Working Paper No. **314**

International
Labour
Organization

Wastewater and jobs

The Decent Work approach to reducing untreated wastewater

Sectoral
Policies
Department

WP 314

Wastewater and jobs:
The Decent Work approach to reducing untreated wastewater

Michael Renner

International Labour Office
Geneva

Working papers are preliminary documents circulated to stimulate discussion and obtain comments

ILO Cataloguing in Publication Data

Wastewater and jobs / International Labour Office, Sectoral Policies Department. - Geneva: ILO, 2017.
(SECTOR working paper ; No. 314)

ISBN: 978-92-2-130837-9 (web pdf)

International Labour Office. Sectoral Policies Dept.

water treatment / employment creation / waste recycling / productivity

17.05.4

Preface

Working papers published by the ILO Sectoral Policies Department aim to disseminate research on relevant and topical issues among policy-makers, administrators, social partners, civil society, the research community and the media. Their main objective is to contribute to an informed debate on how best to address sectoral issues within the overall agenda of full and productive employment and decent work for all, a goal embedded in the 2008 ILO Declaration on Social Justice for a Fair Globalization as well as the 2030 Agenda for Sustainable Development.

In World Water Day, on 22 March every year, the UN community advocates for action on water issues. In 2017, the campaign promotes the reduction and re-use of wastewater. Sustainable Development Goal (SDG) target 6.3 seeks to reduce by half the proportion of untreated wastewater and to increase recycling and safe water reuse substantially by 2030. The measures required to reach this target are strongly linked to the Sustainable Development Goal 8 on decent work economic growth, which calls for upgrading technology to improve productivity (target 8.2), decoupling economic growth from environmental degradation (target 8.4), and protecting labour rights and promoting safe and secure working environments (target 8.8).

This working paper discusses the potential of investments of wastewater and how they impact productivity, livelihoods, job creation, skills needs, occupational safety and health, and women's employment. It further identifies the respective roles of the public and private sectors and of cooperatives.

The working paper was written by Michael Renner, main author of a 2008 landmark report on green jobs produced jointly by the ILO, IOE, ITUC and UNEP. We hope this paper will help to stimulate discussion on the inter-linkages between wastewater and the world of work in the context of the 2030 Agenda for Sustainable Development.

Alette van Leur
Director
Sectoral Policies Department

About the author

Michael Renner is a Senior Researcher at the Worldwatch Institute in Washington, DC and has served as an independent consultant on green jobs and sustainable development. He was lead author of Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World (2008), jointly commissioned by the UN Environment Programme and ILO. His work for ILO includes contributing to Working Towards Sustainable Development: Opportunities for Decent Work and Social Inclusion in a Green Economy (2012), and a forthcoming working paper Employment Impact Assessment in Energy. Since late 2011, he has also co-authored a range of reports for the International Renewable Energy Agency on renewable energy and jobs. He is also the author of two policy briefs for the Norwegian Peacebuilding Resource Centre on Water Challenges in Central-South Asia (2009) and Water and Energy Dynamics in the Greater Himalayan Region (2011). Michael is a German national and holds a Master's degree in international relations from the University of Amsterdam.

Contributors

Carlos R. Carrión-Crespo, Sectoral Policies Department

María Teresa Gutiérrez, Employment Policies Department

Karin Isaksson, Green Jobs Programme

Contents

Executive summary

Based on a literature review, this paper offers a summary of key opportunities and challenges concerning the intersection of wastewater and the world of work. Globally, more than half of freshwater withdrawals are released again as wastewater. Against the backdrop of rising global demand for water and the growing challenge of water scarcity, recognition of the potential beneficial use of adequately-treated wastewater flows is growing.

Doing so would likely either create new jobs or help support existing jobs, in the water treatment sector as well as in a range of water-dependent sectors of the economy. Failure to pursue these opportunities, on the other hand, carries negative health, productivity, and livelihood consequences. But labour aspects—ranging from levels of employment to skills and training needs, and from occupational safety and health to gender issues—have so far received comparatively little attention.

Because more than 80 per cent of global wastewater flows are released without adequate treatment (especially in developing countries), the need for greater investment in new water treatment infrastructure, upgrading of old facilities, and improved services for wastewater collection and treatment is beyond question.

The International Benchmarking Network for Water and Sanitation Utilities offers data on more than 4,000 water utilities worldwide that provide sewerage services for 313 million people. As of 2010, they employed a professional staff of about 623,000. But employment data are often sparse, especially for most developing countries.

Substantial employment can be generated in expanded treatment plants and systems, through reuse of wastewater treated to 'fit-for-purpose' levels, and in a range of water-dependent sectors, especially agriculture. In principle, input-output analysis and social accounting matrices allow a comprehensive mapping of employment impacts. The Sustainable Development Goal to ensure availability and sustainable management of water and sanitation for all (SDG 6) offers a strategic opportunity for substantially improving the management of wastewater, for reviewing national policy frameworks, and for increasing investments. They also offer opportunities to advance several targets included in the Goal to promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (SDG 8).

This paper also discusses wastewater reuse opportunities in the industrial sector and in agriculture, as well as the capture of by-products from wastewater. Wastewater can be recycled within a given industrial plant, or the wastewater of one enterprise can be reused as a resource by adjacent facilities. Such practices avoid expenses for water, energy, and discharge fees, offering a competitive advantage and thus shoring up existing jobs.

A variety of materials can be recovered from wastewater flows, including nutrients; organic matter; thermal, chemical and hydraulic energy; and other useful by-products such as biogas. In developing countries, the construction of small-scale biodigesters, composting toilets, stabilization ponds, and constructed wetlands serves as a source of employment, and the biogas offers opportunities for income generation.

Given the high nutrient content of municipal wastewater, it can be used for agricultural purposes and existing flows are theoretically sufficient to irrigate 40 million hectares (or 15 per cent of all currently-irrigated lands). This is double the up to 20 million hectares of land currently irrigated with wastewater.

A substantial number of farming livelihoods could thus be supported, in addition to jobs in research, agricultural extension, building and maintaining irrigation systems, and in regulatory and public health agencies. In India, for example, it is estimated that wastewater could annually irrigate 1-1.5 million hectares of farmland and generate 130 million person-days of employment.

Nutrient-rich water may also be used in aquaculture operations, and stabilization ponds can create jobs. Wastewater use in fish farming remains widespread in China, India, Indonesia and Viet Nam. However, health safety concerns need to be addressed and the spread of urban areas is putting pressures on available land for fish ponds.

Many countries already face significant staff shortages in the water treatment industry. OECD countries confront the problem of staff attrition due to an aging workforce. Many lower- and middle-income countries have failed to match investments in sanitation infrastructure with an expansion of the human resource base. Professional training needs to be complemented by adequate technical and vocational education and training efforts. In many countries, there is also a lack of coordination between the wastewater sector and training institutions, resulting in a mismatch between the numbers and skills of workers trained and actual sector needs. Improved collaboration is essential for any expansion of wastewater reuse.

Without adequate safety precautions, the use of wastewater in agriculture can contaminate crops, livestock products, soils, and water resources. There are very significant health concerns for agricultural workers because of their direct contact with wastewater. Mechanised cultivating and harvesting practices, crop drying prior to harvesting, and long dry periods between irrigations lower worker risks. Best practices need to be shared widely.

A range of ILO Conventions and standards have specific relevance to the expanded use of wastewater, including the Hygiene (Commerce and Offices) Convention, 1964 (No. 120), the Safety and Health in Agriculture Convention, 2001 (No. 184), the Occupational Safety and Health Convention, 1981 (No. 155), the Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187), and the Occupational Health Services Recommendation, 1985 (No. 171).

The female share of the workforce in the formal wastewater treatment sector is quite marginal, especially in technical and other professional positions. Gender mainstreaming requires a better understanding of key impediments and greater efforts to promote the technical careers of young women (through scholarships, changed recruitment procedures, etc.).

Outside the formal water sector, women play an important role with regard to water, hygiene, and health in many countries and cultures, but exposure to health risks is a concern. Among farmers in India and Pakistan, for instance, female family members commonly serve as low-cost labourers applying wastewater to crops. Women generally need to be included better in decision-making structures and applicable occupational safety and health standards need to take the concerns of female workers into account.

Attention needs to be devoted to the respective roles of the public and private realms. Water privatisations had spread rapidly throughout the world for some years, but often disappointing results led a growing number of communities to insist on returning water and wastewater services to public management (most remunicipalisations have taken place in high-income countries, but some also in middle- and low-income countries). These efforts offer an opportunity for strengthening the governance and quality of public services, improving working conditions and worker participation in decision-making, and for social dialogue. Also, cooperatives are playing an increasingly important role in efforts to provide access to safe water and sanitation services.

The 2016 and 2017 editions of the World Water Development Report most directly pertain to the intersection between the wastewater sector and the world of work. Among the recurring issues addressed by the various editions of the series are the important interconnections among the social, economic, and environmental pillars of sustainability. The demands of equity and decent work interact with adverse ecosystem changes, repercussions of climate change, and pressures of rising water demand and urbanization.

Global goal-setting is another key theme, with the SDGs expected to mobilise greater investment and human resources. The need to engage effectively with all stakeholders—male and female—is a third theme; the critical role of workers deserves growing recognition. Finally, effective institutions are essential—not least the need for greater collaboration and policy coherence among the different relevant actors.

1. Introduction

This background paper is based on a literature review on the topic of wastewater and the world of work. It offers a summary of key issues and experiences—opportunities and challenges—and identifies initial core messages in conjunction with the themes and threads of past World Water Days. Of particular relevance are the 2016 World Water Development Report, which focused on the intersection between water issues broadly and employment, and the 2017 edition, which offered perspectives on wastewater issues. Wastewater is also a topic that links two important sustainable development goals: SDG 6 (universal access to water and sanitation) and SDG 8 (sustainable growth and decent work for all).

The World Water Development Report 2017 (WWAP, 2017) explains the critical role played by a new approach to wastewater in a world that is marked by rising demand for water, in which growing numbers of people are affected by water scarcity, and in which inadequate treatment of wastewater flows causes widespread problems. The report argues that "Addressing the world's wastewater-related challenges is essential to advancing human health and livelihoods, promoting the growth of local and national economies, improving the quality of water, air and land, and protecting and enhancing ecosystems and the services they provide. Indeed, improved wastewater management represents a critical factor in achieving sustainable development for all."

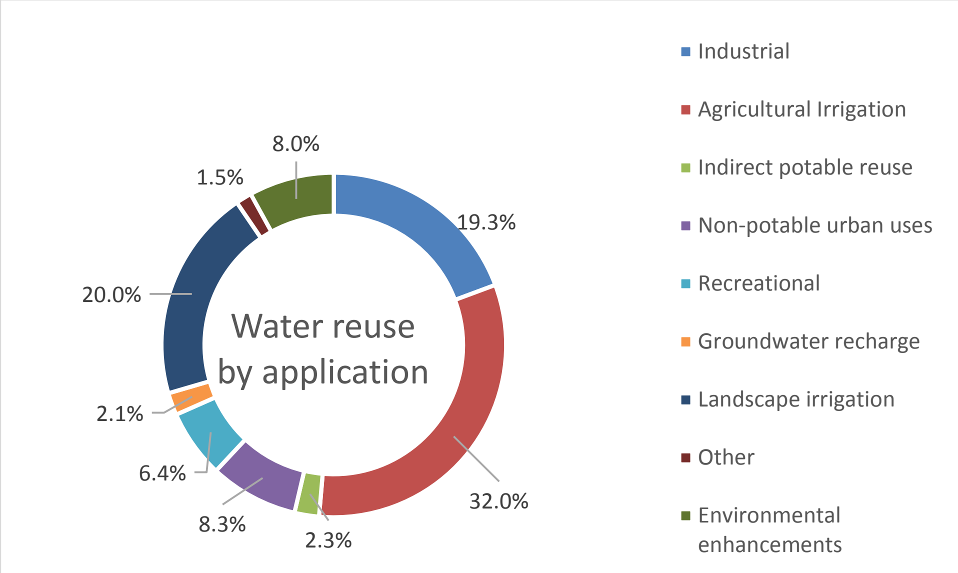
Water scarcity is a long-standing problem, but the population suffering from this condition is projected to grow from some 700 million people in 43 countries today to 1.8 billion people by 2025. Given likely climate change scenarios, close to half the world's population could live in areas of high water stress by 2030. Water use is significantly outstripping population growth in several parts of the world. By 2050, three quarters of the world's population could be affected by water scarcity (UNESCO-UNEVOC, 2012).

Agriculture is the biggest user (and also a significant polluter) of water, claiming roughly 70 percent of the freshwater withdrawals worldwide (Siebert et al., 2010). Projections indicate that world food demand could rise as much as 70 per cent between 2000 and 2050, given population growth and changing diets. Water pressures thus are bound to increase dramatically, and achieving food security globally will continue to be a challenge. Agriculture has a global workforce of almost one billion farmers and farm labourers (WWAP, 2016).

Although greater water use efficiency forms an important part of the solutions to these challenges, there is growing emphasis on reusing wastewater for irrigation purposes. Irrigation can offer crop yields two to four times greater than is possible with rain-fed farming; irrigated areas provide 40 per cent of the world's food from approximately 20 per cent of its agricultural land (Molden, 2007; FAO, 2011).

More than half of global freshwater withdrawals are released again as wastewater—either as municipal or industrial effluent or as agricultural drainage water. There is thus a very significant flow of water—which could, in principle, be used to moderate water pressures. In the process, it could support economic activities and either create or maintain existing jobs—in the water treatment sector, as well as in other sectors of the economy that rely on water reuse. At present, agriculture accounts for close to one third of water reuse following tertiary treatment, followed by industrial users with close to one fifth of treated water reuse flows.

Figure 1. Global Water Reuse after Tertiary Treatment



Source: WWAP, 2017.

However, more than 80 per cent of global wastewater flows are released without adequate treatment (WWAP, 2017). According to Sato et al. (2013), treated wastewater accounts for about 70 per cent of total wastewater flows in high-income countries, but the share is much lower in upper-middle-income countries (38 per cent) and in lower-middle-income countries (28 per cent), and barely registers in low-income countries (8 per cent). China [1], India, and some other emerging economies have undertaken large investments in wastewater treatment and recovery (WWAP, 2016). This has created significant employment opportunities in construction and operations & maintenance.

WWAP (2017) examines some of the regional challenges in this context. In Africa, a major problem is the lack of infrastructure for collection and treatment. High organic loads, unregulated waste inputs, and inadequate investments result in the widespread pollution of surface and groundwater resources. In the Arab Region, close to a quarter of treated wastewater is being used, principally for irrigation and groundwater recharge. But because many treatment plants are overloaded, the resulting effluent is low in quality. In Latin American countries, urban wastewater treatment coverage has increased to reach an estimated 20 to 30 per cent of collected wastewater. But treatment projects are being pursued more often in isolation from each other than as part of an integrated approach, and many plants are characterised by poor maintenance. UNESCO-UNEVOC (2012) adds that vocational training is not extensively developed.

The literature is clear on the need for greater investment—mobilising fresh funds and reallocating existing resources in support of sustainable and equitable solutions. This includes investment in new infrastructure (especially where current coverage is low), but also maintenance and upgrading of old facilities, and improved services for wastewater collection and treatment, and adequate safeguards in wastewater reuse. But it is also important to adopt the most appropriate and affordable technologies in each region and country—and to gain a better understanding of the employment impacts of different choices of infrastructure and equipment. Also important are effective institutions, a strong regulatory framework, adequate enforcement and compliance monitoring of the wastewater treatment industry, and—in the agricultural

[1] China's treatment capacity expanded close to 20-fold between 1990 and 2010. Additional construction is planned, even as many existing plants do not operate at full capacity or function improperly (Deng and Wheatley, 2016).

sector—effective extension programmes to ensure safe use of wastewater resources. All of this requires capacity-building and has significant human resource implications.

Because conventional treatment systems are costly to operate, a high number of treatment plants in large parts of the developing world are in a dysfunctional state. Drechsel et al. (2010) are among the observers who urge that more appropriate and affordable solutions be pursued. They advise that innovative changes are necessary, including "research towards re-engineering conventional wastewater treatment systems to make them more appropriate for irrigation, by optimizing the water and nutrient contents in treated wastewater effluents …" They discuss unconventional wastewater treatment methods such as "the use of low-cost systems such as on-farm ponds, sedimentation traps and biosand-filters while health-protection measures include improved irrigation methods, like drip irrigation, cessation of irrigation before harvesting and produce-washing."

A fundamental handicap is the scarcity of detailed information. The World Water Development Report 2016 acknowledged that "In most countries there is a dearth of information on the quantity and quality of human resources for WASH services …" (WWAP, 2016). The 2017 edition of the World Water Development Report also speaks to the "pervasive lack of data relating to virtually all aspects of water quality and wastewater management, particularly in developing countries." Data gaps include "information on the condition of the existing wastewater infrastructure, the performance of wastewater treatment, the fate of faecal sludge, and the volume, quality and location of wastewater used in irrigation."

The lack of data extends to the employment dimension. There is limited, and often dated, information about existing jobs in the wastewater sector. In addition, it is difficult to quantify the employment potential inherent in stepped up water treatment and in applying "fit-for-purpose" water in various sectors of the economy, such as agricultural irrigation.

2. Productivity and Livelihood Impacts of Inadequate Water Treatment

While improved wastewater management and expanded reuse of such water offers potential employment benefits, a failure to improve or at least maintain water and wastewater infrastructure carries the penalty of strong negative economic, livelihood and employment consequences.

In developed countries, the principal problem is the need to update or rehabilitate aging infrastructure. In the U.S. context, ASCE (2011) reported a capital funding gap for maintaining and upgrading wastewater treatment systems of US$42 billion, warning that the it could grow to US$60 billion by 2020 and US$99.5 billion by 2040. In a worst-case scenario, the repercussions of an unreliable water and wastewater infrastructure could include the loss of 669,000 jobs across the entire economy by 2020. In 2016, the Environmental Protection Agency estimated that the United States needed to spend $271 billion over the course of 20 years to maintain and improve wastewater systems (Cardno, 2016).

In developing countries, the release of untreated or inadequately treated wastewater into the environment remains common practice. Livelihoods in farming, fisheries, aquaculture, and tourism suffer as a consequence (UNEP, 2015). This practice has severe negative health impacts, which translate into reduced productivity and inability to carry out work. (See Table 1.) Inappropriate wastewater disposal prevents or harms close to 65 million life years annually due to hepatitis A infections, worm diseases, schistosomiasis, gastrointestinal infections, and respiratory disorders (Heymann et al., 2010).

Table 1. Negative Impacts of Wastewater on Productive Activities

• Reduced industrial productivity • Reduced agricultural productivity • Reduced market value of harvested crops, if unsafe wastewater irrigation • Reduced number of tourists, or reduced willingness to pay for recreational services • Reduced fish and shellfish catches, or reduced market value of fish and shellfish

Source: UNEP, 2015.

Note: The original table also includes negative impacts on human health and the environment.

In addition, the failure to make adequately treated wastewater flows available undermines the goal of securing a sufficient and safe supply of water available for reuse. This in turn means that jobs in water-dependent sectors (such as irrigation of farmland) may either be lost or not even created in the first place.

Appropriate wastewater collection and treatment, on the other hand, makes for healthier workers, fewer lost workdays, higher productivity, and earnings power. Box 1 offers an example of the experience in Cameroon, where improvements in sanitation infrastructure have provided employment and helped reduce poverty. As WWAP 2017 notes, there are a number of employment and income generation benefits from improved wastewater management:

- It "contributes to the success of nutrition improvement strategies (SDG Target 2.2), reduces preventable deaths among children (SDG Target 3.1) and enhances children's attendance and performance in school (SDG Target 4.7)."

- Further, "reducing the burden of disease also reduces the time spent taking care of sick family members, leaving more time to participate in the formal economy (SDG 8) …"

Box 1. Cameroon: The Yaoundé Sanitation Project (PADY)

Maintenance of infrastructure works on sanitation have a great potential of jobs creation at the local level. The ILO set up the PADY to clean up the Cameroonian capital financed by the African Development Bank (20 billion CFA francs) and by the Cameroonian Government (2.3 billion CFA francs) in 2006-2010. The objective was to reduce poverty by applying labour-intensive approaches for road maintenance works, reducing water-borne diseases by treating the insalubrity of the riverside districts and beautifying the living environment of the populations. The PADY cleaned up underground collectors in the urban center of Yaoundé and re-calibrated the Mfoundi River canal. The number of people who suffered from occasional floods was reduced from 243,000 in 2005 to 120,000 in 2007 and 48,000 in 2009. The PADY established a pre-waste collection system covering 14 districts of the city, benefitting the same 243,000 people.

Indeed, ILO (2016a) argues that "enhanced worker productivity is a central argument for WASH-related provisions in the workplace." Investments in sanitation can bring up to four-fold economic returns in terms of increased health and productivity. An analysis of studies covering 27 African countries, referenced by the ILO report, found that "increasing the access rate to drinking water significantly increases the growth rate of agricultural labour productivity" because of the better health of workers and less time they spend on fetching water.

3. Existing Employment and SDG Targets

The employment relevant to the issue at hand encompasses, in the first place, jobs in the water sector, specifically the provision of sewerage, waste management and remediation activities. As WWAP (2016) points out, there are also "ancillary water jobs" that "provide the water-related enabling environment and necessary support to the activities or operation of an organization, institution, industry or system" including engineers, hydrologists, planners, and specialists for legal, policy, and financial questions. But "while jobs in the water sector may sometimes represent only a minor share of the total employment opportunities, they are a prerequisite to a large number of other jobs" (WWAP, 2016). Using adequately treated wastewater offers potential employment benefits in a range of water-dependent economic sectors.

Employment Data Limitations

Wastewater management and economic uses of water in the agriculture, industrial, and energy sectors require a range of jobs in many disciplines and occupations. These include policy-making, planning, financing, regulatory frameworks, the construction of facilities and other infrastructure, operations and maintenance, and monitoring and enforcement, among others. However, available statistics on employment are limited and offer insufficient detail. WWAP (2016) argues that gathering sufficient "information concerning informal, part-time and/or unpaid work" is one of the greatest challenges.

According to UNESCO-UNEVOC (2012), water supply and wastewater facilities operators employ about 80 per cent of the workers in the water industry (no disaggregation appears to be available to distinguish workers in the water treatment sector alone). Danilenko et al. (2014) reference the International Benchmarking Network for Water and Sanitation Utilities (IBNET), which offers information on more than 4,000 water utilities worldwide. The utilities captured in the IBNET database provide sewerage services for 313 million people (and water supply for 513 million people). As of 2010, they employed a professional staff of about 623,000.

Other than for developed countries, employment data for the water treatment sector are sparse. In the member countries of the European Union, as many as 1.5 million people are employed in water supply, sewerage, waste management and remediation, according to Eurostat (2016). Earlier statistics (Eurostat, 2012) offer a breakout for the sewerage sector, with 139,600 jobs.

But even for a country like the United States, there are varying data. The Bureau of Labor Statistics (BLS, 2015) puts the number of direct jobs for "Water and Wastewater Treatment Plant and System Operators" at 117,000 in 2014. But a higher estimate comes from Grigg (2009) who reviewed a range of data sources and concluded that employment at wastewater utilities may run to about 175,000 (compared with 250,000 jobs at water utilities). But he points out that his figures are only approximations. Accuracy in employment surveys typically is hampered by a number of factors, including a lack of standardized definitions of occupations; a large number of small operators; problems related to outsourcing of certain activities; and others. However, reasonably accurate employment data are essential for drawing up adequate training policies, planning certification programs, and developing effective workforce strategies.

In addition to direct employment in wastewater management, there are many indirect jobs in related fields. A report issued by the United States Conference of Mayors (2008) pointed to the considerable job multipliers in the water sector. A Bureau of Economic Analysis found that for each U.S. water and wastewater sector job there are another 3.68 indirect jobs. While the multiplier obviously varies from country to country, this suggests that investments in water-related services can be very effective for job creation.

Substantial employment can also be generated through reuse of wastewater treated to 'fit-for-purpose' levels, in expanded treatment plants and systems, in the public health sector, and in a range of water-dependent sectors, such as agriculture and agricultural extension, produce marketing and the cultivation of non-food crops. The various types of jobs require a range of skill sets, training and professional development, and capacity development (WWAP, 2016).

Input-output analysis and social accounting matrices allow a comprehensive mapping of the ways in which the water and sanitation sector creates jobs. WWAP (2016) refers to the World Input-Output Database (WIOD) as one useful tool to better understand the intersection between water and employment, for analysis of the quantity of jobs created when governments move to improve water supply, for estimating backwards and forwards linkages, and calculating multiplier effects of investments. WWAP (2016) also highlights the need to generate decent work indicators in the water sector, with regard to job quality of jobs, occupational profiles, safety and health considerations, and skill needs.

There is an undeniable need for investment to expand—and improve existing—municipal wastewater infrastructure, which in turn would create substantial employment in the construction sector and in operations and maintenance. According to a World Bank study, investing US$1 billion in water supply and sanitation network expansion in Latin America would create about 100,000 jobs (Schwartz, et al., 2009). Although this jobs factor will obviously vary across the world's regions (and depend on the degree of capital- versus labour-intensity of operations), it is broadly indicative—and an interesting finding relative to the estimate mentioned in WWAP 2017 that annual global spending on wastewater infrastructure may amount to US$104 billion.[2]

WWAP (2017) notes that investments in water treatment and control technologies in the United States and European Union are increasing. These developed countries have far more extensive, and advanced, treatment systems than poorer countries do, but they also contend with an aging infrastructure and concerns about rising pressure on facilities from rising wastewater volumes. At the same time, there is concern over staff attrition (discussed further below).

The SDG Framework

International policy frameworks such as the Millennium Development Goals and subsequently the Sustainable Development Goals play a critical role in the water context. The MDGs had included a target of halving the share of people without access to basic sanitation by 2015 (MDG 7), though it was not uniformly achieved. Now, the Sustainable Development Goals (specifically, SDG 6) offer a new 15-year framework for improving water resource management. (See Table 2.) Included in SDG 6 are targets for expanded international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, with official development assistance as a key indicator. On the local level, the participation of communities in improving water and sanitation management is to be strengthened. In some respects, the means to achieve this SDG also supports SDG 8 on full and productive employment and decent work.

Table 2. SDG 6 Targets

Target 6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
Target 6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.
Target 6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

SDG 6 offers a strategic opportunity for substantially improving the management of wastewater, for governments to review and adjust their national policy frameworks, and for channelling increased investments into this critical sector. For target 6.3 to be achieved, significant investments will be required in new infrastructure and appropriate technologies to increase the treatment and use of wastewater. Investments are also needed to upgrade and properly operate and maintain current infrastructure, and to monitor and control the quality of water and wastewater (UN Water, 2015). This technological upgrading is also contemplated in

[2] WWAP 2017 references a study by Heymann et al. (2010), but it should be noted that the mentioned report does not in fact contain the mentioned figures; it refers to a range of estimates concerning the entire water market.

Target 8.2, which seeks higher levels of economic productivity. It would also help decouple economic growth from environmental degradation, as proposed in Target 8.4. But the inter-linkages are not limited to Goal 8: for example, target 12.5 also seeks to substantially reduce waste generation through prevention, reduction, recycling, and reuse.

Whether countries will be able to mobilize the required funds required is a key question. For example, WWAP (2017) refers to estimates for Latin America and the Caribbean, which indicate that the countries of the region would need to invest more than US$33 billion to increase coverage of wastewater treatment to 64 per cent by 2030, and a similar amount to expand stormwater drainage systems (Mejía et al., 2012).

A much-needed expansion of wastewater treatment facilities would likely generate a significant number of jobs. IWA (2014) reported on estimates of professionally qualified personnel (water and sanitation professionals and related fields including technicians, management, finance staff, etc.) required to reach the MDG water targets in selected developing countries. However, large differences in needs were reported among the countries included. The study concludes these are due to different methodologies and definitions of professional capacity applied in individual countries. (See Table 3, with particular reference to Ghana.) An additional question concerns the balance between professional staff required and workers with lower levels of qualifications or skills. This will vary from country to country, and depend on the degree to which expensive facilities or lower-cost solutions are pursued.

These investments are part of the transformation of economies, workplaces, enterprises and labour markets into a low-carbon, sustainable economy. They can provide decent employment opportunities, considered "green jobs". Green jobs are decent jobs which contribute to preserving, restoring and enhancing environmental quality.

Table 3. Human Resources (HR) Demand to Meet Universal Drinking Water and Sanitation Targets, Selected Developing Countries

Countries	Total HR demand to meet the universal coverage of drinking water target	Total HR demand to meet the universal coverage of sanitation target
Burkina Faso	43,900	37,800
Ghana	31,400	597,600[a]
Lao PR	730	290
Mozambique	12,700	6,900
Niger	17,100	7,400
Papua New Guinea[b]	6,000	6,000
Philippines[c]	643,407 (low productivity) 576,173 (high productivity)	
Senegal	2,700	1,100
Sri Lanka	4,300	700
Tanzania	19,300	4,700
TOTAL[d]	138,430	662,470 (If Ghana excluded: 64,870)

Source: IWA, 2014.

Notes:

a. The large number for Ghana may include semi and unskilled workers, which was not included in the definition as defined by the methodology.

b. Estimate as HR demand was not fully calculated.

c. Takes into account para-technicians (semi-skilled but not professional workers), and the detailed disaggregation is found in the case study itself.

d. Total figure excludes Philippines demand as it was the only country that included para-technicians, which leads to skewed figures.

4. Jobs Potential in Expanded Wastewater Reuse

Managing and using wastewater can be a source of employment in a number of ways (WWAP 2017):

- Removal of contaminants from waste water streams (fit-for-purpose treatment through a myriad of treatment options)
- Reuse of waste water from municipal, industrial, and agricultural sources in a variety of economic sectors
- Recovery of useful by-products (including biogas)

Particularly the last two items are now receiving growing attention, in order to relieve water shortages and pressures. The use of untreated wastewater is already occurring widely, but too often is done without appropriate measures to ensure acceptable environmental and human health outcomes. For an enhanced wastewater reuse strategy, adequate safety measures are thus required, as are concomitant levels of investment. Given that only a small share of wastewater flows is currently treated and reused, there are enormous opportunities for livelihoods and jobs, in agriculture and other sectors.

The remainder of this section discusses water reuse opportunities in the industrial sector, the capture of by-products from wastewater (particularly biogas), and wastewater use for irrigation purposes in agriculture. But there are of course additional reuse opportunities, including for drinking water purposes. (See Box 2.)

Box 2. Wastewater Reuse in Windhoek, Namibia

According to Jacobson, et al. (2012), Windhoek is one of few cities in the world that recycle treated wastewater for drinking water. The city relies on wastewater for 26 per cent of its total water use. Confronting limited annual rainfall, high surface evaporation rates, and a location far from any perennial rivers, Windhoek faces severe challenges in securing an adequate supply of water. It already fully uses all potable water resources within a radius of 500 kilometres, but demand keeps rising given rapid population growth. Thus, in addition to surface and groundwater sources, Windhoek relies on reclaimed water from two plants that contribute to the potable water supply as well as irrigation water for parks, golf courses, and cemeteries. While Jacobson et al. do not specifically discuss the employment implications of Windhoek's experience, it is clear that wastewater's share of total supply also makes it an important source of jobs.

Wastewater Reuse in Industry

WWAP (2017) refers to a "significant paradigm shift, with wastewater now being seen as a potential resource, and its use or recycling after suitable treatment as a potential way to benefit industry economically and financially." But this is an option suitable primarily for large industries (not necessarily for smaller companies and informal enterprises), and any employment potentials are thus somewhat limited to larger companies.

Wastewater may be recycled within a given plant, often for cooling/heating purposes. But it is also possible that water is reused among various neighbouring facilities. In a number of locations, an "industrial ecosystem" has emerged that allows for the by-products of one enterprise to be used as a resource by others. Kalundborg, Denmark, is a famous example of such practices where, for instance, recycled water from a Statoil facility goes to a local power plant as cooling water, and comes back to Statoil (as well as other businesses) in the form of steam (WWAP, 2017).

WWAP (2017) also points to experiences in two other European locations. In water-starved Tarragona, Spain, facilities in an industry park utilise secondary effluent from two municipal wastewater plants. Ultimately, the aim is for recycled flows to cover 90 per cent of industrial water demand. A chemical plant in Terneuzen, the Netherlands, abandoned a plan to use desalinated seawater due to increasing cost and quality problems. Instead, it relies on reclaimed water to generate steam (processing heat). The water is then again used in cooling towers. Compared with the original plan, the company was able to cut its energy use costs by 95 per cent, and is applying the same approach at another facility in Freeport, Texas (World Water, 2013).

Wastewater reuse in such settings may not necessarily create new jobs, but can assist in maintaining existing employment. This is certainly the case where reuse offers cost savings: avoiding the purchase of fresh process water; avoiding energy purchases needed to run desalination plants; or reductions in wastewater discharge fees. These savings may add up to a significant competitive advantage, and thus shore up a company's economic prospects and secure employment.

Capturing By-products

A variety of materials can be recovered from certain types of wastewater flows, including nutrients; organic matter; thermal, chemical and hydraulic energy; and other useful by-products such as minerals and metals from industrial wastewater (Meda et al., 2012). For example, heat can be recovered either for direct use at a treatment plant or in an adjacent community or industrial facility. Another example concerns the sewage sludge that results from conventional wastewater treatment and is rich in nutrients and organic matter; this can be used as fertilizer (provided concerns about pathogens and heavy metals are addressed appropriately). WWAP (2017) cautions, however, that for large-scale nitrogen and phosphorus recovery to make economic sense, adequate markets need to be developed.

One of the most useful by-products from wastewater is biogas (methane, or CH4), which can be used for power generation purposes or as a gas for domestic use. Biogas recovery is cost-effective. Bioreactors can use aerobic or anaerobic processes, and can vary tremendously in capacity from household- or community-size units to industrial scale. Aerobic processes typically require more energy, but prevent the formation of methane (whose uncontrolled release raises concerns because CH4 has great climate warming potential). Anaerobic processes, on the other hand, require less energy. They generate CH4, but it can be captured. Biogas can of course be generated from a variety of feedstock, including not just wastewater, but also agricultural residues, food waste, landfill gas, etc. However, available information does not always distinguish between these sources.

The process and reuse opportunities vary among rich and poor countries. WWAP (2016) points to the need for low-cost solutions in developing countries, such as small-scale anaerobic biodigesters, composting toilets, stabilization ponds, and constructed wetlands. The construction

Box 3. Biogas Employment in Asia

Biogas use is expanding across Asia in particular. China has built by far the largest number of household biogas digesters: some 42.8 million systems as of 2011 (SNV, 2012), a number that could double by 2020. During 2006–2010, ILO (2010) estimated that construction created close to 90,000 direct and indirect jobs. India has at least 4.5 million units installed (SNV, 2012). Including supply chain employment, the biogas sector was estimated to employ some 85,000 in 2010, a number that could rise to 200,000 jobs over a number of years (MNRE and CII, 2010). Viet Nam has installed more than 150,000 digesters since 2003, and was planning to train some 500 technicians and 2,000 masons in 2007–2012 (Verbist et al., 2013). Nepal's Biogas Support Programme has provided training for many poor rural youth to become biogas masons and employs about 2,000 people. The biogas industry entailed 11,000 direct and indirect jobs at the end of 2005 (ADDCP, 2009).

The construction of household or village biogas digesters is a labour-intensive process requiring masons and technicians. WWF India and CEEW (2013) report that the installation of one 2 cubic metre biogas plant generates about 30 man-days of employment. Nearly 30 per cent of the total cost is spent on providing wages to local workers, and maintenance activities provide additional employment to local technicians.

of such facilities and structures serves as a source of employment. Biogas use is highly developed in parts of Asia (see Box 3.), and the beneficial use of recovered nutrients, energy, etc. offers opportunities for income generation. Analysis of South-East Asian case studies by UNESCAP/UN-Habitat/AIT (2015) demonstrated that revenues from wastewater by-products surpass costs by a substantial margin.

In the Middle East, successful examples of recovering biogas through anaerobic sludge digestion include Jordan's largest wastewater treatment plant, As-Samra. Biogas production allows it to achieve an 80 per cent energy self-sufficiency rate. In Cairo, Egypt, the Gabal El Asfar wastewater treatment facility gets 65 per cent of its power from an anaerobic sludge digestor. (WWAP, 2017).

In the United States, the American Biogas Council (2016) lists more than 2,200 biogas-producing sites, of which more than half (1,269) are anaerobic digesters running on recovered wastewater. The Council does not offer information about employment, but refers to future potential, in which 13,500 new plants could be set up (including close to 3,900 wastewater-based facilities) and some 335,000 short-term construction jobs and 23,000 permanent operations jobs be created.

Wastewater Reuse in Agriculture

Municipal water discharged as wastewater is equivalent to 8 per cent of global water withdrawals or about 330 km^3/year. Given its high nutrient content, much of this discharge water could potentially be used for agricultural purposes. The volumes would be sufficient to irrigate an additional 40 million hectares (or 15 per cent of all currently-irrigated lands). According to Corcoran et al. (2010), up to 20 million hectares (or 7 per cent) of land worldwide are currently irrigated with wastewater, "particularly in arid and semi-arid regions and urban areas where unpolluted water is a scarce resource and the water and nutrient values of wastewater represent important, drought-resistant resources for farmers". This practice is most commonly found in the Middle East and North Africa, the Mediterranean, the United States, and Australia (WWAP 2017; Mateo-Sagasta et al., 2015).

Although the practice is thus by no means new, there is growing recognition that agriculture can benefit from using larger amounts of adequately treated domestic and municipal wastewater. According to Moriarty, et al. (2004), there are a number of studies that have "reported significant returns from irrigated agriculture utilising wastewater."

The expectation is that this practice will expand in coming years and thus support a substantial number of agricultural jobs. However, one of the critical factors is secure land tenure, to give farmers confidence for the needed investments in wastewater storage tanks, etc. Agriculture remains the largest employer, and farming jobs are critical for rural livelihoods and communities. In addition to on-farm employment, jobs are also likely to be created in research occupations, agricultural extension activities, building and maintaining irrigation systems, etc. Further, as wastewater reuse becomes more formalized and occupational health aspects receive greater attention, employment can also be created in regulatory and public health agencies.

In African countries, there is widespread appreciation for the potential of wastewater as an untapped resource. As an example of a practice common on the continent, Drechsel et al. (2010) discuss the experience of urban and peri-urban farmers in Kumasi, Ghana, who switched from freshwater irrigation to wastewater irrigation and reliance on sludge recovery. This practice creates livelihood opportunities, but also implies serious health threats for farmers and customers. This is also a problem in Latin America, where the use of contaminated water for irrigation near large cities is widespread (especially in arid and semi-arid areas) and mostly practiced by small-scale farmers growing fruits and vegetables. But WWAP (2017) also points to cases of successful reuse of treated wastewater in Argentina, Bolivia, Chile, Mexico and Peru—without, however, offering details on livelihood or employment outcomes.

In the Indian context, Kaur et al. (2012) observe that wastewater-irrigated fields generate considerable employment opportunities for both female and male agricultural labourers. They refer to estimates that wastewater can annually irrigate 1 to 1.5 million hectares of farmland in India, and could generate 130 million person-days of employment. Challenges include the location of wastewater plants compared to irrigated land, potential mismatches between wastewater fertilizer content and crop requirements, risks of over-application, among others.

Fit-for-purpose wastewater can also be used in the livestock sector and aquaculture. Wastewater used in the livestock sector might be derived from municipal or industrial sources or from livestock operations themselves, but require a minimum of secondary treatment (WWAP 2017).

Nutrient-rich water (effluent or sludge) may also be used in aquaculture operations, where fish can feed on algae and other organisms. As many of the world's regional fisheries are increasingly under stress from overfishing and wild catch has largely stagnated for the past quarter century, aquaculture production continues to rise rapidly as an alternative, with output having expanded 7-fold since 1987 (FAO, 2016).

These trends would suggest that there is growing demand for wastewater use in aquaculture. However, WWAP 2017 notes that global usage of wastewater is actually declining in this sector, in part because of safety concerns. Urbanization pressures are another countervailing force. Farmers in Kolkata, India, have long used domestic sewage for aquaculture and for growing vegetables, the world's largest such effort. The system peaked at 12,000 ha of ponds, but since then has shrunk to one third its size due to urbanization, with adverse effects for the livelihoods of poor people dependent on it.

UNEP (2002) notes that wastewater reuse systems for aquaculture (stabilization ponds) provide increased employment for locals. Without offering detailed information, the report mentions a UNDP / World Bank-sponsored pilot project in Lima, Peru, which demonstrated the feasibility of farming tilapia in tertiary-treated effluent and affirmed the employment potential. Wastewater use in fishponds remains widespread in China, India, Indonesia and Viet Nam.

5. Staffing Gaps and Skills Training

Opportunities abound, but many countries already face significant staff shortages in the water treatment industry. OECD countries confront problems such as staff attrition due to an aging workforce and the erosion of job experience that comes with retirements. But there is also weak interest from younger workers to join the sector (WWAP, 2016).

But it is staff shortages in developing countries that present the greatest challenge, particularly with regard to technicians and engineers (IWA, 2014). Substantial investments in sanitation infrastructure have been undertaken in lower- and middle-income countries, but there has not been a corresponding expansion of the needed human resource base. According to IWA (2014), many developing economies lack "significant numbers of water professionals, and the necessary knowledge, experience and specialist skills to meet the rising demand for water and sanitation services."

IWA (2014), UNESCO-UNEVOC (2012), and WWAP 2016 find that a number of challenges and bottlenecks need to be overcome, particularly in developing countries:

- Wastewater operations and maintenance face the greatest staff shortages. In many countries, the wastewater sector is stigmatised.

- "… most developing countries are not able to provide the needed human resources for the provision of adequate sanitation services. There is an urgent need to address the dearth and inadequate quality of curricula covering sanitary engineering in universities, as well as sanitation-related vocational training. Greater efforts are needed to establish courses put in place incentives to attract more students." -- "Appropriate public policies need to be in place to support job creation, which involves investing in skills to support labour supply …" (IWA, 2014)

- Rural systems are less complex than urban systems to operate and maintain, and require less highly-qualified workers. But it is nonetheless difficult to attract skilled workers to work in rural areas, and sanitation systems there often rely on semi-skilled or unskilled workers and on local NGOs. Efforts to expand wastewater use in irrigation confront a critical staffing and skills bottleneck.

- A lack of financial resources has multiple consequences. It hampers hiring and retaining staff, and limits worker salaries and benefits. Funding shortfalls also make it difficult for educational institutions to attract teaching staff of sufficient quality and to acquire needed equipment and materials. IWA (2014) bemoans "inadequately-trained staff, a lack of equipment, outdated curricula and a mismatch between the graduate qualifications and market demands."

UNESCO-UNEVOC (2012) points out that there is growing acknowledgement that "sustainable solutions for water challenges strongly depend on the availability of adequately trained human resources, from high-level experts to communities and stakeholders." Professional training needs to be complemented by technical and vocational education and training (TVET) efforts. (See Box 4.)

At present, training levels and staff qualifications in the water and wastewater sectors differ widely from country to country, according to UNESCO-UNEVOC (2012), and continuous learning systems do typically not exist in many countries. Vocational training systems in the wastewater sector have developed in diverse ways around the world. UNESCO-UNEVOC (2012) explains that in Europe, a number of countries (Austria, Germany, Switzerland, France) have established their own official qualification standards for the water and waste sectors. Some countries, like Germany, have a dual training system, with responsibilities shared by the state and by private firms. Others, such as Romania and Bulgaria, have yet to establish specific vocational training. The European Qualification Framework (EQF) was initiated to harmonize the vocational training and certification within the region.

Box 4. Costa Rica: An Individual's Vocational Training Experience

In 2011, José Ramirez Blanco enrolled in a 9-month vocational-training course at the National Learning Institute of Costa Rica to become a wastewater treatment plant operator. He subsequently spent more than a year at the GAIA laboratory near San José, which provides maintenance services for wastewater treatment plants but is also involved in plant design and wastewater sampling and analysis. At GAIA, José gained experience in plant maintenance, supervision and monitoring, as well as in wastewater sample collection and analysis. José then worked for two years at the LAQAT atmospheric chemistry laboratory at the National University of Costa Rica, conducting water and air quality analyses. At present, he works in the university's Laboratory of Environmental Analysis, an accredited government laboratory.

José considers the general lack of environmental consciousness and capacity in the workplaces he visits as a major hindrance to the pursuit of more sustainable practices. He calls for environmental education programs in schools and nationwide government action for environmental awareness raising, knowledge and capacity building, and providing information at individual and enterprise level. (Source: ILO, 2016b)

In the Arab region, most large water and wastewater enterprises have set up training centres. But typically they offer only short-term training sessions, limiting the transferability of skills gained by workers. Officially-recognized vocations do not exist in the sector, and although vocational training schools are gaining in importance, they are often not seen as attractive compared with a university education. Collaboration between the industry and vocational schools is rare (UNESCO-UNEVOC, 2012). On the positive side, ACWUA—the Arab Countries Water Utilities Association, launched in 2009, allows its members from 18 countries to step up collaboration by exchanging information and bringing together training managers across the region (ACWUA, n.d.).

Wastewater management processes in African countries are handicapped by a lack of skilled professionals and scientific, technological, and institutional shortcomings. “TVET has been neglected in the national and international education policy agenda for many years in Africa, for a variety of reasons, including: the mismatch between training and labour market needs, high training cost and poor quality of training.” (UNESCO-UNEVOC, 2012)

A number of Asian economies face an increasing wastewater management challenge against the backdrop of rapidly growing economies. In Viet Nam, for example, the government set a 2020 target of treating 60 per cent of the country’s total wastewater (up from only 10 per cent at present) and connecting 80 per cent of urban households to a sewerage system (up from 60 per cent). But the shortfall in skilled workers is estimated at about 8,000 through to 2020. With support from the German government, Viet Nam is carrying out a pilot TVET programme in the wastewater sector. Germany’s GIZ is assisting in the training effort in close cooperation with enterprises and the Vietnam Water Supply and Sewerage Association (VWSA). (Source: Development Asia, n.d.)

In many countries, there is a lack of coordination between wastewater sector needs and training courses offered by universities and technical and vocational training institutions. The result is frequently a mismatch between the numbers and skills of professionals and trained workers entering the job market, and what is needed in the sector (IWA, 2014). In many countries, UNESCO-UNEVOC (2012) argues, “there have been few serious attempts to inform TVET teachers and trainers about the links between TVET and the water sector.”

Improved cooperation may flow from the kind of collaborative network and learning alliance proposed by Jacobson et al. (2012). (They discuss water management collaboration specifically in the African context). Such a network would involve collaboration among a range of organisations, including municipalities and other governmental authorities, educational and training institutions, nongovernmental and not-for-profit organizations, water service providers and utility operators. This could facilitate knowledge and technology sharing and provide practical support.

Meanwhile, the water and wastewater sector is undergoing changes that involve the introduction of more sustainable practices and technologies. The expansion of wastewater reuse adds to these pressures. These changes require a significant upgrading of skills and reinforce the importance of a close cooperation with the education and training sector (UNESCO-UNEVOC, 2012). This is as true at the professional wastewater management level as it is in the agriculture sector, where farmers and farm labourers need to have adequate knowledge of the proper handling of wastewater. Some traditional occupations will also undergo significant changes in the context of green building: for example, plumbers may have to consider the recycling of wastewater. (See Box 5.)

WWAP (2016) addresses this need: “A new generation of scientists, engineers and professionals, addressing different aspects of wastewater management, needs to be trained to face the problems that arise from increasingly complex and interconnected issues at different scales. Future wastewater managers will require a mix of technical and managerial skills in order to develop and implement a compendium of solutions across the various wastewater flows, from pollution abatement at the source through collection and treatment to water reuse and the recovery of useful by-products.”

Box 5. Australia: GreenPlumber®- Social Dialogue for skills-building

Australia suffers from water shortages. Realizing that up to 70 per cent of the environmental water and energy savings in buildings are affected by plumbing-related work, in the year 2000 employers and trade unions established a specific qualification: the GreenPlumber®. Post-trade training to obtain the qualification is delivered by a joint employer–union training enterprise.

Trainees acquire the skills needed to advise consumers on the benefits of energy efficiency, on water conservation and on the most appropriate and cost-effective appliances. Five separate units are nationally accredited: Climate Care, Caring for our Water, Solar Hot Water, Water-Efficient Technology and Inspection Reports.

By 2010, over 9,000 plumbers from 4,000 firms had been trained in Australia. The programme has recently been expanded to New Zealand and the United States, where California has purchased a licence for the training of up to 40,000 people (Source: ILO, 2012).

6. Occupational Safety and Health

Given that the global area irrigated with untreated wastewater is perhaps ten times as large as the area using treated wastewater (Drechsel and Evans, 2010), there are very significant health concerns for agricultural workers because of their direct contact with wastewater. In addition, those who consume wastewater-grown crops are vulnerable. These concerns might increase due to climate change and increasing strong weather events such as heat waves and flooding.

Without adequate safety precautions, the use of wastewater in agriculture can contaminate crops, livestock products, soils, and water resources, with potentially severe health impacts. The *WASH@Work* Handbook (ILO, 2016a) cautions that "equitable, reliable and universal access to water and sanitation remains elusive in many rural areas. Limited access to safe water is the cause of a long list of water-related diseases that hamper the productivity of community members."

Drechsel et al. (2010) explain that untreated wastewater "may contain excreta-related pathogens (viruses, bacteria, protozoan and multicellular parasites), skin irritants and toxic chemicals like heavy metals, pesticides and pesticide residues. When wastewater is used in agriculture, pathogens and certain chemicals are the primary hazards to human health by exposure through different routes. These exposure routes are mainly contact with wastewater (farmers, field workers and nearby communities) and consumption of wastewater-grown produce (consumers). In addition, contamination may be due to poor post-harvest handling that can also lead to cross-contamination of farm produce." They point to several studies that indicate that "the greatest risk for farm workers in wastewater-irrigated agriculture derives from intestinal nematode infections and for produce consumers, from bacterial disease infections."

While the level of health risk for consumers depends on the crop selection, FAO (2010) points out that prevention is key to worker health safety. Mechanised cultivating and harvesting practices, crop drying prior to harvesting, and long dry periods between irrigations lower worker risks. High dust areas, manual cultivation and harvesting, moving sprinkler equipment, and direct contact with irrigation wastewater are high-risk activities.

Farmers, however, do not necessarily perceive irrigation with wastewater as a significant potential risk to their health. Drechsel et al. (2010) argue that risk-reduction measures thus need to be "'sold' well […] or address more than health concerns; an example is the provision of water-saving drip kits which also avoid pathogen exposure of farmers and crops." Also, issues such as wastewater salinity affecting crop performance can be of concern to farmers, prompting them to develop coping strategies and adaptations to maintain or increase yields. Drechsel et al. discuss examples of farmer wastewater management practices that have direct or indirect health impacts. (See Box 6.)

Box 6. Managing Health Risks of Agricultural Wastewater Use

Farmers in Hyerdabad, India, alternate the use of groundwater with wastewater, a practice that increases yields and decreases pest impacts and farm worker infections. In Dakar, Senegal, coastal area farmers use wastewater to dilute the salinity of groundwater. This also dilutes contaminants in the wastewater. In Accra, Ghana, farmers created wastewater ponds with sandbags that not only allowed them to more easily fetch water, but also created a cascade of worm egg traps and sedimentation ponds, reducing pathogen levels. In Dakar and in Lomé, Togo, farmers fixed mosquito nets over the intake holes of their watering cans. Primarily intended to keep debris out, this measure also reduced the intake of pathogens. (Source: Drechsel et al., 2010).

Properly treated and applied, wastewater can indeed be a very valuable resource and shore up rural livelihoods. Beyond individual farmer adaptations, wastewater reuse for food production requires strict regulations and robust monitoring—activities that in their own right generate employment. In this context, the joint WHO-FAO-UNEP Guidelines for Safe Use of Wastewater in Agriculture and Aquaculture offer a comprehensive approach to ensure safe water reuse and safeguard human health (WWAP 2017).

The *WASH@Work* Handbook (ILO, 2016a) refers to a variety of ILO Conventions and standards with specific relevance to the expanded use of wastewater. WASH-related provisions can be "a means to increase productivity by reducing vector-borne diseases: for example, for the Hygiene (Commerce and Offices) Convention, 1964 (No. 120), and the Safety and Health in Agriculture Convention, 2001 (No. 184)." Also relevant are the following:

- Occupational Safety and Health Convention, 1981 (No. 155), including rights and duties of workers concerning the prevention and control of occupational hazards.

- The accompanying Recommendation (No. 164) "provides more precise indications for sanitary facilities and the provision of drinking water."

- "The Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) contains a general duty of member States to "promote continuous improvement of occupational safety and health to prevent occupational injuries, diseases and deaths."

- The supplemental Recommendation No. 197 advises member states to "take into account the instruments of the ILO relevant to the promotional framework for occupational safety and health."

- The Occupational Health Services Recommendation, 1985 (No. 171), in supplement to the Occupational Health Services Convention, 1981 (No. 161), mandates occupational health services to "supervise sanitary installations and other facilities for the workers, such as drinking water, canteens and living accommodation, when provided by the employer."

- Several sectoral instruments, like the Hygiene (Offices and Commerce) Convention, 1964 (No. 120), the Code of practice on safety and health in underground coalmines (2006) and the Code of Practice on Safety and Health in Agriculture (2010) cite drainage as a means to maintain a pathogen-free workplace.

These international standards support the efforts to promote safe and secure working environments under Target 8.8 of the SDGs.

7. The Gender Dimension

The female share of the workforce in the formal wastewater treatment sector is quite marginal, with women often effectively being excluded from entry to technical and other professional positions. On the basis of studies in 15 developing countries, IWA (2014) found that women accounted for an average of just 17 per cent of all staff. The share in the non-governmental sector was much higher than in the public and private sectors.

As a result, WWAP (2016) advises that concrete efforts are required to train female researchers in the wastewater field, and to promote a greater number of female scientists in the higher echelons of scientific institutions and decision-making in developed and developing countries alike.

Gender mainstreaming in policies for water and sanitation services is essential. This requires a better understanding of key impediments to females' entry into the water sector, as well as of what may motivate women to seek a career in the sector. Such an understanding is necessary to promote the technical careers of young women more effectively (IWA, 2014). Scholarships at education and training institutions would also be of help. Further, recruitment procedures need to be adapted. In addition to changes in professional training, the traditional role of women in household and community water management needs to be recognized in the context of TVET efforts.

The situation is very different in informal settings. In many countries and cultures, women play an important role with regard to water, hygiene, and health in families. WWAP (2017) points to examples in Jordan, Tunisia, and Viet Nam, where women carry responsibility for greywater or wastewater use. This is a role that could be advantageous in improving the social acceptance of safe wastewater use and related innovative training approaches, but women's exposure to health risks is a concern. This is particularly the case in indigenous communities, where wastewater management falls heavily on women's shoulders.

Moriarty et al. (2004) note the common practice in a number of countries of relying on low-cost agricultural labour for the use of wastewater. Much of this work is carried out by female family members. In India and Pakistan, women work to control the spread of weeds. But this puts them at elevated health risks from pathogen exposure in the water or in the soil. ILO (2011) expresses concern that occupational safety and health standards have effectively discounted the concerns of female workers; standards and exposure limits to hazardous substances have been drawn up based on male populations and laboratory tests. Greater worker participation in the design of appropriate OSH in agriculture and inclusion of women in the process, is essential.

Reyes (2014) examines the situation in the Philippines, where women are not only participating in, but also holding decision-making positions in Water and Sanitation Councils (although this is not an outcome of intentional or deliberate governmental efforts towards promotion of gender equality). Gender-responsive programming for the water supply sector could improve the situation (Philippine MDG-F Final Report (2013). An ILO-led UN joint project in Nicaragua contributed to women's empowerment through capacity building and other means. Women constituted 60 per cent of the members of local water and sanitation committees (but only 30 per cent of those in decision-making positions), and 39 per cent of government officials participating in water and sanitation sector management training (Tanzarn and Gutierrez, 2015).

8. The Roles of Public and Private Sectors and of Cooperatives

There are important issues concerning the public and private realms. WWAP (2016) argues: "Within a suitable regulatory framework, public-private partnerships (PPPs) offer prospects for much needed investment in water sectors …" Similarly, WWAP (2017) states that "Public–private partnerships in the provision of wastewater services have spurred a wave of revisiting regulation, particularly during the 1990s." But in the last 15 years or so, a new dynamic has emerged leading to a reset of policy-making along the public-private spectrum.

Remunicipalisation

Water privatisations had spread rapidly throughout the world for some years, but in several cases the results have been disappointing (experiences include rising tariffs and the failure by private operators to deliver on promises). A growing number of communities around the world have insisted on returning water and wastewater services to public management, a trend known as remunicipalisation. The changes either involve a private contract termination, a contract that expired and was subsequently not renewed, or a sale or withdrawal by a private operator (Water Remunicipalisation Tracker, n.d.).

Water and sanitation remunicipalisations worldwide grew from just 3 cases in 2000 to 235 in 37 countries by early 2015, affecting over 100 million people. Although the majority of them took place in high-income countries (especially in the United States and France), there were 51 cases in middle- and low-income countries. Latin America accounts for 18 cases, Africa for 14, and Asia for 13 (Kishimoto et al., 2015).

Jakob and Sanchez (2015) discuss remunicipalisation as an opportunity to rethink the way in which water and other public services are provided. It offers a framework for strengthening the governance and quality of public services, recognising that committed and qualified workers are key to providing good services, and improving working conditions and worker participation in decision-making. They write that "Public sector workers tend to have higher protection through collective bargaining coverage and are less affected by precarious work." But conditions vary from location to location, and the authors do acknowledge that the available literature about employment conditions in the wake of remunicipalisations is still quite limited.

Jakob and Sanchez point to improved the transparency of local service provision and broader consultation with workers following remunicipalisation in the cities of Paris, Naples and Hamilton. In principle, remunicipalisation thus offers greater opportunities for decent work and social dialogue. Workers have also played active roles in building public water services in Buenos Aires. Workers own 10 per cent of shares in the new public companies and training for workers has increased dramatically. Cooperatives have assisted in efforts to restore drinking and wastewater plants, and have reached out to neighbourhood associations and communities, substantially expanding water access in low-income neighbourhoods (Kishimoto et al., 2015).

Cooperatives

Given problems and failures in the public and private sectors, cooperatives are playing an increasingly important role in efforts to provide access to safe water and sanitation services. ILO and ICA (2014) refer to a number of examples. Among them is SAGUAPAC in Santa Cruz, Bolivia, which is the world's largest urban water cooperative and serves three-quarters of the city's inhabitants. In Binangonan, the Philippines, the city decided to allow cooperatives to provide water services in light of severe financial, managerial, and corruption problems. Other examples exist in countries such as Ghana, Ethiopia and South Africa. In the United States, some 3,300 cooperatives in rural and suburban communities provide water and wastewater services. In India, the National Cooperative Housing Federation has played a major role in assisting the urban poor with sanitation services through more than 92,000 housing cooperatives with more than 6.5 million members.

9. Pulling Forward Threads from Past World Water Development Reports

In its own way, each of the World Water Development Reports (WWDR) offers a comprehensive examination of the ways in which the world's water resources are managed, taking a close look at trends, challenges and pressures, possible solutions, and cross-cutting themes. This literature review has drawn specifically on the 2016 and 2017 editions, as they most directly pertain to the intersection between the wastewater sector and the world of work. But the previous reports contain relevant aspects and threads as well, in that they address the three central pillars—social, economic, and environmental—of sustainable development.

Among the recurring issues addressed by the report series are the interconnections among the pillars of sustainability and various related concerns; the context of global goal-setting; the need to engage with stakeholders; and the need for effective, capable institutions. These are highly relevant for messaging around the issue of wastewater and jobs.

Interconnections. The 2009 report (WWAP, 2009) was the first to expressly take a holistic approach and address a number of linked concerns. It addressed themes critical to the future of water resources such as climate change, the MDGs, groundwater, biodiversity, water and migration, water and infrastructure, and biofuels. It is beyond question that world of work concerns are deeply affected by the way in which an array of challenges are addressed—from water supply to water use efficiency to wastewater treatment and reuse. Without a more sustainable and equitable approach to water, many jobs are at risk in a world that not only needs to deal with the pressures of urbanisation and rising demand, adverse changes to ecosystems, and the shortcomings of existing water infrastructure, but is also confronting the repercussions of climate change, as WWAP (2006) discussed. And without greater attention to educating and training sufficiently-skilled workers, it will prove difficult to address and solve these challenges.

Global Goal-setting. A number of WWDR reports (WWAP 2006, 2009, 2014, and 2017) discussed the implications and opportunities for the water sector inherent in the MDG and SDG frameworks. Although realization of some MDG targets has fallen short in parts of the world (WWAP, 2006 and 2009), the SDG targets for improved water management and sanitation imply that greater resources will be made available in fulfilment of the agreed goals. This in turn implies that greater human resources will flow into the sector, opening up new horizons and opportunities (WWAP, 2014). Greater efforts will thus need to be undertaken in the realm of skills development and training at both the professional and vocational levels. Messages and insights from earlier reports—lessons learned, failures, and successes—thus acquire renewed relevance.

Stakeholders. Another, and closely related, recurring issue is the central importance of engaging effectively with a broad array of stakeholders in efforts to encourage more sustainable use and management of water resources. WWAP (2012) in particular addressed the need to bring all relevant stakeholders together to improve the quality and legitimacy of water-related decision-making. It aimed to encourage all actors in government, civil society, and businesses to engage early in decision-making processes to improve the quality and acceptance of decisions and the probability of successful implementation. WWAP (2014) does so with particular focus on water-energy nexus and actions to be taken by various actors and stakeholders. The WWAP (2015) makes reference to the need to draw more fully on the potential inherent in both women and men, in their roles as either water professionals or as interested citizens. It is clear, however, that women represent a relatively small share of the water-related workforce and that they face particular hurdles. Correcting this imbalance will need special attention especially from a world of work perspective.

WWAP (2016) shines a light specifically on connections between the water sector and jobs questions, but other reports in the series do not prominently feature world of work concerns and actors. Even so, it is clear that workers play a critical role in all aspects relating to water. Water use and management affect large numbers of jobs and livelihoods, both inside and outside the water sector proper. The skills of workers are essential for reaching water-related goals. And issues of job quality and occupational safety and health are important, particularly in the wastewater sector.

Institutions. Effective institutions are critical for addressing the social, economic, and environmental challenges discussed in the various editions of the WWDR, as well as for ensuring meaningful stakeholder engagement. There is also a need to ensure policy coherence among different government departments and agencies. And, as mentioned earlier in this review (and discussed in WWAP, 2017), there is in particular a need for greater cohesion among actors in the water sector and the education and training sector. All of these issues will be affected by the governance of the water sector—the particular mix of public and private, and top-down versus bottom-up approaches.

These dimensions—the cross-connections, the goal-setting framework, the inclusion of stakeholder, and the creation of more effective institutions—all influence and shape each other.

10. Conclusion

The literature summarized in this paper points out to strong linkages between wastewater issues and the world of work. By strengthening these linkages, governments can advance the achievement of both SDG 6 and SDG 8, as well as others like SDG 12. A variety of stakeholders, individually and collectively, are required to drive this change and enforce standards. Through social dialogue, participation in decision-making, training and evidence-based integrated water resource management, governments can harness the energies of employers and workers towards this objective.

The World Water Development Report 2017 makes this case convincingly. By incorporating many of the aspects of the decent work agenda outlined in this paper, the Report highlights the many ways that member States can take measures to meet the SDGs in mutually reinforcing ways. UN-Water's forthcoming Synthesis Report on SDG 6, which will coincide with the High-Level Political Forum in 2018, will constitute a new step in this direction, and help inform policy-making through UN-wide collaboration.

With the commitment of member States, workers, employers and civil society to this agenda, these objectives can be fully achieved.

Bibliography

ACWUA (Arab Countries Water Utilities Association). n.d., “About Us”. http://www.acwua.org/about-us.

ADDCN (Association of District Development Committees of Nepal). 2009. *Decentralised Rural Energy Development in Nepal*. *Challenges, Opportunities and Strategic Options*. Proceedings of two days National Conference, Kathmandu, Nepal, 22–23 January.

American Biogas Council. 2016. “Biogas Handout,” 31 October. https://www.americanbiogascouncil.org/pdf/ABC%20Biogas%20101%20Handout%20NEW.pdf.

ASCE (American Society of Civil Engineers). 2011. *Failure to Act. The Economic Impact of Current Investment Trends in Water and Wastewater Treatment Infrastructure.* Reston, VA. http://www.asce.org/uploadedFiles/Issues_and_Advocacy/Our_Initiatives/Infrastructure/Content_Pieces/failure-to-act-water-wastewater-report.pdf.

BLS (Bureau of Labor Statistics, U.S. Department of Labor). 2015. *Occupational Outlook Handbook*, *2016-17 Edition*, Water and Wastewater Treatment Plant and System Operators. https://www.bls.gov/ooh/production/water-and-wastewater-treatment-plant-and-system-operators.htm (accessed 24 February 2017).

Cardno, C.A. 2016. “EPA Says U.S. Requires Significant Spending on Wastewater Infrastructure”. http://www.asce.org/magazine/20160202-epa-says-u-s--requires-significant-spending-on-wastewater-infrastructure/.

Corcoran, E., C. Nellemann, E. Baker, R. Bos, D. Osborn, H. Savelli (eds). 2010. *Sick Water? The central role of waste- water management in sustainable development.* A Rapid Response Assessment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal.

Danilenko, A., van den Berg, C., Macheve, B. and Mofitt, L. J. 2014. *The IBNET Water Supply and Sanitation Blue Book 2014: The International Benchmarking Network for Water and Sanitation Utilities Databook*. Washington, DC, The World Bank.

Development Asia. n.d. “Closing the Skills Gap in the Wastewater Treatment Industry”. http://development.asia/case-study/closing-skills-gap-wastewater-treatment-industry (accessed 26 January 2017).

Deng, Y. and Wheatley, A. 2016. “Wastewater Treatment in Chinese Rural Areas,” *Asian Journal of Water, Environment and Pollution*, Vol. 13, No. 4 (2016), pp. 1–11. DOI 10.3233/AJW-160033.

Drechsel, P. and Evans, A. E. V. 2010. “Wastewater Use in Irrigated Agriculture,” *Irrigation and Drainage Systems*, 24 (1), pp. 1–3. DOI: 10.1007/s10795-010-9095-5.

Drechsel, P., Scott, C. A., Raschid-Sally, L., Redwood, M. and Bahri, A. 2010. *Wastewater Irrigation and Health*. London/ Ottawa/Colombo, Earthscan/International Development Research Centre (IDRC)/International Water Management Institute (IWMI).

Eurostat. 2016. “Water supply, sewerage, waste management and remediation statistics - NACE Rev. 2”. http://ec.europa.eu/eurostat/statistics-explained/index.php/Water_supply,_sewerage,_waste_management_and_remediation_statistics_-_NACE_Rev._2 (accessed 24 February 2017).

Eurostat. 2012. “Archive: Sewerage statistics - NACE Rev. 2”. http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Sewerage_statistics_-_NACE_Rev._2&oldid=90692 (accessed 24 February 2017).

FAO (UN Food and Agriculture Organization). 2016. *The State of World Fisheries and Aquaculture 2016*. Rome.

FAO. 2011. *Climate Change, Water, and Food Security,* FAO Water Reports No. 36. Rome.

FAO. 2010. *The Wealth of Waste: The Economics of Wastewater Use in Agriculture*. Rome. http://www.fao.org/docrep/012/i1629e/i1629e.pdf.

Grigg, N.S. 2009. "Water and Wastewater Workforce Stats. The Case for Improving Job Data," *AWWA Journal* (American Water Works Association), Vol. 101, Number 8 (August), pp. 76-77.

Heymann, E., Lizio, D. and Siehlow, M. 2010. *World Water Markets: High Investment Requirements Mixed with Institutional Risks.* Deutsche Bank Research, Germany. http://www.dbresearch.de/PROD/DBR_INTERNET_EN-PROD/PROD0000000000258353.PDF.

ILO. 2010. *Study on Low Carbon Development and Green Jobs in China*. Beijing: International Labour Organization.

ILO. 2011. *Safety and Health in Agriculture. ILO Code of Practice.* Geneva: International Labour Office.

ILO. 2012. *Working Towards Sustainable Development : Opportunities for Decent Work and Social Inclusion in a Green Economy*. Geneva: International Labour Office. http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_181836.pdf

ILO. 2016a. *WASH@Work: A Self-training Handbook: First Module: International Policy Framework*. Geneva: International Labour Office.

ILO, 2016b. "José's Career in Wastewater Management," in *Green Jobs Progress Report 2014-2015.* Geneva: International Labour Office.

ILO and ICA (International Co-operative Alliance). 2014. *Cooperatives and the Sustainable Development Goals. A Contribution to the Post-2015 Development Debate.* Geneva and Brussels. http://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_240640.pdf.

IWA (International Water Association). 2014. *An Avoidable Crisis: WASH Human Resource Capacity Gaps in 15 Developing Countries*. London, IWA Publishing. http://www.iwa-network.org/downloads/1422745887-an-avoidable-crisis-wash-gaps.pdf.

Jakob, C. and Sanchez, P. 2015. "Remunicipalisation and Workers: Building New Alliances," in Kishimoto et al. 2015, pp. 76-85.

Jacobsen, M., Webster, M., and Vairavamoorthy, K. (eds.). 2012. *The Future of Water in African Cities: Why Waste Water?* Directions in Development. Washington, DC: World Bank. doi:10.1596/978-0-8213-9721-3.

Kaur, R., Wani, S.P., Singh, A.K., and Lal, K. 2012. "Wastewater production, treatment and use in India," Presentation at the Second Regional Workshop of the Project 'Safe Use of Wastewater in Agriculture', 16–18 May, New Delhi. http://www.ais.unwater.org/ais/mod/page/view.php?id=61.

Kishimoto, S., Lobina, E., and Petitjean, O. 2015. *Our Public Water Future. The Global Experience with Remunicipalisation*. Amsterdam, London, Paris, Cape Town and Brussels: Transnational Institute, Public Services International Research Unit, Multinationals Observatory, Municipal Services Project, and the European Federation of Public Service Unions.

Mateo-Sagasta, J., Raschid-Sally, L. and Thebo, A. 2015. Global wastewater and sludge production, treatment and use, in: Drechsel, P., Qadir, M. and Wichelns, D. (eds), *Wastewater – Economic Asset in an Urbanizing World*. Springer Netherlands.

Meda, A., Lensch, D., Schaum, C. and Cornel, P. 2012. "Energy and Water: Relations and Recovery Potential", in Lazarova, V., Choo. K., and Cornel, P. (eds), *Water-energy Interactions in Water Reuse*. London: IWA Publishing.

Mejía, A., Requena, B., Rivera D., Pardón, M. and Rais, J. 2012. *Agua potable y saneamiento en América Latina y el Caribe: metas realistas y soluciones sostenibles*. Corporación Andina de Fomento (CAF) / Banco de Desarrollo de América Latin. http://publicaciones.caf.com/media/17238/libro_agua_esp.pdf.

MNRE (Ministry of New and Renewable Energy) and CII (Confederation of Indian Industry). 2010. *Human Resource Development Strategies for Indian Renewable Energy Sector*. New Delhi.

Molden, D. (ed.). 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management for Agriculture.* London and Colombo, Sri Lanka: Earthscan and International Water Management Institute.

Moriarty, P., Butterworth, J. and van Koppen, B., 2004. *Beyond Domestic: Case Studies on Poverty and Productive Uses of Water at the Household Level*. Technical Paper Series No. 41. Delft, The Netherlands: IRC International Water and Sanitation Centre.

Philippine MDG-F Final Report (2013), "Final Evaluation of the Joint Programme: "Enhancing Access to and Provision of Water Services with the Active Participation of the Poor" (MDG-F 1919)," http://www.unicef.org/evaldatabase/files/Philippines_2013-002_MDGf_1919_Final_Report_28082013.pdf.

Sato, T., Qadir, M., Yamamoto, S., Endo. T, and Zahoor, M. 2013. "Global, Regional, and Country Level Need for Data on Wastewater Generation, Treatment, and Use," *Agricultural Water Management*, 130: 1-13. http://dx.doi.org/10.1016/j.agwat.2013.08.007

Schwartz, J., Andres, L. and Dragoiu, G. 2009. *Crisis in Latin America: Infrastructure Investment, Employment and the Expectations of Stimulus*. Washington, DC: The World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/4201/WPS5009.pdf.

Siebert, S., et al. 2010. "Groundwater Use for Irrigation–A Global Inventory," *Hydrology and Earth System Sciences*, vol. 14, p. 1863.

SNV. 2012. "Production Rate of Biogas Plants Increased", in *Domestic Biogas Newsletter*, September. www.snv.org/public/cms/sites/default/files/explore/download/snv_domestic_biogas_newsletter_-_issue_7_-_september_2012.pdf.

Reyes, S.L. 2014. *Gender, Access to Water and Promotion of Decent Work: A Philippine Case Study* (ILO and UN Women, unpublished).

Tanzarn, N. and Gutierrez, M. T. 2015. *Public works programmes: A strategy for poverty alleviation. The gender dimension revisited in Employment Intensive Investment Programmes in 30 countries in Africa, Asia, Latin America and the Caribbean*. Employment Working Paper No. 194. Geneva: International Labour Office. http://www.ilo.org/employment/Whatwedo/Publications/working-papers/WCMS_426588/lang--en/index.htm.

UNEP (United Nations Environment Programme), 2015. *Economic Valuation of Wastewater - The Cost of Action and the Cost of No Action.* http://unep.org/gpa/Documents/GWI/Wastewater%20Evaluation%20Report%20Mail.pdf.

UNEP. 2002. *International Source Book on Environmentally Sound Technologies for Wastewater and Stormwater Management.* London: IWA Publishing). http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-15/2-9/9-2-2.asp.

UNESCAP/UN-Habitat/AIT (United Nations Economic and Social Commission for Asia and the Pacific/United Nations Human Settlements Programme/Asian Institute of Technology). 2015. *Policy*

Guidance Manual on Wastewater Management with a Special Emphasis on Decentralised Wastewater Treatment Systems (DEWATS). United Nations/AIT. http://www.unescap.org/resources/policy-guidance-manual-wastewater-management.

UNESCO-UNEVOC (United Nations Educational, Scientific and Cultural Organization - International Centre for Technical and Vocational Education and Training). 2012. *Skills Challenges in the Water and Wastewater Industry: Contemporary Issues and Practical Approaches in TVET*. Bonn, Germany: UNESCO-UNEVOC.

United States Conference of Mayors. 2008. *Local Government Investment in Municipal Water and Sewer Infrastructure: Adding Water to the National Economy*. Washington, DC. http://www.usmayors.org/urbanwater/documents/LocalGovt%20InvtInMunicipalWaterandSewerInfrastructure.pdf.

Verbist, B.; Ton, V.D.; Phlix, G. 2013. *Mid-term Evaluation SNV programme 2007–2015: In-depth Study of the Vietnamese Biogas Programme*. ACE Europe. www.iob-evaluatie.nl/sites/iob-evaluatie.nl/files/In-depth%20report%20on%20SNV's%20biogas%20programme%20in%20Vietnam.pdf.

Water Remunicipalisation Tracker, n.d. Home Page. http://www.remunicipalisation.org/front/page/home.

WWAP (United Nations World Water Assessment Programme). 2017. *The United Nations World Water Development Report 2016: Wastewater. The Untapped Resource*. Paris, UNESCO.

WWAP. 2016. *The United Nations World Water Development Report 2016: Water and Jobs*. Paris, UNESCO.

WWAP. 2015. *The United Nations World Water Development Report 2015: Water for a Sustainable World*. Paris, UNESCO.

WWAP. 2014. *The United Nations World Water Development Report 2014: Water and Energy*. Paris, UNESCO.

WWAP. 2012. *The United Nations World Water Development Report 2012: Managing Water under Uncertainty and Risk.* Paris, UNESCO.

WWAP. 2009. *The United Nations World Water Development Report 2009: Water in a Changing World.* Paris, UNESCO.

WWAP. 2006. *The United Nations World Water Development Report 2006: Water, a Shared Responsibility*. Paris, UNESCO.

WWAP. 2003. *The United Nations World Water Development Report 2003: Water for People, Water for Life.* Paris, UNESCO.

WWC/OECD (World Water Council/Organisation for Economic Co-operation and Development). 2014. *High Level Panel on Financing Infrastructure for a Water-Secure World*. Briefing Note & Issues Paper. Paris: OECD.

World Water. 2013. “Fresh Thinking to Improve Business and Sustainability.” http://msdssearch.dow.com/PublishedLiteratureDOWCOM/dh_08d9/0901b803808d92c4.pdf.