district level officials and NGO representatives" (Sanan 2011). The trip included an impressive presentation in Ahmednagar district and time spent in two ODF villages - WadgaonAmli and Borban. The visits demonstrated how the often voiced constraints to securing toilet coverage were addressed by motivated communities. In WadgaonAmli, three years of drought meant that the village cattle were being kept near a functioning borewell miles away. The village well was dry and replenished with tanker supply, once a day.

Yet toilets were in use and kept spick and span in every village house. In Borban, closely packed houses offered little space for toilets; in some cases, pits had been dug in room corners and elsewhere individual toilets had been grouped together in blocks at the end of a street. Sanitation had become a priority for these communities and they had found ways to address seemingly insurmountable constraints to meet this requirement.

In February 2004, another state level workshop was held. Key representatives of Panchayati Raj institutions and participants from the departments of rural development, water supply, health and women and child development endorsed the core principles for a new rural sanitation strategy. The Deputy Commissioner of Kullu district who had been on the exposure visit to Ahmednagar, began a district level campaign to create open defecation free villages on the basis of collective reward and no household subsidy. His campaign met with early success and enthused political representatives in his district.

**A New Strategy is adopted**

In January, 2005, the government of Himachal Pradesh formally approved a comprehensive new rural sanitation strategy for the state with every one of those features that CLTS adoption and scaling up seemed to require.

The key principles of the new strategy were:

- Introduction of a holistic concept of sanitation
- Have a demand oriented, outcome based approach
- For this, generate awareness of a 'need' for sanitation amongst people individually and as a community
- Involvement and ownership of the community
- Shift from individual subsidies to community incentives
- Local bodies undertake responsibility for sustainable delivery of services
- Identify appropriate institutional arrangements for delivery of services and relevant capacity support including partnership with NGOs/ CBOs and address interdepartmental co-ordination
- Emphasize monitoring and evaluation to determine success and outcomes.

The most important section of the strategy, from the perspective of ensuring that the CLTS message was not diluted, was the one on the manner in which funds would flow to the communities. "TSC subsidy for below poverty line (BPL) households shall be converted into a community reward. A lumpsum grant amounting to the total number of BPL families in any habitation / village that becomes open defecation free shall be given to that community. The reward money shall be spent by the community as decided by the relevant Up Gram Sabhas [wards of the GP] preferably on sanitation linked community needs" (Government of Himachal Pradesh 2005). In addition a Sanitation Competition Scheme for rural local bodies was proposed with an important condition that to become eligible for the competition, the applicant GP would have to be open defecation free.

"What enabled this remarkable success in policy change? The prevailing environment of indifference to rural sanitation was both the greatest asset in pushing forward the new approach and the greatest challenge in taking it forward. Politicians and civil servants were weary of pushing something in which people showed little interest. Unlike in many states there was no organization like UNICEF keeping the sanitation issue alive for government. The presence of a CLTS champion at the state level, seemed to result in great progress but his absence could also mean only a paper victory" (Sanan 2011). The champion left soon after the new policy was adopted and in a sense, the programme passed through a lean phase through 2005 although the WSP team still ensured that regular prodding kept it alive. A workshop in June, 2005 saw the release of a technology manual handbook. Thereafter, formative research for an IEC manual kindled interest in many areas and regular review ensured that district level committees were set up and identification of persons capable of taking responsibility and acting as master trainers was started. The stage was thus set for more impressive gains in future years.



**Implementing a CLTS based Strategy**

All these efforts were directed at securing the follow up steps to implement the strategy the state had already adopted. Critical in this was putting in place the institutional arrangements at the state and district level and getting the state and districts to engage the NGO support to roll out state and district level action plans. A key feature of the action plans was the training of master trainers in the districts, so that they could create CLTS motivators to reach out and help trigger behaviour change in each GP.

Three events helped move the agenda forward. The first was a decision by WSP to engage an external organisation to train district level master trainers instead of asking the state to do this on its own. A five day training module was prepared for a workshop in Barog, H.P. in May, 2006 with Kamal Kar as a key resource person. The Barog training workshop was the precursor of many district workshops across the state to create a band of master trainers and spread the CLTS mantra to every part of the state.

The second event was the emergence of a home grown champion. Even as WSP began the process of energizing CLTS at the district level, Subhashish Panda, the young Deputy Commissioner of Mandi, had initiated his own campaign in his district. Subhashish was the only Deputy Commissioner to initially implement the rural sanitation strategy adopted by the state. He made sanitation his priority and imparted that feeling to the entire district team. Committees were constituted, action plans were drafted; while PRIs were kept as the central pillar in the campaign, a committed support organization (NGO) was engaged, motivation tools were honed and improved with time and the message transmitted across the district. In 2007 when Himachal Pradesh entered the NGP award lists for the first time, 17 out of the 22 winners, were GPs from Mandi. The key to his success, Subhashish acknowledged was the 'no subsidy but collective behaviour change' approach mandated by state policy (Personal conversation of author with Subhashish Panda, 2008). His success became a rallying call for propagating the message across the state and in various workshops, Subhashish proved a more than able messenger.

The third occurrence was another change of guard at the state level. After a period of rapid turnover in Secretaries, a new pro-active person was given a stable tenure as Secretary, Rural Development and Panchayati Raj in Himachal Pradesh from the middle of 2006. Seeing the success in Mandi and WSP's persistent advocacy, he encouraged district level trainings and participated in workshops at both state and regional level. A state level rural sanitation review committee was set up in 2007. This enabled continued interaction and the evolution of an excellent monitoring system that helped track the CLTS effort across the state. The new monitoring system focused on the processes to create ODF villages instead of counting toilets and state expenditure on hardware. The officials responsible for programme implementation were no longer being held accountable for toilets constructed and funds disbursed. Instead they were answerable for the extent to which communities were being facilitated to undertake the responsibility they had assumed for improving their own sanitation situation. The programme ran effectively in campaign mode and the results became clearly visible in the years that followed.

**The Remaining Challenge**

The remaining challenge in carrying forward the sanitation story in Himachal Pradesh is twofold. On the one hand is the task of building on the achievement in rural sanitation and completing the unfinished agenda. On the other hand, the gains have to be extended to the more difficult area of urban sanitation, which involves 10% of the state's population.

*Last Mile in Rural*

The unfinished agenda in rural sanitation comprises first covering the remaining ground in communities still short of becoming ODF and secondly, ensuring that the ODF environment is sustained by the communities that have already achieved this status. The challenge in their case is ensuring migrants and public areas

and institutions have properly maintained facilities. Thirdly, the sanitation story has to extend from safe confinement of excreta to proper disposal of solid and liquid waste.

The challenge in moving to finish this agenda lies in a mix of factors. The champions who spearheaded the sanitation campaign in those years from 2006 to 2011 or so, have moved on. The new teams at state and district level have missed out on the understanding necessary to pursue the CLTS approach. At the same time, the pressure to avail of maximum funding from the centre encourages a pursuit of subsidized toilets for households, institutions and public places. The centrally funded TSC has been reformulated in 2012 as the Nirmal Bharat Abhiyan (NBA Clean India Campaign) with more liberal norms of subsidies for household coverage, more funds for toilets in institutions and public places as well as for solid and liquid waste management.

The monitoring system for achieving ODF status has fallen by the wayside and it is likely that the policy of only rewarding an ODF environment may be given up in favour of subsidizing individual household toilets. There is thus a real danger that having achieved so much in such a short time, the last mile may stay just out of reach for a long time. The relapse into counting toilets and pushing subsidies by programme managers will inevitably bring a loss of community feeling and ownership of the task.

*Urban Gap*

In traditional thinking about urban sanitation, the perception is that it is largely a matter of funding network infrastructure to reach the entire city and a regulatory framework so that connectivity and safe disposal are ensured by inhabitants. In actual fact, even after funding infrastructure, its utilization ratios are dismal historically and little thought has been given to arrangements for safe disposal in areas not connected to the network. The conception that sanitation must be thought of and addressed in a holistic, city wide manner is not really present in policy and practice. There has been little attempt to relate health issues to poor sanitation which must be addressed with city wide solutions.

City level analysis of sanitation and related issues to secure CLTS type collective behaviour change and action appears to be called for. However, CLTS has conventionally been used only in rural areas and the different characteristics of an urban setting pose a challenge in adapting techniques and processes while adhering to the core principles of triggering collective behavior change leading to meaningful collective action. The urban community is spread over a bigger area, it is less homogenous in its composition and has a complexity in institutional structure brought about by the larger population and of technological requirement by its denser concentration. It is possible to use conventional CLTS to trigger individual peri-urban slum communities but for sustainable results, the entire city must be involved in looking at safe disposal and tackling constraints that stand in the way. City involvement is often complicated by the fact that various matters can involve State or National level decisions (like land tenure or regulatory standards) and very often funding mechanisms are controlled by state/central levels.

The understanding that it is necessary that the city prioritizes and plans its sanitation related intervention on its own and that various issues require a view at the central and state level in order to ensure that the city is empowered to address its sanitation situation, lay behind the National Urban Sanitation Policy (NUSP) adopted in India in 2008. The NUSP sought the adoption of State Sanitation Strategies (SSS) to address state level issues. City Sanitation Plans (CSPs) were expected to follow after that. In these CSPs, cities would, in a participative manner, focus on improving outcomes, based on a detailed situation analysis as well as the monitoring requirements and resource envelope made available to them by the State Sanitation Strategy (SSS).

In actual practice, central infrastructure financing schemes have sought the preparation of CSPs as a precondition (even without the SSS). In Himachal Pradesh, the largest urban concentration is in the capital, Shimla. It has recently seen the preparation of a CSP without the state taking up adoption of a State Sanitation Strategy that would provide the guiding framework of regulation, resource availability and monitoring system to assess and compare the situation across different towns. A broad city level analysis of the existing sanitation situation was carried out. Consultations were then held on proposals to fill the overall gaps based on the funds likely to be available under the central scheme. Most glaring was the omission of data and analysis that could have been the basis of a city wide sanitation campaign to galvanize the community to seek better outcomes and address the collective behaviour that was preventing this from happening. In effect, it was perceived largely as a technical exercise to tie up funding for the infrastructure gaps that are conventionally central to sanitation planning. The CSP has thus become a vehicle for securing central funds rather than the outcome of improvement in safe disposal of waste generated by the city.

In the face of pressure to secure and utilize central funds, the necessity to build city wide awareness and participation in a meaningful plan has been lost. It is unlikely to occur without national and state level policies/strategies that are conducive to such an effort. Consequently funding for the Shimla, CSP may result in sewerage treated going up somewhat from the existing 10/12% but the city's tryst with a fully sanitized environment, free from the scourge of frequent hepatitis epidemics, still seems distant.

**Lessons**

The first lesson from the experience of Himachal Pradesh (and the over 50 countries where CLTS has been introduced) is about the efficacy of CLTS principles. Achieving success on the sanitation front, is about raising consciousness of this need at a collective level. This can be done with an appropriate engagement that enables the community to undertake an analysis of its own situation. Once triggered, communities are capable of collective action at their own level to improve their sanitation situation. Rapid scale up is possible with proper planning, commitment and capacity building.

The second, more sobering, lesson is how easily this pathway to success can reach a dead end if the policy environment does not enable a proper application of CLTS principles. In India, the overall policy environment in both the rural and urban context is inimical. A combination of chance events enabled favourable policy and process to succeed in rural Himachal Pradesh. But sustaining this or translating this in the urban domain is a tall order. India must somehow learn not merely from Himachal Pradesh but its neighbours Bangladesh and Nepal (the recent South Asian Conference on Sanitation – SACOSAN V held at Kathmandu from October 22-24, 2013, brought out the tremendous strides made by those two countries by followig CLTS principles) and numerous other countries in Africa and Asia, for the world's sanitation situation to improve.

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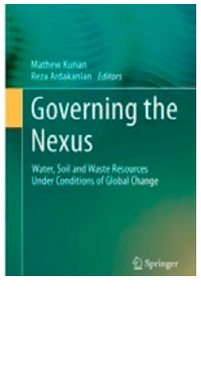
# 9. Follow-up and Outlook

The kick-off workshop resulted in various direct outcomes and outputs besides these proceedings and, as intended, provided the conceptual background for the future Dresden Nexus Conference.

## 9.1 Publications Resulting from the Kick-off Workshop


**White Book**
The draft White Book which had been prepared for the kick-off workshop was finalized according to comments received by the participants and has been published as reference material for the upcoming "Dresden Nexus Conference" (DNC, see below). The white book is available at (http://flores.unu.edu/white-book)




**Springer Books**
Some of the ideas presented and discussed during the kick-off workshop have been taken up by the authors and elaborated further. Complemented by some additional contributions they became part of a book on "Governing the nexus", see http://www.springer.com/environment/sustainable+development/book/978-3-319-05746-0.



## 9.2 Dresden Nexus Conference (DNC2015)

As an immediate follow-up, the concept for the first of the regular bi-annual Dresden Nexus Conferences was prepared. Based on the workshop discussions and considering the ongoing process of defining SDGs, the main theme of DNC2015 will be "Global Change, Sustainable Development Goals and the Nexus Approach".

The concept for DNC2015 (see http://flores.unu.edu/dresden-nexus-conference) states that "The nexus approach to the sustainable management of water, soil and waste integrates environmental management and governance across sectors and scales. This approach is based on the understanding that environmental resources are inextricably intertwined. Global change will put additional pressure on environmental resources and related ecosystem services as well as on the economic development. The DNC2015 will deal with these challenges. There will be three thematic topics on three consecutive days; each day will deal with one aspect of global change: climate, urbanization and demography. It will be discussed how the integrated management of environmental resources guided by nexus approach may help to achieve the potential targets of the post-2015 agenda". For each of the three key themes mentioned below the conceptual background as well as expected outcomes and key questions have been formulated.

**Key theme 1: Climate**
How adopting a nexus approach may mitigate the growing water, food and energy insecurity due to climate change from an environmental resources perspective.

**Key theme 2: Urbanization**
Exploring opportunities for multi-level governance arrangements that foster inclusive forms of urbanization based on an improved understanding of trade-offs and scope for synergies.

**Key theme 3: Demography**
How the management of environmental resources guided by a nexus approach can support the sustainable and economically feasible intensification of biomass production.

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