REACHING THE MILLIONS

DEAL BOOK

8 investment profiles to achieve 3R impact

IMPLEMENTING RAINWATER HARVESTING AT SCALE

ACACIAWATER

META META

Rain

JUSTDIGGIT

Aqua for All

Acknowledgements

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Preface

Deal Book: Reaching the Millions

The authors of this Deal Book present promising investment profiles for rainwater harvesting at scale, in order to replenish critical water ground and surface water sources. These investments will help to address challenges across the Sustainable Development Goals (SDGs).

The World Economic Forum Global Risks Report 2018 is dominated by environmental risks, just like in the 2017 ranking and in the years before. The top four challenges are all water related (extreme weather events, natural disasters, failure of climate change mitigation and adaptation and water crises), resulting in migration, conflicts and food crises.. Almost half of the world's population lives in water stressed river basins, lacking access to safe drinking water, adequate sanitation and living with precarious food and health security.

This 3R Deal Book provides insight into how the retention-recharge-reuse (3R) approach can contribute to tackling these global challenges and contributing to many of the SDGs.

Many stakeholders, including governments, civil society, the financial sector, businesses, and, importantly, people living in vulnerable areas, face losses as long as the SDGs are not achieved. Recent calculations show that the costs of non-action amount to trillions of dollars across all sectors. With a fraction of this amount invested in cost-effective solutions, including 3R, those costs can be avoided. In addition, those investments – improving integrated water resources management – have social and economic returns that represent an even higher value.

The potential impacts of the 3R investment profiles outlined in this document include the enhancement of peace and security, the creation of sustainable food chains, effective climate adaptation, more resilient cities, improvements in economic growth and jobs, decreases in healthcare costs, landscape restoration, infrastructure safeguarding, and overall poverty reduction. Capturing rainwater at scale would not only reduce the negative impacts of drought and extreme rainfall events; it would also have positive social impact whilst securing economic resources and restoring the water cycle.

With an outcome driven pricing model, a perfect deal can be offered to all kinds of social and commercial financiers and other stakeholders, getting value for money, acquiring leverage, sharing risks, and protecting economic interests.

This proposition is too good to be ignored, especially when fragmented finance streams, including our own Development Cooperation budgets, could be matched as described, thus unlocking private capital markets with promising social and financial returns.

Rainwater harvesting at scale is a great deal. Let's make it happen!

Prof. Sybe Schaap

Chairman of the Netherlands Water Partnership
Chairman of Aqua for All

World Water Day, 22 March 2018

Contents

1. We have a deal for you

We have a deal for you. It is a deal for all four stakeholders investing in global challenges: providers of Official Development Assistance, philanthropists, impact investors, and actors in the private capital market.

The deal is to invest in the capture of rainfall at scale: the collection of runoff and flood waters, the retention and storage of this water, and its use when required. We call this the 3R approach. The return on investment comes in the form of reduced operational costs, disasters averted, higher productivity, and healthier people and landscapes.

We have two key messages:

» The business proposition is obvious. We can save billions, if not trillions of dollars per year if we only invest a fraction of that amount to avoid losses as a result of not achieving the SDGs, while at the same time creating social and financial impacts and spinoff effects. This can be partly realised through rainwater harvesting at scale.
» To make this happen, we need to combine the four available finance streams in a new financial model, which we call an 'outcome payment model,' offering all finance streams more effectiveness, efficiency, leverage, and risk sharing.

We invite you to explore with us how we can make this deal a reality.

When looking at SDG 6, upon which the achievement of many SDGs depend, approximately US$ 300-600 billion annually is generated by the negative externalities of the absence of reliable WASH services (Hutton & Varughese, 2016). These are costs that could have been prevented! The negative externalities due to the absence of effective rainwater harvesting at scale (climate change effects, agricultural losses) are even higher, reaching trillions of dollars. At the same time, we know that intervention costs to achieve SDG 6.1 and 6.2 are calculated at US$ 114 billion per year, a fraction of the avoidable costs of US$ 300-600 billion on an annual basis. Currently only one-third of this budget is available at current investment levels. This example shows the magnitude of the challenge and the evident business case, which should translate into action to close the finance gap. This case has been underlined by the recently published outcome document of the High Level Panel on Water, convened by the UN and the World Bank Group (HLPW, 2018).

3R solutions – or rainwater harvesting at scale – can play a major role in the investments needed to achieve transformation to a water-secure world. The OECD calculates the cost of achieving a water-secure world at US$ 500 billion per year (HLPW, 2018). 3R investments will bring benefits to many pressing issues and in efforts to achieve multiple SDGs, such as Zero Hunger, Sustainable Cities and Communities; Reliable Infrastructure; Better Life on the Land; Peace and Justice; and Climate Action. Such investments will limit costs and generate a wealth of social and economic benefits.

Bridging the financing gap by connecting the diverse finance sector with the fragmented water sector is a challenge. It requires innovative alternative partnerships and finance constructions that price not only the financial profit from volatile cash flows, but that price the impact of water driven intervention as well. The short-term risk needs to be taken to gain the long-term added value. 3R programs connect both social and financial returns, which are crucial for the variety of investors that we need on board, thus offering the opportunity to connect and unlock the different finance streams.

3R and its impact on many SDGs

This deal book offers investment profiles to make a substantial contribution to many of the SDGs by pitching sets of measures that are collected under the acronym 3R: water recharge, retention, and reuse (Steenbergen et al., 2011). Water is recharged in the soil and retained in reservoirs. From there it is reused when required – during dry periods or as an additional source of water. In this way, a hydrological buffer is created. These measures help increase the resilience of the economy and the environment.

To demonstrate the opportunities, we describe eight 3R investment profiles in this publication. We showcase a 10+ year track record built up by the 3R consortium, with qualitative descriptions of the impacts and scaling potential of 3R interventions. All profiles show evidence that where rainfall is captured, the resource base convincingly changes for the better. Rather than letting rain and runoff cause damage, it is stored and turned into an asset: more groundwater, better soil moisture, and filled reservoirs. This assures better water buffers, more food security, generally more fertile soils, more conducive microclimates, and less erosion and degradation. As a result, we see positive social and economic impacts.

The intensive harvesting of rainwater at scale helps to resolve many of today's global and local challenges, many of which are addressed in the Sustainable Development Goals. 3R provides the added value of safe drinking water and sanitation, enhanced food security, and stronger value chains, safeguarding

Figure 1. Variety of 3R measures that can buffer water highs and lows (Source: Acacia Water, 2017)

infrastructure, creating sustainable urban communities and coastal areas, kick-starting landscape restoration, managing the micro-climate, and making humanitarian aid delivery more cost effective.

Each investment profile is related to at least one SDG. Each profile describes the magnitude of the challenge, showcases 3R's contribution to addressing it, and provides sample projects. The necessary initial investments significantly reduce the operational costs of water infrastructure, increase infrastructure efficiency, and generate independent revenue streams. 3R measures turn resource challenges into long-term sustainable water solutions, particularly when it comes to water management challenges in agricultural value chains and local economies. At the same time, there are considerable gains to be made by avoiding the cost of not replenishing groundwater resources (i.e., non-action costs).

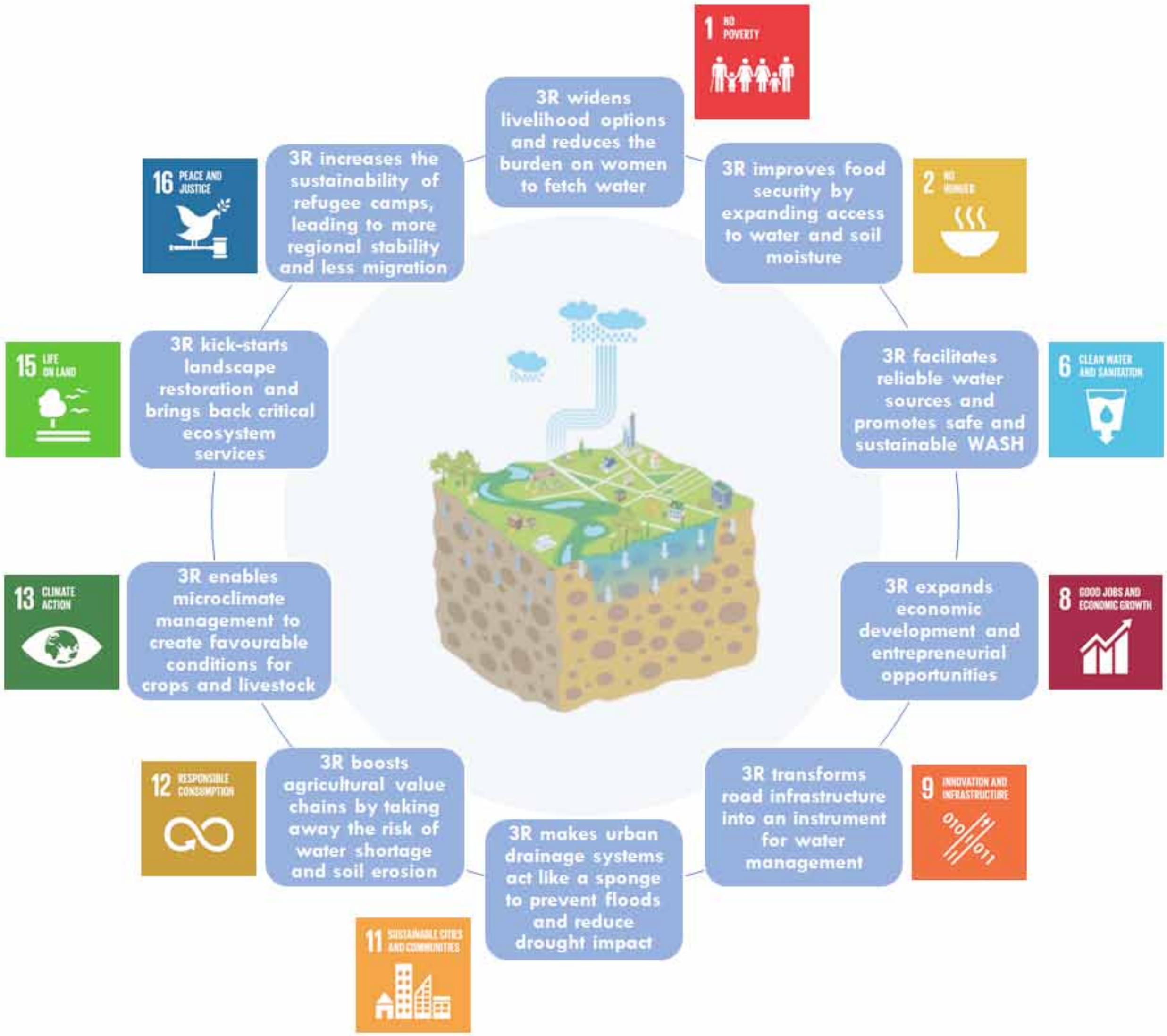

Figure 2. 3R impacts many SDGs
Source: adapted from OneWater Naturally, 2017

How do we develop the business case?

In the past ten years, intensive rainwater capture through 3R has transformed several areas. We believe many more can follow. That is why we invite you to work with us to reach the millions: millions of dollars in investment capital, which will reach millions benefitting from the systematic recharge, retention, and reuse of rainfall.

The business case seems obvious: money is available, investments are at risk, the negative externalities are significant, and opportunities to improve the current situations are many. We believe that with the eight investment profiles and with 3R's track record, we can bring financiers together to bridge the finance gap and create the necessary scale and impact. We need to overcome the current state of fragmentation and stimulate cohesion and collaboration. This requires a multistakeholder approach with a clear social and financial return on investment for different financial streams.

This outcome payment model – connecting the financiers – may pave the way for parties that do not want to invest upfront in 3R interventions, but who are interested in paying for the outcome that is being created. Outcome payers function as contingent payers for the results of 3R measures. Outcome payers value avoided future costs or avoided investment risks related to water. Those that pay upfront for 3R interventions are impact investors. They are donors and other risk-taking financiers who know that they will be repaid once the outcome and scale are achieved. The challenge is to match the different kinds of finance that are already available to catalyse and leverage private capital markets and corporations to bridge the financing gap. This requires co-development of 3R programmes with the key players, investors, and local stakeholders (governments and communities), matching the knowledge and experience of the 3R consortium and engineered through an aggregator (Aqua for All).

Our plea

This publication is a plea to all who are working towards the achievements of the SDGs and to finance sector players (grant-makers and donors, philanthropists, impact investors, and private capital markets investing in the SDG challenges) to consider their actual interests in 3R programs from this outcome payment model perspective. This offers more effectiveness, efficiency, leverage, and risk-sharing for all parties. Specifically it provides:

- For private capital markets and corporates: avoiding the depreciation of value and grasping the potential of expanding markets
- For impact investors: a social return on top of financial returns, which increases business viability and bankability
- For philanthropists: monetising positive effects and social benefits related to the mission
- For donors / grant-makers: leverage and programs at scale

We hope you are interested to achieve more value for your money, so deal with us!

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2. CLEAN WATER, SANITATION AND 3R

The world faces challenges in delivering clean drinking water

Water scarcity affects over 40 percent of the world's population and is projected to increase, with many regions, particularly in Sub-Saharan Africa and South Asia, experiencing population growth (UN, 2017). The water scarcity trend will intensify the challenge of fulfilling basic water, sanitation, and hygiene (WASH) needs. Limited access to WASH is directly related to the prevalence of waterborne diseases like dysentery and typhoid, and is one of the factors driving high child mortality rates (Hutton, 2012). Furthermore, access to clean water is linked to lower crop productions, increased food insecurity, and reduced livelihood options (Critchley & Gowing, 2012). Research points to the benefits of 3R measures in creating drinking water sources and ensuring access to water and sanitation for all (Helmreich & Horn, 2008). When adding the fact that 3R can increase household productivity and income (Cofie et al., 2004), its potential is widespread. It is now more important than ever to put an integrated and sustainable approach to WASH high on the agenda.

From a WASH perspective, the retention and recharge of rainwater is essential for maximizing the efficiency of wells and boreholes by increasing groundwater levels (Kisekka et al., 2018). Less often considered is the positive effect of water storage on decreasing floods, which are often sources of contamination. Particularly in densely populated areas, storm water tends to pick up pollution, spreading its contamination. Preventing the cause of the spread is better than treating the diseases that follow from it.

3R measures show advantages over other approaches

WASH programmes have long focused on using all available water with insufficient consideration for returning water to the system. The 3R approach is a means of improving the resource base from which water is extracted to increase access and sustainability of WASH services and minimize water scarcity and its negative effects. When looking at the resource base for WASH, the competing claims of other users like the agricultural sector cannot be ignored.

Taking a more integrated approach allows all needs to be met in the best possible way, and points to the need to make investments in the water resource base when demand exceeds supply. By installing in-situ rainwater harvesting and water tanks, 3R can provide water users with a reliable and safe source of drinking water at their doorstep. In addition to providing water security, this can save households (mostly girls and women) a lot of time, as they will not have to fetch water from a distant borehole. Time can be reallocated to working or going to school, which in turn increases the productivity and food security of a household.

One of the recurring questions related to water harvesting and WASH is that of water quality: is shallow groundwater and water from roofs is suitable for drinking? As shown for sand dams (Avis, 2014; Cranfield University, 2017) and roof water tanks (Gould, 1999), the answer is mostly yes, except in densely populated areas. Pollution through contact with air or surfaces can cause contamination, but these toxins and pathogens are often few and relatively harmless compared to pollution sources found in boreholes or water points in densely populated areas. Through design and safety measures like first flush devices, bio-filters, and other treatments, this risk can be further minimised.

The alternative to water harvesting, deep boreholes, has multiple associated risks. These include pollution with chemicals such as fluorite and arsenic, which are present in deep groundwater or boreholes that get polluted due to poor engineering (e.g., the absence of bentonite sealing in the borehole shaft). When comparing the benefits and externalities of implementing 3R to meet clean water and sanitation goals, what strikes immediately is that there are significant social, economic, and environmental benefits to implementing 3R (figure 3).

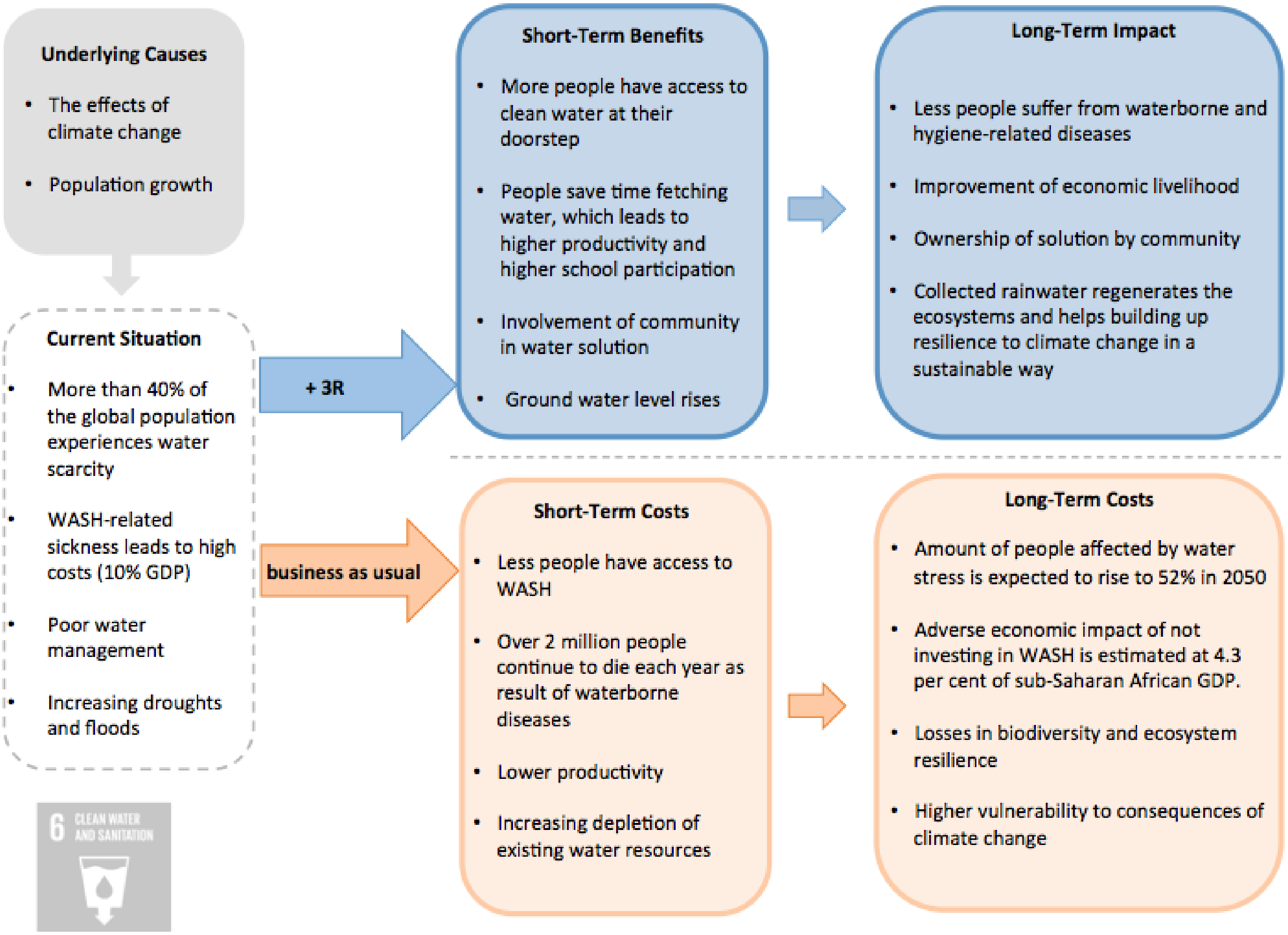

Figure 3. 3R versus business as usual scenarios

Multiple players can take up 3R in the WASH sector

3R can easily be integrated into programmes that deal with issues of water scarcity in relation to environmental management and poverty reduction. 3R helps to systematically improve the resilience of local communities to water scarcity while strengthening the natural resource base. Since 3R is not a blueprint, its components can be added to projects, starting from different perspectives.

More specifically, applying 3R in WASH is interesting for multilateral organisations and NGOs, with UNDP and UN Water being large WASH-investors that also invest in rainwater harvesting investments. Many governments have also indicated that access to water and sanitation is a priority. The potential of 3R measures is widely recognised by the governments of Uganda and Rwanda, for example. WASH investments and ODA disbursements for WASH are increasing in most countries, and it is estimated that for every dollar invested in WASH, US$ 4.30 is generated in economic returns via increased productivity (UN, 2017). Hence, 3R investments in the WASH sector are profitable for governments. Lastly, the private sector has shown interest in WASH investments. For example, Unilever has a partnership with WaterAid to work on this theme. Companies that are active in countries where WASH is a concern can contribute by providing access to WASH for workers in supply chains and communities.

CASE 1
Rain for Sale, Rwanda

The combination of water scarcity and high competition for limited resources often translates to high costs for poor communities in accessing water. Particularly, women and children are affected by the consequences of limited access to WASH. The alternative for many people is to use unsafe and unclean surface water to fulfil their daily needs, resulting in diseases such as typhoid. Another option is to buy water from expensive vendors. Since access to WASH is already a serious challenge in many urban areas, rainwater harvesting methods have become increasingly popular as a mitigation measure to fulfil water needs.

To contribute to the development of new 3R measures, an innovative concept has been launched called 'Rain for Sale' (R4$). The concept tests the business case for the sale of stored rainwater by local entrepreneurs in urban and peri-urban areas. More specifically, the project aims to prove a business case whereby money – that is either collected from selling water or saved as a result of not buying water – is used to finance the construction of rainwater harvesting structures. Local entrepreneurs are provided with a rainwater harvesting installation on credit. They can sell the harvested rainwater for a reasonable amount of money, so that water availability in the community is increased. In instalments, the entrepreneurs pay back the investment of the installation while profiting from their water selling business.

First, selected entrepreneurs receive training on business skills, technical background, and water quality. Second, a 50 m^3 rainwater harvesting installation, including a ferro-cement tank, a first flush device for filtration, water meters, and a tap-stand, is provided on credit. In Uganda, the entrepreneurs are on a payment schedule and deliver promising results for a strong business case. Based on these results, the same business case is now applied in Rwanda, where six water tanks have

Figure 4. Rainwater harvesting tank, Uganda

Figure 5. Digging a water tank in Rwanda

Table 1. Costs and benefits of ferro-cement tanks

Investments		Cost savings		Direct benefits	
Above ground ferro-cement tank, 50 m^3	€ 2,300	No need to buy water at a high price (€ 0.1) for one's own house-hold	€ 150	Selling at least 200.000 litres of water per year at €0.1 per 20-litre jerry can	€ 1,000
Labour	€ 550				
Annual maintenance	€ 550				
Total (15 years)	**€ 11,100**	**Total (15 years)**	**€ 2,160**	**Total (15 years)**	**€ 15,000**

been constructed so far. With results looking promising again, a test phase has been started in Ethiopia to find out whether implementation is desirable.

As shown in table 1, investing in a rainwater harvesting installation pays itself back and allows entrepreneurs to profit from rain-water sales. These (conservative) numbers are based on data from reports and the Rain Water Harvesting Handbook, published by the Government of Uganda. It shows that there is a business case for Rain for Sale.

Based on the extensive testing of the Rain for Sale concept in different regions of Uganda and Rwanda, there is great potential to upscale the business case for rainwater storage and sales. Different governments and other stake-holders have expressed interest. The Government of Rwanda strongly encourages citizens to practice rainwater harvesting as a mitigation measure. This increased interest is an opportunity for this project to build upon, particularly in urban and peri-urban areas.

CASE 2

Recharging boreholes in Rwambu, Uganda

Rwambu used to be a green hilly area with meandering rivers and wetlands in the valleys. Over the last decade, however, Rwambu has seen a significant influx of people migrating into the region. Population pressure has pushed people to the wetlands and up the steep slopes where slash-and-burn agriculture has increased runoff from the hills. In the hills, erosion has become widespread, while in the valley, water no longer saturates the ground. This has led to a decrease in groundwater tables, as revealed by the drying of springs and boreholes on the hillside. As a result, women and children must walk longer distances to access water sources in the valley. These are unprotected sources, and runoff carries along waterborne diseases like dysentery and typhoid.

Figure 6. Using pools in the wetland for drinking water

In 2012, RAIN developed a 3R strategy to increase access to WASH, with the aim of demonstrating that water harvesting can be integrated at the catchment level to sustain WASH. The project took the whole system into account, from the hilltops to the wetlands, and implemented a variety of 3R measures – infiltration pits, check dams, grass bunds, and tree planting – to restore the water table, thereby relying on the labour and materials available in the communities.

After two years, the water table increased by two meters and the boreholes became operational again. The contaminated runoff decreased and, assisted by sanitation training, the people obtained greater access to safe drinking water. With soil degradation being reversed, crop production also increased (Kisekka et al., 2018). It can be expected that in the years to come, as the ecosystem and water table are further restored, yields and access to WASH will continue to grow. The practical nature of the project attracted the interest of other communities, local and international NGOs, and the government, and every year 50-150 people visit Rwambu to see the 3R measures.

In table 2 we present the investments, cost savings, and extra earnings of this 3R project. The numbers are based on project reports and a government report (GoU, 2013). As can be seen, the initial investment of € 9,000 is regained when compared to the costs (€9,475) saved. Taking into account extra earnings through increased production, the benefits greatly exceed the investment costs. It must be kept in mind that it is difficult to quantify the benefits of a more resilient ecosystem and an increased water table (4 meters higher); hence, this is excluded from this comparison.

The Ugandan government recognizes the potential of 3R and takes Rwambu as an example of a successful IWRM-case (GoU, 2014). Consequently, interest has been expressed in expanding the 3R-approach and implementing it in comparable wetland areas across the country. Because 3R is an adaptable approach, it is easy to scale up and adapt to the different contexts of an area. In addition, this type of intervention can be taken as an example and implemented in WASH programmes around the world.

Table 2. The investment savings and additional earnings of 3R measures

Investments		Cost savings		Extra earnings	
In-situ measures (e.g., stone bunds)	€ 9,000	Annual costs for fetching / buying water from vendors at € 0.15	€ 167 / 55	Increased crop yields of between 40 and 60 percent	€ 325
Other measures (e.g., small check dams)	Outsourced to community	Drilling deeper wells (1 per 10 years)	€ 7,000		
		Reduced prevalence of diseases	-		
Annual maintenance costs	€ 100	Annual pump maintenance costs	€ 100		
		Annual time saved (60 min a day)	€ 325		
Total (15 years)	**€ 9,000**	**Total (15 years)**	**€ 9,475**	**Total (15 years)**	**€ 4,875**

CASE 3

The SMART Centre approach

In large parts of Africa, there is a lack of access to water and sanitation facilities. In addition, there is a high rate of non-functioning facilities due to lack of spare parts and skilled technicians. This adds up to the general challenge of managing common resources such as water. A combination of mismanagement and climate change result in declining water tables.

The SMART Centre approach has been rolled out across multiple countries to deal with the above-mentioned challenges. The approach entails training and coaching technicians and entrepreneurs to produce, sell, and maintain simple, market-based, affordable and repairable technologies (SMARTechs). Some examples of SMARTechs are tube recharge systems, water harvesting techniques, rope pumps, manually-drilled wells, HWTS (household water treatment and safe storage), and improved toilets, like the SatoPan Flapper toilet. The SMART Centre approach enables more sustainable communal systems and the possibility of moving away from communal water supplies to (supported) self-supply, whereby ownership of water points is clearer and non-functionality is lower.

The project tackles market-related challenges such as the lack of employment opportunities for technicians and small entrepreneurs. By enabling sustainable access to water for around € 25 per person, the SMART Centre approach intends to facilitate spinoffs from increased water availability. Examples are the sale of surplus crops on the market, purchase of irrigation equipment and other agricultural inputs, and transportation of surplus crops. Importantly, the SMART Centre approach works on both sides of the water chain, putting water into and taking water out of the hydrological system in a balanced way.

The core business of the SMART Centre is training and coaching of technicians and small entrepreneurs. This is not a one-off training. Entrepreneurs who show enthusiasm and potential are guided and coached for a longer period and are trained in the financial and marketing skills needed to sustain a business. Technicians and small entrepreneurs only sell products and services for which there is a real demand. Hence, a profit-based sustainability mechanism is in place.

SMART Centres are set-ups focused on financial sustainability from the start. While establishing and building the reputation of new Centres may, in most cases, need support, each SMART Centre will be able to run independently in time, with several income sources. These include: 1) training and coaching fees, either paid directly by entrepreneurs and technicians or by development agencies (UNICEF, NGOs, local governments); 2) production and installation of SMARTechs (with a fee for the Centre for coordination and quality control).

Besides the initial training and support that is subsidised, entrepreneurs need to run their business commercially from the start. Each succesful entrepreneur who is trained by the SMART Centre will have a business-driven scaling path. The benefits of water extraction SMARTechs such as hand pumps, toilets, and water filters are immediate. The benefits of tube recharge and water harvesting systems become tangible only after one or two rainy seasons.

Figure 7 and 8. SMARTech training and implementation (Source: MetaMeta, 2017)

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3. VALUE CHAINS, ZERO HUNGER AND 3R

Agricultural growth depends on a reliable water supply

Smallholders often find themselves with limited access to agricultural services and far away from the advantages of economies of scale. Investing in these smallholders and making them climate resilient by improving water productivity will become an essential part of achieving the SDGs. More crop per drop, through 3R measures, can bring the world closer to feeding billions of people (Bouma et al., 2016). 3R can give subsistence agriculture a boost and can push people towards more profitable production. The potential of 3R in smallholder cash crop value chains is currently largely untapped. Similarly, medium and larger agricultural companies that operate in arid and semi-areas can improve the crop yields, quality, stability, and sustainability of the production process by investing in 3R measures. In this way, they increase the attractiveness of their business model to international investors and traders.

Rain-fed areas have the greatest potential to increase yields considerably through soil moisture management. Current rain-fed farming systems operate with a water gap of 29 percent relative to their potential when water is unconstrained (Jägermeyr et al., 2016). The same study estimates that combining in-situ with ex-situ 3R measures may increase global kcal production by 7 to 24 percent, meaning that rainwater management can make a crucial difference in many situations. Currently, poor water control systems in areas with irregular and unreliable rainfall inhibit water storage for later use. Water retention in upper catchments can reduce peak flows and increase dry season base flows that can benefit downstream irrigation. Harvesting rainwater from roofs for vegetable gardens in the community has similar effects on a smaller scale. Through 3R, infiltration and soil moisture can increase, preventing overall crop failure when drought strikes.

Challenges in the face of growing demand and uncertain climates

The world needs to produce an estimated 60 percent more food by 2050 to ensure global food security (FAO, 2015). Around 2.5 billion people, who manage 500 million smallholder farms, provide over 80 percent of the food that is consumed in much of the global south (IFAD, 2013). Although in theory there is enough water available to satisfy growing demand, both increased competition for water and climate change effects are impeding agricultural growth by driving water imbalances. This results in crop loss as a result of unpredictable drought as well as erratic rainfall. While rain-fed farming is the dominant livelihood in Africa, about 50 percent of rainfall may be lost to unproductive sinks (Biazin et al., 2012). At the same time, failing to address water shortage issues endangers the future supply of crops grown in such a vulnerable context.

In current agricultural value chains, soil and water productivity are often seen as an externality. However, extending the value chain to include the soil and water supply of the crops has a direct impact on the value chain and has multiple environmental benefits. Through local action it is possible for areas to change from food importing to food exporting areas through water the harvesting that initiatives of individual farmers (Tiffen et al., 1994). 3R measures at the farm level are an essential mechanism to increase crop production, stimulate employment, and stabilize agricultural supplies throughout the years. Here, business benefits are effectively connected to development benefits and have the ability to contribute to poverty alleviation.

3R-driven water supply benefits smallholders and agri-business

The adoption of 3R has positive effects on yields, particularly when coupled with other good practices such as agroforestry and crop rotation (Cofie et al., 2004). In such cases, crop yields can increase by 40 percent (Kisekka et al., 2018). In a study conducted with Kenyan and Burkinabe smallholders, 3R measures resulted in a net profit of US$ 151 to US$ 626 per year per hectare in Burkina Faso, and US$ 109 to US$ 477 in Kenya (Fox et al., 2005). Real benefits are even greater as a result of the time and money saved fetching water, which can be invested in improving crop productivity further.

3R interventions form an essential part of risk management, both for subsistence farmers and for farmers who are part of a local, national, or international value chains. Large agri-businesses are recognising that long-term water supply in their value chains is at stake. Companies like Unilever, Nestlé, Heineken, and Sodexo have commitments to source (part of) their supply chain sustainably by 2020 and to invest in smallholders. In addition, local businesses, farmer cooperatives, and national governments are interested in improving the reliability of future water supplies through 3R. It is often also a chance for national governments to work with investors to create an enabling environment for improved agricultural production.

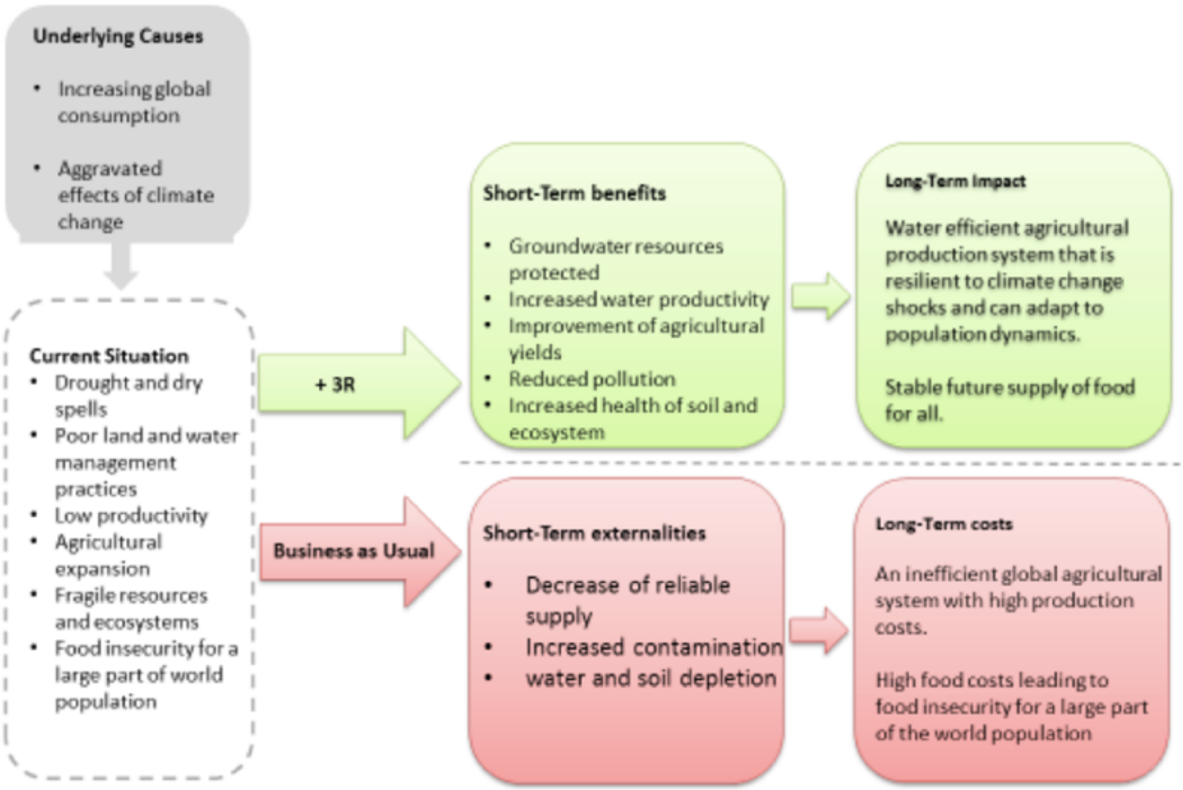

Figure 9. 3R versus business as usual scenarios

CASE 1

The untapped potential of coffee production, Uganda

Coffee production and export have been on the rise in Uganda, in line with a government plan to accelerate coffee production from 3.5 million to 20 million bags (of 60 kg) by 2020 (UCDA, 2017). Today, coffee is Uganda's most valuable export product, accounting for 12.6 percent (US$ 371.5 million) of total export earnings in 2016 (UBN, 2017). The country's coffee industry is dominated by smallholder farmers who are estimated to produce about nine times less than their potential (UBOS, 2010).

Figure 10. A ferro-cement tank (Source: URWA, 2017)

The Mount Elgon region is very suitable for coffee production. Nevertheless, the coffee farms in the area experience low productivity and food insecurity throughout the year. One of the root causes is water imbalance, which results in shortages for irrigation and processing, depletion and pollution of community water sources, and loss of time and fuel to get water. As a result, both the vulnerability of communities and the entire coffee value chain is increased.

December to February are the critical months during which coffee is harvested and processed. Rooftop ferro-cement tanks can store enough water to fulfil coffee production and processing needs during these months, thereby ensuring higher yields and quality (URWA, 2016). The tanks save farmers time and money collecting water from other sources. In addition, on-farm coffee processing allows used water to be led back to the fields to increase soil moisture levels.

The data in the table below are estimates of the Ugandan Rainwater Association (URWA) based on household data from the Kapchorwa region. Although the initial investment is high (US$ 1,500), savings and extra income can lead to earning back costs in a few years' time. Already from the annual costs saved on water that would have otherwise been purchased (estimated at US$ 350 annually), the costs can be earned back within approximately 4.5 years. If the farmer manages to increase productivity, extra earnings can half the time to earn back initial costs. The tanks have the potential to significantly increase local income through cost saving and yield improvement.

Table 3. Monetising the installation of ferro-cement tanks

Investment		Cost Savings		Extra earnings	
Instalment of a ferro-cement tank (10,000 litres)	$ 1,500	Annual water costs for domestic and production purposes	$ 350	3 bags of coffee beans	$ 400
No operation costs for 15 years		Annual costs for fuel (depending on location)	$ 100		
		Annual time saved (at least 1 hr per day)	$ 400		
Total (15 years)	$ 1,500	Total (1 year without time and fuel costs)	$ 350	Total (1 year)	$ 400
		Total (15 years)	$ 4,750		
		Total (1 year without time and fuel costs)	$ 850	Total (15 years)	$ 6,000
		Total (15 years) without time	$ 13,750		

CASE 2

Fruit juice farming, Ethiopia

A fruit juice company in Ethiopia operates two farms on 2,000 ha in total, growing fruit crops such as passion fruit, citrus, papaya, and mango. The products are marketed as juice concentrate and pulp for export and fresh fruit for the local market. The performance of the two farms greatly depends on the nearby river for irrigation. In recent years, various events have caused concern about the viability of farm operations in the future. One such event is drought, which affects fruit production as fruit trees cannot be irrigated. In addition, the company's access to an irrigation canal was blocked. Not acting in this situation would mean either reducing activities or closing the company completely.

A viable alternative is a seasonal tributary stream that flows to the main river. In the area, seasonal rivers fill up during the three-month rainy season but quickly lose their water due to seepage, leaving the riverbed dry for the rest of the year. Depending on soil characteristics, 3R measures like weirs and leaky check dams can assist in retaining enough water to meet the company's water needs during the dry season. Weirs and check dams can be connected to the companies' existing irrigation infrastructure.

By reducing dependence on a water source that is increasingly insufficient to meet the water demands of all the users, and replacing it with an alternative relatively untapped source, the company is ensured a stable future supply of water throughout the year. This reduces risk and increases resilience when drought strikes without negatively affecting other water users in the area. In addition, community conflicts can solved by making use of a different water source or sharing the new source with the communities.

Table 4. Two scenarios that offer an alternative other than using river water

Scenario 1: Investment in boreholes	Scenario 2: Investment in 3R measures
115 boreholes at $ 40,000 each	Construction of weirs and leaky check dams, earth dams: US$ 500,000 Investing in water-saving drip irrigation: US$ 3 million
Total estimated cost: US$ 4.5 million	**Total estimated cost: US$ 3.5 million**

When different water management scenarios are considered, 3R solutions show significant cost-saving potential. A water needs assessment shows that the farm would need 115 boreholes to serve all production and processing needs. At a cost of around US$ 40,000 per well, this would be an investment of US$ 4.5 million, and possibly more when considering electricity needs. In contrast, 3R measures can be built at an estimated maximum cost of US$ 500,000. Combining these measures with a drip irrigation system will bring additional benefits, as this form of irrigation can increase water productivity up to 400 percent. This case shows how catchment analysis combined with small-scale 3R measures can safeguard a water-intensive production process in a semi-arid region. Once installed, the 3R benefits will be evident after the first rainy season.

CASE 3

Promoting off-season horticulture, Burkina Faso

The agricultural sector makes up 35 percent of Burkina Faso's GDP and involves more than 80 percent of the labour force, which is dominated by smallholders. In the dry north of Burkina Faso, pressure on water is exacerbated by improper water management and low water use efficiency in prevailing irrigation practices. For example, 70 percent of the water wells dry out when they are used for off-season vegetable production. With a business environment that is neither attractive nor conducive to increasing private investment, the local economy is mainly characterised by the non-productive and vulnerable agricultural sector. Among the root causes of this vulnerability are water scarcity towards the end of the production season and the use of traditional water extraction and irrigation methods that have not been improved. In current conditions, farmers do not produce from July to December, when the vegetable prices are high at the market.

The Drops for Crops project implements integrated water management measures and efficient water use to boost the off-season cultivation of onions. The project introduces a Water Use Master Plan, founded on 3R-principles, which includes the implementation of on-farm 3R measures on 3,200 ha of agricultural land in the upper catchments, the institutionalisation of local decision-making with water use

 

Figure 11 and 12. Water collection and onion cultivation in Burkina Faso. (Source: Acacia Water)

and management committees, and improved water infrastructure and water application systems. In addition, the project will develop an innovative approach to using small dams as infiltration pans to increase water availability for crop production, and will also introduce solar pumps and drip irrigation systems to ease access to increased water use efficiency.

First and foremost, the project aims to improve access to water for irrigation and to extend this access further into the dry season. This will support a higher quantity and quality produce, and it will allow for off-season horticultural production that yields higher profits. The national production of onions is estimated at around 242,000 tons and is insufficient to satisfy the increasing demand for onions for national and regional consumption. Price fluctuations over the years are high, varying from 12,000 FCFA per bag from February to March to 50,000 FCFA per bag from October to December, when onions are scarce on the market. The project aims to facilitate the involvement of farmer cooperatives to target the market when prices are highest. Higher prices and additional production, made possible by implementing 3R measures, easily cover the investments. At the field level, return on investment is possible within several growing seasons, depending on the exact measures implemented. The expected indirect benefits of 3R are an increase in social cohesion as a result of the decentralisation of water management.

The project's 3R measures are tailor-made for the north Burkinabe environment and climate, but similar approaches can be deployed in water scarce areas throughout rural Africa. On-farm 3R measures can yield benefits within one growing season, while measures at the catchment level are more oriented towards the longer term.

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4. INFRASTRUCTURE AND 3R

The relationship between roads and water can be positive

Infrastructure has a substantial impact on watershed hydrology. This impact is often negative, as processes of uncontrolled flooding, erosion, sedimentation, and wetland loss clearly show. Roads may block water, concentrate runoff in limited drainage canals, and affect sub-surface streams. Roads are a main reason for drainage congestion and water logging. This trend can be reversed, with roads becoming instruments of beneficial water harvesting and management.

There are many measures that can be implemented to manage water with roads and make roads instruments for food and water security, landscape management, and environmental protection. Road bodies and drainage infrastructure can be used to harvest water in dry areas by guiding water runoff from roads to recharge areas or surface storage or applying it directly to the land. Roads can also be used to manage water catchments by controlling runoff speed, compartmentalising and mitigating floods, and influencing sedimentation processes in catchments. Table 5 provides an overview of road water harvesting options for semi-arid areas.

Table 5. Water harvesting from roads: Options for semi-arid areas

Component	Design options
Road surfaces	» Harvest water from the road through lead-off drains and rolling dips » Use of low filtrating stone bunds in flat areas » Plant roadside vegetation to intercept contaminants from the road's first floods
Cross drainage and culverts	» Compartmentalise by dividing the road runoff into smaller flows » Use grade reversal, and in- and out-sloping to make runoff manageable » Prevent gullying of drainage streams with check dams and armouring » Direct runoff to storage and recharge areas » Provide storage and enhanced recharge structures on runoff paths
Roadside drains	» Select road template so as to collect runoff in drains » Build storage and enhanced recharge structures on lead-off drains
Borrow pits	» Use borrow pits for water storage or as seepage / recharge ponds
Road foundation	» Use permeable substrata, lateral, or transversal drains on paved roads
Newly opened springs	» Collect newly opened spring flows in cisterns or storage reservoirs that are adequately dimensioned and have spillway facilities
Irish bridges and flood water spreading weirs	» Use Irish bridges to stabilise dry river beds » Combine Irish bridges with sand dams » Use access roads to create flood water spreading weirs
Roadside vegetation	» Use vegetation – combined with filtrating bunds – to slow runoff, control erosion, increase infiltration, and trap contaminants
Sedimentation	» Controlled sand harvesting from Irish bridges, sand dams, and sand traps

(Source: adapted from Garcia-Landarte Puertas et al., 2014)

Meeting different development needs

Overall, the implementation of road water management provides three types of benefits. First, road and landscape damage are reduced when flood events strike. Second, economic potential is unlocked by reducing the downtime of roads after flood events that would otherwise hamper economic activity in an area. Third, the use of the harvested water from roads has benefits for men and women in rural communities, such as improvements in agricultural productivity and water availability; expanded livelihood opportunities in terms of crop choices, agroforestry, and livestock grazing; improved health and nutrition; and economic empowerment. Table 6 summarizes positive environmental impacts derived from road runoff harvesting.

For roads to truly become multipurpose infrastructure, close collaboration between the agencies responsible for road development and those that promote agriculture and watershed management is required. Moreover, local communities need to be involved in the design phase to indicate local water needs and identify opportunities and constraints for water capture along roads. This will require a different style of working for road engineers, but it may go a long way in reducing water damage to roads – now the single largest cost in road repairs.

Table 6. Environmental impact of road water harvesting

Environmental impact	Ecosystem services	Impact on local communities
Greater plant growth and diversity	Biological production and carbon sequestration	Availability of wood and fodder
Increased soil biodiversity	Improved nutrient cycle	Higher crop production and diversity
Increased insect diversity (bees and other insects)	Pollination and integrated pest management	Additional income sources (e.g., honey production)
Increased soil moisture and base flows	Better water regulation through recharge	Increased water and food security
Increased soil nutrients and reduced soil erosion	Nutrient availability, flood regulation	Greater agricultural production and resilience to extreme events

(Source: adapted from Kubbinga, 2011)

3R measures can greatly reduce maintenance costs of roads

The annual investment in roads amounts to close to € 2 trillion. The impact that roads can have on water retention can be enormous when 3R measures are applied, benefitting road and agricultural authorities and rural communities. Measures will decrease road maintenance costs, making them attractive to infrastructure investors. In addition, 3R can reduce damage caused by road water to adjacent lands, providing an incentive to agriculture and environmental authorities alike. The table below provides an economic comparison between a conventional approach to resilient roads and the Roads for Water approach. In the Roads for Water approach, the environment around the road is managed and the road is made an integral part of the landscape, whereas in the conventional resilience approach the design specification is adjusted to make the road better able to withstand adverse rainfall events.

To systematically include water harvesting in road infrastructure, a more integrated and dynamic framework for road planners is required, which would allow them to integrate runoff manipulation into design packages in a way that goes beyond merely dealing with protective road drainage. At the same time, water harvesting from roads should be a standard element in watershed projects, including the protection of sensitive road sections by those responsible for watershed protection. Complementary or co-financing programmes can be developed to increase value to all parties.

Figure 13. Roadside infiltration pond in Ethiopia (Source: MetaMeta, 2017)

Table 7. Comparing the costs and benefits of conventional and roads for water resilience approaches per 10 kilometres of road

	Roads for Water	Conventional Resilient Roads
Cost		
Paved roads	US$ 1,800	US$ 45,000*
Unpaved roads	US$ 1,800	US$ 31,200
Benefit		
Reduced damage		
Reduced road maintenance cost - Unpaved	US$ 1,100	Comparable
Paved	US$ 2,200	
Periodic - Paved	US$ 3,400	
Periodic - Unpaved	US$ 1,870	
Reduced damage due to erosion	US$ 2,675	Negative: more erosion than baseline
Reduced damage due to flooding	US$ 1,762	Negative: more flooding than baseline
Reduced damage due to sedimentation	US$ 180	
Unlocking the economic potential		
Less down time of roads	US$ 3,800	Comparable
Reduced impact from climate change	US$ 550	Comparable
Co-benefits		
Use of water harvested from roads	US$ 4,500	

* This figure comes from Cervigni et al., 2016.

CASE 1

Roads for Water in Ethiopia, Nepal, and Yemen

The Roads for Water approach has been successfully implemented in Ethiopia and Kenya since 2014 and has been expanded to other countries. As mentioned, water from roads often causes local flooding, erosion, sedimentation, and waterlogging. In a survey carried out along a 64 kilometre road in Ethiopia, 159 problems spots were identified – close to three per kilometre (Steenbergen et al., 2018). Nepal and Yemen are not an exception, with roads causing landslides, erosion, and sedimentation of farmland and reservoirs (Devkota et al. 2014; Steenbergen et al., 2014).

Since 2014, road water harvesting has been integrated into soil and water conservation efforts undertaken by the annual community mobilisation works in Ethiopia's Tigray and Amhara regions. Good practices, like diverting water from culverts, using the springs that have opened up with road construction, or reusing excavation pits as storage reservoirs are now part of this mobilisation. The approach has expanded to Oromia and the Southern Nations, Nationalities and Peoples' Region as well. In the past four years, more than 2 million people have benefited from increased water availability and soil moisture in adjacent fields.

Figure 14. Applications of road water harvesting in a) Nepal, b) Ethiopia, and c) Yemen (Source: MetaMeta)

Road water harvesting measures have great potential in Nepal and Yemen as well. In the hilly areas of Nepal, road drainage from culverts and side drains are used for livestock watering and irrigation. This is also the case in Yemen, where water scarcity is more severe. Yemen has a long history of water harvesting using roads, including diverting water to roadside cisterns combined with silt-traps to maintain water quality. In addition, hillsides can be stabilised with water retention measures in combination with bio-engineering to prevent landslides. In the plains, roads can be used to compartmentalise water with gated culverts and to create areas for farming and fish farms. Moreover, roadside ponds and trenches can be used for water collection and groundwater recharge. The latter has major potential in Yemen, where water in the plains can be used to feed shallow wells, countering ever-decreasing groundwater levels.

The implementation in Ethiopia so far has led to an average yield increase of 35.5 percent. Soil moisture has increased up to 100 percent and groundwater levels have risen. It is estimated that the decreased damage to landscapes will amount to US$ 4,617 per km per year, while the costs of implementing the 3R measures is US$ 1,800 per km per year. Moreover, the cost saving in road maintenance through better water management would amount to US$ 3,400 per year. By 2050, it is estimated that there will be 2,883,905 million km of roads: 15 percent paved, 72 percent unpaved, and 13 percent unknown (Cervigni et al. 2016). To scale up the Roads for Water approach, road design criteria and maintenance arrangements need to be adjusted.

The positive impact of beneficial road water management can be seen after one rainy season and will increase over the years. Farmers will benefit from the additional water and soil moisture for crop production during the dry season. They benefit through improved livestock production as well, because floods can be diverted to increase the amount of drinking water in ponds after one rainy season, improving grass production.

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5. SUSTAINABLE COMMUNITIES AND 3R

Urban settlements can be turned into sponge towns

Cities are hubs of economic and social development that deliver infrastructure and basic services at low per capita cost (Cohen, 2006). However, urbanisation also brings together a range of environmental challenges. The loss of surfaces in cities reduces rainfall infiltration into the soil and increases surface runoff and waterlogging. Water that would have been infiltrated in forests and grasslands and stored in natural surface depressions now directly flows into rivers. This has resulted in sudden high peak floods that occur at a higher frequency (Konrad, 2014). Such hazards can be reduced with the careful planning and integration of 3R measures to create “sponge towns.” In a sponge town, the drainage system operates like a sponge to absorb, store, infiltrate, and purify rainwater and release it for reuse as needed.

One measure is to replace traditional pavements with permeable ones (Liu et al., 2015). In addition, roads, roofs, and other hard surfaces can be designed to perform as a catchment area, and water can be redirected for infiltration or storage in urban parks. The idea is that urban infrastructure should not be seen as obstacle, but as an opportunity to effectively deal with storm water drainage while storing water for reuse in the dry season. This not only helps to mitigate flooding, but also reduces the impact of heat waves by releasing water vapour into the air, alleviating urban heat islands and improving water quality and impact on natural ecosystems (Li et al., 2017).

To keep settlements sustainable and safe in the future

Sudden large peak discharges occur more often in places with more impervious surfaces (Konrad, 2014). Thus, cities face greater exposure to flood hazards. An assessment on storm runoff response shows that an increase in impervious cover from 11 to 44 percent results in a reduction of flood duration by over 50 percent and an increase in peak flows of more than 400 percent (Miller et al., 2014). A study in China estimates that peak flows increase 1.5 to 6 times following urbanisation (Jiang et al., 2018).

It is estimated that global exposure to river and coastal flooding in 2010 amounted to US$ 46 trillion, with figures expected to increase to US$ 158 trillion (Jongman et al., 2012). In the EU, the average annual economic losses due to flooding are expected to increase to €23.5 billion in 2050—more than five times the amount for the 2000 to 2012 period (€4.6 billion) (Jongman et al., 2014). At the same time, common consensus exists that urbanisation increases the vulnerability of the population to water shortages. More than 300 Chinese cities are facing water shortages, resulting in major economic losses (Jiang, 2009). Barcelona's 2007 drought cost € 1.6 billion, about half of Catalonia's GDP (Martin-Ortega et al., 2012). It is also estimated that over 23,000 life years were lost each year as a result of heat waves in Europe in the 1990s (Baccini et al., 2013).

Cities are already home to almost half of the global population, with estimates that around 66 percent of the global population will live in urban areas by 2050 (UNESA, 2014). At present, more than 400 cities in the world have more than 1 million inhabitants (Cohen, 2004). Smaller towns and cities with less than 500,000 inhabitants are also flourishing, and it is estimated that more than 50 percent of urban population growth in the near future will be in smaller towns and cities (UNPD, 2011). These figures show the significant task at hand to mitigate flood and drought risk, as well as heat waves.

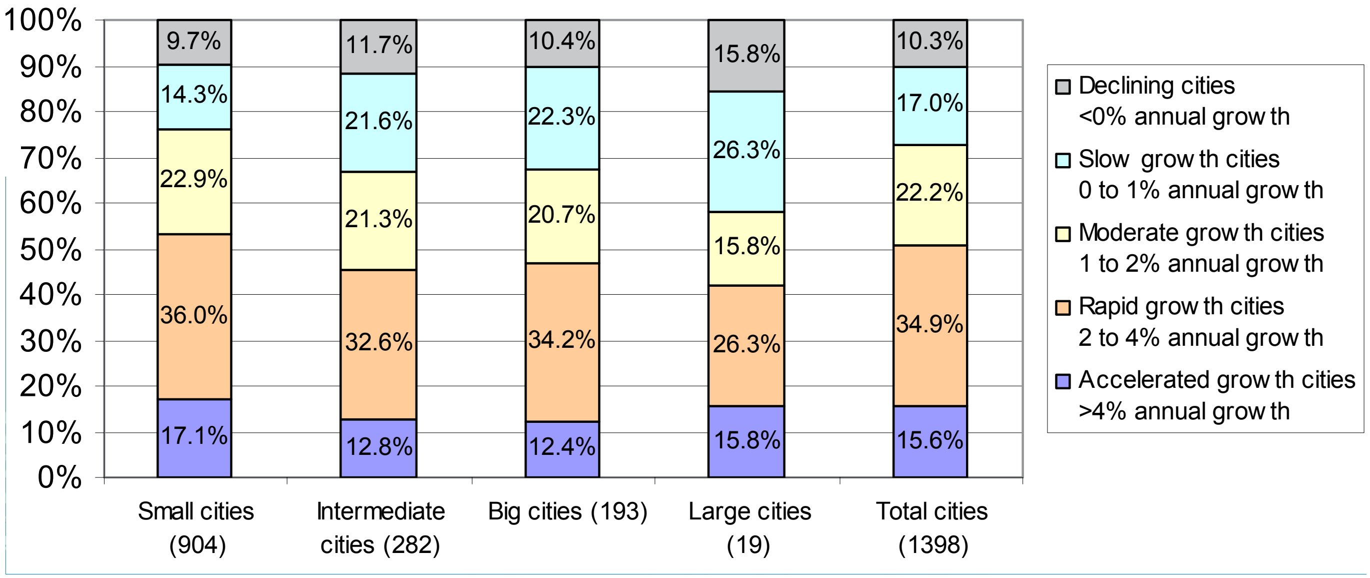

Figure 15. Population growth rates of cities in the global south. Small cities: 100-500; intermediate cities: 500-1,000; large cities: 1,000-5,000; very large cities: > 5,000 (x 1,000 inhabitants) (Source: UNPD, 2011)

3R thinking can help to make cities water-smart

Resilient city design should involve 3R measures at its core. Sponge towns can seem expensive, but many agree that it is cost effective in the long run. Local governments can greatly gain from the sponge city concept, and some have started to heavily invest in it (Liu et al., 2015). In 2014, China started implementing a pilot of 30 sponge cities across the country at an annual cost of US$ 60-90 million (Li et al., 2017), and there are plans to expand this pilot project to 657 Chinese cities at a cost of US$ 1.5 trillion (Jia et al., 2017). The pilot is not only planning to control urban flooding, but also to retain 70 to 90 percent of annual rainwater in China's urban environments by applying green infrastructure like vegetation and permeable pavements. Local governments in other countries also engage in good practices. Seattle in the United States has reduced runoff by 98 percent in some areas by narrowing the pavement and incorporating vegetated swales and native plants in public spaces (Konrad, 2014). Philadelphia is experimenting with pervious pavements that allow water to soak into a stone subsurface reservoir at a cost of US$ 2 billion for 25 years (Gaines, 2016). In addition to pervious pavements, green roofs and tree trenches will be used to capture and slow storm water allowing it to evaporate before reaching city drains.

Similar advantageous investments can be made in the global south. More municipalities and environmental NGOs should take the lead to incorporate these practices in their urban planning and scale up the sponge town concept. Pilot projects need to be expanded and made mainstream to keep pace with the current trend of urbanisation while securing the well-being of city inhabitants.

CASE 1

Sponge towns, Kenya

By 2030, Kenya is expected to be a more urbanised country with half of its population living in urban centres (Ngetich et al., 2014). Towns are growing all over Kenya, and communities in the semi-arid regions are facing the pressing need for more water in the dry season, while destructive flood events and waterlogging occur more frequently as well. The sponge town concept addresses issues related to equitable and efficient water use in urban and peri-urban agriculture, reliable water harvesting, and storage and flood adaptation.

The initiative to develop sponge towns in Kenya's Kajiado and Kitui districts started in 2016, based on the realisation that runoff from hard surfaces should become an opportunity rather than a hazard. Measures focus on making parks, roads, and roofs function as catchment and recharge areas, assisted by infiltration pits and galleries. In this way, they absorb precipitation and reduce storm water flows. In addition, the projects focus on preventing storm runoff from forming gullies by constructing retention structures like tanks and basins, and by preventing rubbish from being dragged into small rivers that would clog them. Less flooding means less economic damage and fewer health hazards. Storing flood water with sand dams and subsurface dams helps to recharge groundwater and enhance vegetation cover.

Increasing water availability in towns located in semi-arid areas creates a wide range of benefits. Besides improved water availability in boreholes, positive impacts include fewer gullies, urban beautification through increased vegetation cover, and the dilution of groundwater pollutants from pit latrines and poor sewage systems by adding clean water to the subsurface.

The business case largely focuses on making urban planning sensitive to water flows, thereby reducing damage from waterlogging and making good use of stored water. This means that roadside drains become retention and infiltration basins, open spaces become catchments, and large roofs provide opportunities for water storage. By including flow gardens and parks as well as improving road drainage and retention basins, there will be an increase in usable groundwater, a decrease in road maintenance, and an increase in real estate prices. Currently, small-scale sponge town options for arid zones are not well established and need to be brought to a larger audience. When this happens, the approach should be possible in just about any small town in an arid environment that wants to improve water challenges, with results needing a few years to produce effects.

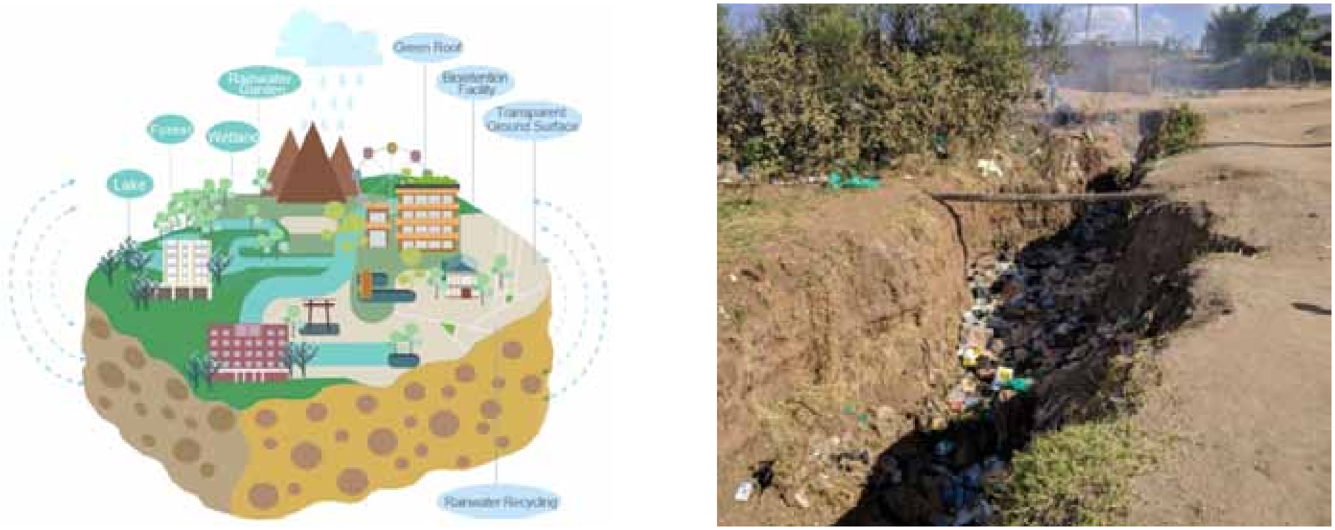

Figure 16 a) sponge town concept; b) storm water gully in Kajiado turning into a rubbish dump (Source: RAIN, 2017)

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6. DELTAS, COASTAL AREAS AND 3R

Specific water solutions apply to coastal areas

Currently, about 50 percent of the global population lives within a range of 150 km from the sea (Cohen et al., 1997). The high population density in deltas and coastal areas is strongly related to the presence of transportation and trade routes (Olsen et al., 2003), economic activity, and the abundance of ecosystem services. As the world's population keeps growing and the climate is changing, concerted efforts are needed to sustainably increase agricultural production and improve access to food (UN, 2018). At the same time, fresh water availability in deltas is under serious threat due to sea level rise, land subsidence, aquifer over-exploitation, saline water intrusion, and pollution.

Water resources need to be better protected and managed to ensure sustainable agricultural production in coastal areas. A particular and widespread water challenge in coastal areas is saline water intrusion and the consequent salinization of soils. This leads to changing groundwater dynamics and a serious reduction in agricultural opportunities. 3R measures can help to mitigate the pressure by replenishing over-exploited aquifers and creating fresh water lenses on top of saline water layers. The latter can be accomplished through the use of innovative tile drainage. Renewed fresh water availability and irrigation options that come with 3R measures enable farmers to adapt to saline conditions. Implementing 3R in deltas has a wide range of direct and indirect benefits, including:

- Improving agricultural productivity by increasing fresh water availability
- Improving water availability for domestic purposes in fast growing urban areas
- Maintaining unique environmental quality and ecosystem services in deltas
- Replenishing aquifers that in many cases are over-exploited

3R is a cost-effective way of managing water resources in coastal areas. An example is provided by the Netherlands, where 3R measures contribute to the success of the agricultural sector. Excess rain water is infiltrated into the aquifers for reuse. During extremely dry circumstances, this additional water has been proven to boost crop yields by 20 percent (Winkel, 2018). Farmers acknowledge that 3R holds promises for the future, as water storage options constitute considerable drought risk reduction. As 3R measures prove their success, Dutch farmers consider upscaling them in coastal areas where salinization and water availability are among their greatest concerns.

3R brings in much-needed fresh water to safeguard crop production

Coastal areas and deltas harbour half of the world's population and are crucial in terms of food production. Securing fresh water availability in these areas is therefore of great importance. Reactive and ad-hoc responses prevail when farmers are faced with water shortages. The proposition is a fresh water strategy in which decentralised measures at the local level are central. Farmers often need a boost to be taken out of the low-yields and no-room-for-investment cycle. Other investors could take the first step, such as local governments aiming to stimulate agricultural production in their urban deltas; international companies and farmer cooperatives seeking to secure production rates; drinking water companies that have a great interest in water security; and firms that are specialised in irrigation techniques and that aim to gain market leadership.

CASE 1

Spaarwater, the Netherlands

Securing fresh water availability in the area along the Wadden Sea is of major importance to the economic position of the Dutch agricultural sector. Rising sea levels, soil subsidence, and exacerbating weather patterns, such as drought and erratic summer rains, increase farming risks in the region, which is well-known as one of most productive agricultural areas in Europe. The Wadden Sea area currently produces 50 percent of the Dutch flower bulbs as well as most of its seed potatoes. The area is characterised by a shallow fresh-salt water interface. A thin fresh rainwater lens that floats on top of the saline groundwater allows for the cultivation of crops that depend on fresh water. As a result of land subsidence and sea level rise, it is expected that the fresh rainwater lens will decrease significantly. If no measures are taken, it is expected that the lens will be replaced by brackish groundwater that will reach the root zone of crops through capillary rise and cause salt damage to the plants.

Spaarwater develops and tests 3R measures to mitigate salinization by ensuring the availability of clean, fresh water. It works to optimize the technical feasibility of measures and make them economically viable at the same time. The project works in six locations across the north of the Netherlands in the provinces of Noord-Holland, Friesland, Groningen, and Flevoland, where the following components are tested and implemented:

» Collecting fresh drainage water and storing it underground to promote year-round water availability
» Rolling out drip irrigation for the efficient use of water
» Increasing the fresh rainwater lens through controlled tile drainage to mitigate salinization

The project seeks to demonstrate whether it is possible to guarantee similar levels of agricultural production for the Wadden Sea region in the future, and whether the area can continue to be profitable for the cultivation of flower bulbs and seed potatoes. Spaarwater focuses on making farmers self-sufficient and less dependent – even independent – of an external water supply. With the applica-

Figure 17 and 18. Construction of bio drain in The Netherlands (Source: Acacia Water, 2016) tion of technologies such as drip irrigation, Spaarwater aims to take the next step in innovative agriculture. Their goal is to combine an increase in crop yield with a reduction in water and fertiliser use. The latter should lead to reduced outflow of polluting nutrients into the surface water. The freshwater lenses float on top of the saline groundwater and are vulnerable to changing conditions like sea level rise. System controlled tile drainage aims to control salinization by strengthening existing rainwater lenses, creating new lenses and reducing the discharge of salt and nutrients into the surface water.

Investments in Spaarwater measures increase agricultural yields and reduce the risk of harvest losses resulting from drought and salinization. By storing their own water, farmers no longer rely on water authorities for their irrigation water, which in itself is an important risk reduction. Next to increasing crop yields, farmers invest in the long-term viability of agricultural production on the land. When farmers team up to make a large-scale investments, they benefit, as the average cost per hectare drops by 50 percent from a 10 hectare plot to a 100 hectare plot.

In the past five years, the salinization risk and potential to upscale Spaarwater's measures have been mapped for the Dutch coastal area. Based on this assessment, the measures seem to be promising for large parts of the low-lying coastal zone. Farmers in the Netherlands are ready to participate and invest. The Spaarwater measures yield the strongest benefits during dry years, when the rainfall deficit is large. In the short term, Spaarwater measures deliver several benefits to farmers, like increased crop yields and a decreased risk of salt and drought damage. Even when there is no severe drought, the measures help to maintain and strengthen the leading position of the agricultural sector in the Wadden Sea region.

CASE 2

Increasing agriculture productivity, Bangladesh

In the 1960-70s, embankments were built to protect coastal areas (polders) against flooding and to halt the intrusion of saline water. The existence of these embankments is critical to ensuring agricultural productivity in the delta, and the polders used to drain during low tide. However, expanded human settlements and internal roads obstruct natural water flows, causing waterlogging on farmland. Without considering their impact on water management, roads were constructed with too few culverts to drain the water and without gates to control water flows inside the polder. As a result, waterlogging is causing serious delays in the sowing of crops and crop losses of up to 70 percent, thereby directly affecting the livelihoods of local communities.

Comprehensive field assessments were conducted in four coastal polders, and various promising, low-cost actions were outlined to increase the delta's agricultural productivity. They include improving the location, size, and number of water crossings to increase internal water drainage; using gated crossings to retain and control water; and re-excavating canals (*khals*) to reconnect the drainage system. The results of the assessment were used by

Figure 19. Waterlogged field (Source: MetaMeta)

Figure 20. Coastal polders

Figure 21. Gated culvert

the Bangladesh University of Engineering and Technology (BUET) for a hydrological modelling exercise for the drainage of Polder 26. Based on this project, seven locations were selected with local representatives of water management groups. At these locations, new gated culverts are needed to improve drainage conditions and decrease waterlogging.

Gated culverts along roads offer opportunities to control water flows and create retention areas. These can be used for irrigation, fish farming, and domestic purposes. Khal excavation increases water storage and recharges aquifers that have lowered as a result of excessive pumping during the dry season. If waterlogging decreases, farmers are able to grow Boro rice and vegetables and increase crop production by up to 300 percent. Reduced waterlogging in 60 percent of Polder 26 (± 1,200 ha) frees up land for a double crop production—an added benefit of over € 1 million, assuming a mixed cropping system of irrigated Boro rice, pulses, and oil seeds. When this strategy is scaled up to more coastal polders, better drainage conditions will improve water quality and sanitation inside the polder area. At present, people are affected by gastric problems, colds, and skin diseases. Moreover, ensuring continuous accessibility to health centres, schools, and markets will enhance the overall well-being of communities.

Water Management Committee Associations (WMCA) are responsible for the operation and maintenance (O&M) of drainage systems and infrastructure works inside the polders. However, while they should be following agreed guidelines to carry out O&M, this is not working properly. To improve O&M, a programme is working together with the WMCAs on small water infrastructure works to improve drainage and increase agriculture production. If waterlogging is reduced on 60 percent of the total surface area of the programme (69,000 ha, 22 polders and 6 million people), the benefit will be ± US$ 70 million. Moreover, improved water retention on 20 percent of the surface area (23,000 ha) will result in a net benefit of US$ 22 million.

The benefits of improved drainage can be noticed within the same growing season. Seeds can be sown sooner after the monsoon instead of waiting several weeks until the waterlogging has disappeared, making the growing season longer. Moreover, water that used to inhibit the fields from being sown can now be stored and used to irrigate crops during the dry season. The greater diversity of crops will increase rural incomes and overall well-being as a result.

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7. LANDSCAPE RESTORATION AND 3R

Integrated approaches to land and water management

More than 2 billion hectares of land has been degraded worldwide due to deforestation, soil erosion, and soil fertility depletion (Pistorius & Freiberg, 2014). As a result, there is a decrease in the availability of goods and services that can be sourced from landscapes – such as water and biomass – and reductions in agricultural production and household income. Therefore, it is necessary to find approaches to address the restoration of many millions of hectares of land, involving millions of smallholder farmers and others. This can only be achieved with simple and low-cost management techniques. Among such techniques are 3R measures, which can assist in restoring critical hydrological functions of degraded lands and enhance human well-being, thereby pushing entire landscapes forward.

The 3R rationale within landscape restoration is essential in delivering large-scale, systemic change to recover natural capital assets for people and nature. Some examples of measures and approaches that are required include farmer-managed natural regeneration, agroforestry, and improved land management to accommodate a mosaic of land uses, including agriculture, protected wildlife reserves, riparian areas, and more (IUCN, 2018). By strengthening ecosystem-based processes through integrated landscape management, we can meet the present and future needs of landscape users. Benefits include:

- Ecosystem services: water flow regulation, water quality protection, nutrient cycling, carbon sequestration, and restored landscape beauty
- Livelihood improvements: enhanced access to water, food and medicine
- Access to nature-based products: timber, non-timber forest products, and fish
- Biodiversity

Landscape restoration is both about small-scale 3R measures and the facilitation of integrated landscape management. Water retention and erosion prevention are essential to kick-start restoration processes and sustain ecosystem services (Wiegant & Steenbergen, 2017). We also see benefits to crop quality and quantity through improvements in micro-climate and soil conditions (Pretty et al., 2006). It was found that with in-situ 3R measures, like tied ridges, runoff can be reduced by 49 to 85 percent, and soil loss can be reduced by 60 to 90 percent (Woldegiorgis, 2017). More water retention and less fertile soil loss means that the ecosystem has more assets to quickly recover from a state of deterioration. Another successful restoration example is the Sukhomajri watershed development project in India, in which improved pasture quality was realised, resulting in a six-fold increase in milk production, while downstream siltation rates were reduced by 95 percent (Marginnis & Jackson, 2005).

As with watershed management, the 3R approach to landscape restoration needs to be based on economic efficiency, social equity, and environmental sustainability (Foster & Ait-Kadi, 2012). 3R-inspired restoration measures can best be defined based on the challenges, opportunities, and objectives that are felt by landscape users. To deliver significant impact, flexible packages of site-based specific 3R measures need to be designed based on a thorough understanding of the links between natural and social landscape elements. Often, this requires a focus on large spatial units, making the process inherently multi-stakeholder. 3R to landscape restoration touches on important dimensions, such as the integration of temporal and spatial scales and participatory and equitable stakeholder inclusion to recover a functioning landscape (Hulshof & Hürlimann, 2018).

Figure 22. Land use mosaic with a gully cutting through (Source: Acacia Water, 2017)

3R measures are an important piece of the puzzle

Large investments are now made in water storage and treatment, while 3R-assisted restoration can re-establish (some of) the services in a natural manner. De Groot et al. (2012) calculated the indicative cost-benefit ratio of restoration and found numbers between 1:2 to 1:35. Governments and development agencies play crucial roles in creating favourable enabling conditions for rural communities to engage in restoration actions and reap the rewards. The added value of 3R is that it helps to look at landscapes from the perspective of the hydrologic cycle and the demands placed on it. In this way, multi-stakeholder processes can be designed to deal with competing claims over water and increase the water balance through 3R and restoration.

Partnerships between public, civic, and private actors are crucial in this approach. Stakeholders need to develop a joint understanding and a common language, recognising and comprehending diverging interests. Civic organisations need to ensure that ideas and measures are aligned with the needs and visions of local communities (Mulder, 2016). Only then can the private sector work in a secure and low-risk environment and invest in restoration-oriented 3R measures for the long-term viability of value chains. Factors to make landscape investments successful are:

- Aggregation: bundle projects to make returns match transaction and monitoring costs
- Proactive government: build capacity to absorb private capital and provide catalytic funds
- Risk mitigation: blend finance with technical assistance—landscape restoration programmes address risk through holistic design and resource use.

Investors who may be interested in using 3R measures for landscape restoration are: organisations that convene public and private actors and co-fund landscape initiatives to realise inclusive green growth; companies that source agricultural commodities and want to improve the reliability of their supply chains; agricultural cooperatives who work within global value chains and look for ways to increase their yields; and private equity funds that discuss the environmental objectives for their estates and how these can be matched with stewardship activities. Furthermore, in countries such as the United States, negative development impacts need to be offset. Landscape restoration can be a way to do so, either directly or more commonly by buying mitigation credits from specialised firms (Mulder, 2016).

CASE 1
Jijiga restoration atlas, Ethiopia

The Fafan Catchment in Ethiopia's Somali Region is characterised by intense and prolonged drought events. The region's drought crises are protracted and persistent, often worsened by resource-based conflicts (Catley & Iyasu, 2010). The carrying capacity of the landscape is low, partly due to ecosystem degradation and population expansion. This has resulted in soil erosion, nutrient and vegetation loss, and low infiltration rates. Lengthy periods of drought followed by intense flooding, have led to low crop and pastoral productivity and poor water access (Acacia Water, 2016a; ERCS, 2014).

An integrated resilience building approach through ecosystem restoration is being applied by means of a partnership between the Netherlands Red Cross, Ethiopian Red Cross, Red Cross Climate Centre, Wetlands International and the local government. The project focus is capacity building to motivate users to manage the landscape sustainably. The approach combines 'soft' (regulation, coordination) and 'hard' 3R measures (bunds, trenches, dams) to reverse soil degradation. The project builds the case for communities, governments, and NGOs to invest in small-scale 3R measures that generate short-term profit while contributing to overall landscape resilience in the long term. The 3R measures are ecological building blocks. Step-by-step, these building blocks are put in place until natural revitalisation processes start again.

The project started with the development of a knowledge base that consists of a baseline to identify challenges and opportunities. Based on this, suitable measures were selected, combined into case studies, and presented in a manual for implementation. This manual then formed the basis for a training series to disseminate the approach. Four types of 3R measures are combined (Acacia Water 2016b):

- Protection and management of ecologically-sensitive and valuable areas, so that these can recover and achieve their full ecosystem service potential
- Soil and water conservation (3R) measures, including the construction of physical structures to counteract gully erosion, and good agricultural practices to increase infiltration
- Off-stream water storage, including measures that collect water from surface runoff to store in open water reservoirs or in the subsurface
- In-stream water storage, aimed at storage in seasonal riverbeds or open water reservoirs built across flow accumulation areas

The aim of such 3R measures is to build resilience by strengthening ecosystem services in the Fafan Catchment, thereby enhancing water and food security and reducing disaster risk. The combined interventions aim to decrease drought frequency and impact on the landscape. Building resilience through 3R-supported ecosystem restoration measures results in immediate and direct benefits, like improved water and fodder availability that increases livestock and crop productivity. Benefits in terms of food security can be noted within one year, as improved soil moisture conditions have an immediate impact on the quantity and quality of crops. However, projects like this also aim to ensure that the area becomes more sustainable in the long-term. We expect to see real impact 10 to 20 years after interventions have been implemented at scale.

Building resilience through 3R measures is a low-cost solution in terms of hardware. Promoting resilience is mostly about a series of mind-changing, capacity building, and institutional measures that motivate communities to manage their landscape more sustainably. Capital expenditure is relatively small in that sense, although it is essential to jumpstart the intended change. Similarly, a share of the operation and maintenance can easily be covered by the communities, as long as local and regional governments have the capacity and resources to offer support. The situation in Ethiopia's Somali Region is extreme, but similar approaches can be used throughout rural Africa and beyond.

CASE 2

Building with nature for wetland restoration in Acholi, Uganda

In the last decade, northern Uganda has emerged from civil war and now faces considerable development challenges. Refugees returning to their communities have found the infrastructure and facilities in ruins and their livelihoods (livestock raising and subsistence farming) destroyed. With their return, the pressure on natural resources has increased. In need of water for domestic and agricultural uses, communities in Acholi have been relying on the remaining boreholes and a limited number of new water sources. But as cattle herds increased in size, forests and wetlands were encroached upon in the search for more grazing lands. Water has become a scarce commodity. Without any measures to mitigate these trends, considerable ecosystem damage, food insecurity would occur, and conflict could re-emerge.

Since groundwater levels in the area are low, increasing water supply through new boreholes would not have been a sustainable solution. To offer a way forward, a project was started to restore wetlands by implementing small-scale 3R measures such as earth dams, elevated road culverts, and weirs in seasonal rivers. By creating shallow reservoirs, wetlands are regenerating and the area's water holding capacity has increased. The case for water harvesting and 'building with nature' in Acholi was based on local research in which informants described how accidentally blocked culverts increased water storage and wetland vegetation, and how dry season base flows of small headwaters increased (Riddell et al., 2010).

There are several benefits observed in the area. By adding alternative water sources, the project has reduced pressure on boreholes. Acholi's community members now use boreholes to obtain clean drinking water and wetlands for livestock watering and bathing. In addition, the wetlands have reduced the risk of floods and drought considerably, thereby increasing food security in the area. Restoring the local ecosystem is beneficial for subsistence agriculture and income generating activities through small-scale irrigation. The wetlands have also created a healthier local ecosystem and are now known for their large fish populations and serve as a stopover for migratory birds.

Figure 23. Wetland in Acholi, Uganda (Source: RAIN, 2017)

A continuation of the previous situation would certainly have resulted in periods of food insecurity throughout the year, and the costs of food aid could have run into the millions. In the restored wetland scenario, the healthier ecosystem will be able to push communities out of poverty through the combined advantages of improved nutrition, income, and health, paving the way for further economic activity in Acholi. The potential for more artificial wetland construction is high in northern Uganda. The actual costs are relatively high, but there is great potential to tie this in with road construction, agricultural development schemes, WASH, or resilience programmes.

CASE 3

Farmer-managed natural regeneration, Tanzania

Land degradation and climate change have made rural livelihoods harder to sustain. Based on the rationale that more trees on the land can create favourable agricultural conditions, farmers in several parts of Africa now allow on-farm trees to grow back. Farmers protect and manage root systems and seeds that are already present in the soil or that are dispersed by animals (Reij & Garrity, 2016). This process is called farmer-managed natural regeneration (FMNR) and is a form of re-greening occurring alongside agroforestry and sustainable land management practices. FMNR reduces the exposure and sensitivity to climate shocks, as trees create favourable microclimates and diversify the mechanisms of communities to cope with shocks. Household benefits from FMNR come through direct human consumption or the sale of tree products, with many species being a source of fruits and leaves (Reij & Winterbottom, 2015). During dry years, farmers can survive on trees by cutting a few and selling the wood on the market, thereby obtaining cash to ensure their food security. Other FMNR benefits relate to increased yields and higher livestock production due to specific microclimates that favour crops and pastures (Ismangil et al., 2016).

In 2017, a project was started to re-green Tanzania's Dodoma region. It builds on the knowledge and know-how of hundreds of famer facilitators who, in their respective communities, are seen as re-greening champions. In addition to training these champion farmers, an awareness campaign aims to inform the public about the importance of sustainable land management and the benefits of trees. In every village, a video event is organised to make all community members aware of the benefits of FMNR and to give them instructions on how to participate. This is complemented with an advertisement campaign and famous ambassadors to enhance the uptake of FMNR. Farmers are particularly motivated to protect their on-farm trees when they are supported by local champions who show the benefits of re-greening and show how it can be implemented practically.

The economic rate of return of FMNR is better compared to tree planting. FMNR has a return rate of 37 percent, while it accounts only 13 percent for tree planting. These figures are based on estimates of the value of on-farm trees over a period of 20 years and a 5 percent increase in crop yields (Reij & Winterbottom, 2015). In the business case for FMNR, smallholder farmers who practice on-farm tree protection reap the rewards. Reij & Garrity (2016) estimate that FMNR costs well below US$ 20 per hectare, with very low recurrent annual labour costs to manage it. The project's aim is to assist local re-greening champions to visit farmers who do not practice FMNR to help them gain experience. The socioeconomic and environmental benefits grow as the natural regeneration of trees progresses. The first results can be expected after two to four years.

Figure 24. Farmer-managed natural regeneration (Source: MetaMeta, 2015)

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8. CLIMATE ACTION AND 3R

Managing microclimates yields many benefits

There is little chance that humans in the near future will be able to modify the global climate on any large scale. However, focusing on landscapes and the agro-ecological systems within them, there is a lot that can be done. A large share of the effects of global climate change can be buffered by building microclimatic resilience at the local level (Gliessman, 2015). When farmers plant trees in or around their field, and when communities dig bunds to improve water retention, they change the local climate around them (Ismangil et al., 2016). Water and vegetation are crucial microclimate factors and can be managed through a combination of 3R measures and re-greening (Adams, 2010). Understanding microclimate factors is the starting point in transforming a landscape towards greater climate resilience.

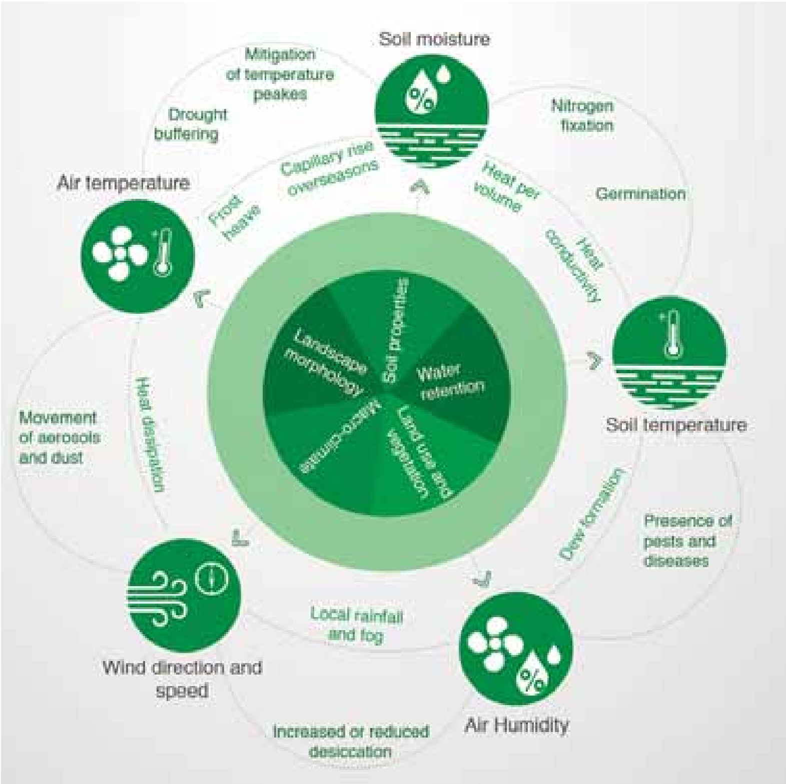

Figure 25. Microclimate components (Source: MetaMeta)

Soil moisture and air humidity make the difference between barren, arid zones and moist, fertile zones. While bare, arid deserts tend to get very hot, tropical rainforests have fairly mild temperatures. This is a result of evapotranspiration by plant leaves, which transfers water from the surface to the air. In this way, trees act as a water pump to the atmosphere. The evaporation process helps vegetation to let go of the heat from the sun's radiation, making the air cooler than it would otherwise be. As a result, a more balanced microclimate with lower air and soil temperatures is created, enabling plant growth (Adams, 2010). Tree roots can reach many meters into the ground, helping them to sustain good rates of evaporation long after the topsoil has dried out (Ismangil et al., 2016). In this way, trees continue contributing to favourable microclimate conditions long after the rains have passed.

It is crucial to have enough water in the subsurface to sustain the evaporation process. Applying 3R measures is key to better retaining water in the landscape and enables microclimates to play their role. By investing in 3R measures and re-greening their farmlands, farmers not only decrease the risk of soil moisture shortage on their land, but also immediately benefit from favourable microclimate conditions in their cropping systems.

In addition, trees act as windbreakers, slowing the drying or cooling winds that blow across farmland. At downwind distances of 1, 5, and 10 tree heights from a windbreak, evaporation rates are 40, 60, and 80 percent of what open field evaporation would be (Caborn, 1957). Reducing exposure to wind and maintaining humidity through lower evaporation rates of soils and crops can greatly increase water use efficiency. Shade and reduction in wind speed can lower air temperatures by 5 to 10°C, soil temperatures by up to 20°C, and increase air humidity by 10 to 15 percent (Adams, 2010).

Managing microclimates should be a priority in a warming and drying world

Microclimates are largely unattended. In view of the climate change that can be observed today, this is a significant missed opportunity. Microclimate management has the potential to be a proactive approach, alongside adaptation and mitigation, to building the resilience of agricultural systems. When an individual tree evaporates water and cools itself, it contributes to the heat and moisture balance of the whole forest and landscape (Adams, 2010). Added up and averaged out, the mesoclimate is the sum of all microclimates across a landscape. More trees and forest cover contributes not only to the microclimate, but also to the mesoclimate.

Air temperature and humidity levels play a large role in determining the crop species that can grow in an area. All crops have an optimum growing temperature and a minimum and maximum temperature threshold. Maize growth is hindered above 35°C, while onions have a maximum threshold of 25°C. For shade crops like coffee, the effect is even stronger (Lin, 2007). When such temperatures are exceeded, growth is delayed or even prevented, which can result in yield or plant loss. With temperature extremes increasing under climate change, the number of days that are too hot to support crop growth will increase if nothing is done to manage microclimates. If re-greening and 3R potential is not used, cropping systems will not be protected against worsening drought and temperature extremes.

3R is instrumental in creating favourable microclimates

Microclimate investments pay off, particularly in the context of rising temperatures and increasingly erratic rainfall. Trees and 3R measures moderate soil temperatures, reduce wind speed, increase soil moisture retention, and enable micro-organisms to improve soil fertility (Lasco et al., 2014). Microclimate management is attractive for governments, individual farmers, and development agencies that work closely with them, as it brings life back to desiccated farms and landscapes.

Microclimate management is a wide-ranging topic relating to forests, soils, water, livelihoods, and food. It needs to be addressed holistically. It is a call for intensive change that does not rely on isolated interventions, but on a critical sum of measures that create systemic change at the landscape level (Van Steenbergen et al., 2011).

CASE 1
Hydrologic Corridor potential map, Africa

Overexploitation of water resources and poor land use planning and soil management are undermining natural regulation processes of evaporation, cloud formation, and rainfall. This results in a decrease in water availability for domestic and productive use on one hand, and it increases the frequency and intensity of floods on the other hand. The impact is particularly acute in areas with fragile ecosystems, where rural communities greatly depend on natural resources for their livelihood.

To deal with these challenges, a series of largescale re-greening projects, called Hydrologic Corridors, are being developed to optimize the land's water holding capacity, mitigate negative climate change impacts, and improve livelihood conditions. The projects combine 3R measures – such as micro-basins and controlled grazing – to re-green a landscape by preventing erosion and harvesting rainfall. The underlying idea of the Hydrologic Corridor is that when vegetation is restored in areas of over 10,000 ha, cooler air and more humidity as a result of evaporation can positively impact the mesoclimate. To maximize impact on a region's climate regulation, the geographical layout of project areas is crucial.

To guide the process properly, a Hydrologic Corridor potential map was elaborated for Africa based on soil and land use characteristics. The map identifies areas that are likely to yield the highest impact on the mesoclimate and to upscale the Hydrologic Corridor approach.

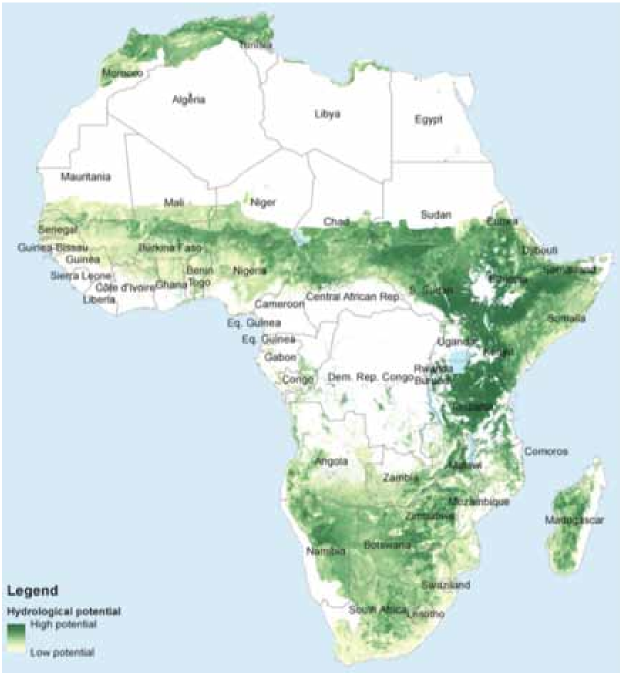

Figure 26. Hydrological corridor potential map of Africa (Source: Burger et al. 2016)

The availability of groundwater as well as more favourable microclimate conditions can be improved within a few years. However, impacts on mesoclimate and carbon sequestration are to be expected in the longer term. Therefore, even though the projects are based on the use of 3R measures that contribute to climate regulation, they need to be beneficial to rural communities in the short term. It is only then that scale can take place. Proposed measures contribute to an increase in crop production, recovery of springs and wells for water provision, and improvement of water quality in rivers.

CASE 2

Water harvesting and re-greening, Kenya

Like other parts of the world, large parts of Africa have gone through a centuries-long process of land degradation and drying of the land due to ongoing over-exploitation by pastoralist and farmer communities. The herds of Maasai pastoralists in Kenya have placed pressure on the land, which has resulted in a degrading of the soil-water-vegetation balance. More pressure on land translates into lower vegetation cover, higher runoff, soil erosion, and less capacity to retain water. As a result, the soil has lost its capacity to cool down through the evaporation of moisture. Soils hence suffer from greater temperature extremes. At the same time, runoff washes away the nutrients and seeds that are naturally present in the soil, limiting the vegetation's ability to regenerate.

To break this vicious circle, the local water balance is restored by promoting 3R measures such as the in-situ storage of rainwater, sustainable land use planning, grazing management, and tree husbandry. As a starting point, 72,000 low-cost micro-basins have been constructed in the Kuku area to improve the area's water holding capacity. It is expected that in 2 to 4 years, the vegetation cover will have been improved to the extent that groundwater recharge and controlled grazing can take place again.

Successful landscape husbandry starts with the creation of sustainable benefits for the community through the strengthening of the natural resource base and vegetation cover with the help of 3R measures. Microclimate management in Kuku is accompanied by the development of local fodder sources, as part of Olopololi plots. These are traditional Maasai grazing management practices that allow heavily degraded lands to recover from periods of intensive grazing and that can be used for dry season grazing and as a seed bank. This has brought multiple benefits, including an increase in income from the sale of grass as livestock fodder and seeds, in addition to improved groundwater recharge, soil moisture, and natural vegetation in the direct surroundings of the grass seed banks.

In many places, pastoralist systems have eroded due to years of under-investment and misdirected development. Therefore, the potential of pastoralist systems to generate additional income and regulate ecosystem services remains largely untapped. This project counters the old paradigm that frames pastoralist livelihoods as inefficient, unproductive, and backward looking. In fact, pastoralism plays a major role in safeguarding natural capital across one-quarter of the land globally.

Figure 27. Micro-basins in Kuku, a) during construction and b) after one year (Source: Justdiggit, 2017)

CASE 3

Managing the microclimate, Tigray

Ethiopia's Tigray region provides a compelling case of how improved 3R measures can bring (ground)water levels back up, thereby influencing the microclimate. With a rainfall of between 400 and 700 mm, the region has a semi-arid climate. Over the last couple of decades, a wide variety of soil and water conservation measures have been taken. These include physical measures, like terraces, bunds, and micro-basins; biological measures such as grass strips and reforestation; and water harvesting measures like check dams and spring development (Tuinhof et al., 2012). In the period of 2004 to 2009 alone, a total of 6 million soil and water conservation structures were built and 900 million seedlings were planted.

Currently, the land rehabilitation programme is greatly focused on maximizing the capture and infiltration of runoff as well as local planning, with a focus on cultivated and non-cultivated land (Tuinhof et al., 2012). Cultivated lands are mainly to be conserved by the farmers themselves, while non-cultivated parts are to be conserved through community mobilisation. Areas are systematically closed for animals for at least five years to allow for the regeneration of indigenous trees, shrubs, and grasses. Other elements include gully treatment and the planting of grasses and fruit trees on treated lands to strengthen livelihoods. Following these 3R measures in Tigray, some farmers and visitors observed:

- Enhanced water infiltration and increased moisture to the farmland
- Continuous base flows in streams and reduced erosion and downstream sedimentation
- Changing microclimates around treated watersheds and enclosed areas
- Increased crop yields (50 to 100 percent) as a result of improved moisture conditions
- Emergence of new springs in lower parts of the catchment and rising groundwater tables

"The rainfall amount has considerably decreased, but due to the conservation measures on our farm, soil moisture has increased in my land as well as production."

- Farmer in Tigray

Farmers in Tigray indicate that the production has increased, largely as a result of the soil being able to hold moisture for a longer period of time after the last rains have passed (Ismangil et al., 2016). This indicates that there is a business case for individual farmers and agri-business to integrate 3R measures and re-greening on their farms. The impact of 3R measures on water availability and the microclimate can normally be observed after two rainy seasons. The impact of re-greening on the microclimate increases gradually over the years until trees and their roots have reached full maturity. Once the rooting system of trees is deep enough to tap into more permanent groundwater layers, their cooling capacity through evaporation is stronger.

Figure 28. 3R measures in Tigray, Ethiopia during the a) dry and b) rainy season (Source: MetaMeta, 2016)

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9. HUMANITARIAN AID AND 3R

PEACE, JUSTICE AND STRONG INSTITUTIONS 16

Growing refugee crises put water around the camps in the spotlight

The United Nations High Commissioner for Refugees (UNHCR) reports that 65.6 million people were registered as displaced in 2016, amongst whom 10.3 were million newly displaced people. Many stayed in camps the size of a small city on marginal borderlands in places like Zaatari in Jordan (80,000), Rhino camp in Uganda (270,000), and Kukuma camp in Kenya (370,000). In addition, there are hundreds of smaller internally displaced person (IDP) or refugee camps in Sudan, Lebanon, and Turkey, and recently 77,000 refugees from Myanmar in Bangladesh.

Such refugee camps are usually set up to last a few years. However, as conflicts protract, the years become decades and settlements start sprawling around the original camp creating huge groundwater and surface water issues. Infrastructural facilities are overstretched and the natural resource base, including trees and water sources, is depleted. In these permanent refugee camps, water availability remains one of the main drivers of local unrest. Kebkabiya in Sudan's Darfur region used to be relatively green, but after 15 years of hosting large groups of displaced people, no standing tree is to be found in a circumference of 10 km from the camp. This leads to the situation that the camps' surroundings are bone-dry throughout the year and immediately flood when it starts raining. In many of the camps, water sources are depleting or polluted. Organisations are drilling more and deeper boreholes, and even trucking in water from other locations. People have to rely on limited boreholes on the unprotected surface waters nearby. When outbreaks of typhoid, cholera, and hepatitis A occur, these can be attributed to poor hygiene and a lack of safe drinking water.

3R measures have most relevance in places where the humanitarian situation will not be resolved in one or two years and where camps are likely to provoke considerable environmental degradation. Even in short-term settlements, planning with a 3R mind-set may help to address basic questions related to the water balance and how water can best be managed to prevent depletion. Short-term solutions for water extraction, like more boreholes and bringing in water with trucks, can meet immediate water demands, but do not alleviate environmental risks such as floods and groundwater depletion. In such situations, 3R measures need to be considered to ensure that underground reservoirs are recharged in time and so that they are available for a longer period of the year. In some cases, it is possible to take measures to divert surface water into the ground at strategic locations to locally increase water levels. The strengthening of water resources is the key to sustainability. An overreliance on a single source creates vulnerability and long queues.

After IDP camps have been abandoned, challenges remain. Returning refugees often move back to lands without functioning water facilities. Their orderly settlement requires

Figure 29. Refugees' daily struggle for water (Source: shutterstock.com)

3R solutions as well. More than in any other situation, water facilities need to be robust, secure, and designed with conflict prevention in mind. This means small-scale rather than larger infrastructure, and few management requirements, as particularly in post-conflict situations the construction of large infrastructure projects can reignite resource conflicts. Establishing water security through 3R measures like pumps connected to riverbeds, infiltration galleries, and small check dams can provide water to many people and decrease their continued dependency on aid. Furthermore, water reserves can jumpstart the local economy as more water is available for livestock and irrigation.

3R can reduce the costs of water supply in the medium-term

Budgets for refugees and IDPs continue to grow, with UNHCR spending US$ 7.7 billion in 2017 (UNHCR, 2018). UNHCR is the main actor in this space, supported by other humanitarian and refugee organisations. Despite enormous budgets, the movement of refugees has not decreased and resource shortages remain a serious problem. Looking at the costs of various measures, the benefits and losses of scenarios with and without 3R can be compared. In doing so, examples focus on the average costs of water infrastructure, the operational costs, and capital expenditure. These are ballpark figures and vary in different countries over time.

» Borehole scenario: the mechanised drilling of boreholes to a reasonable depth will be € 10,000 in capital expenditure. Annually recurring maintenance costs are € 1,500 where the drilling is successful. Depending on the water yield, around 2,000 people can use the hole in a crowded area or 1,000 people in a more dispersed setting.
» Water trucking: this is a costly endeavour. To supply 1,000 people with 20 litres means that 20,000 litres must be brought into the camp on a daily basis, which is the size of a medium water truck. Numbers from northern Uganda show that a 20,000-litre water truck costs € 90 per trip (driver, fuel, rent), meaning € 32,850 per year in trucking costs. The cost of water purification is € 0.01 per 20 litres, meaning an annual € 3,650 for 1,000 people.
» 3R scenario: The construction of ten gully plugs, check dams, or three sand dams that manage to retain water for six dispersed hand pumps can also meet the needs of 2,000 people. The capital invest-

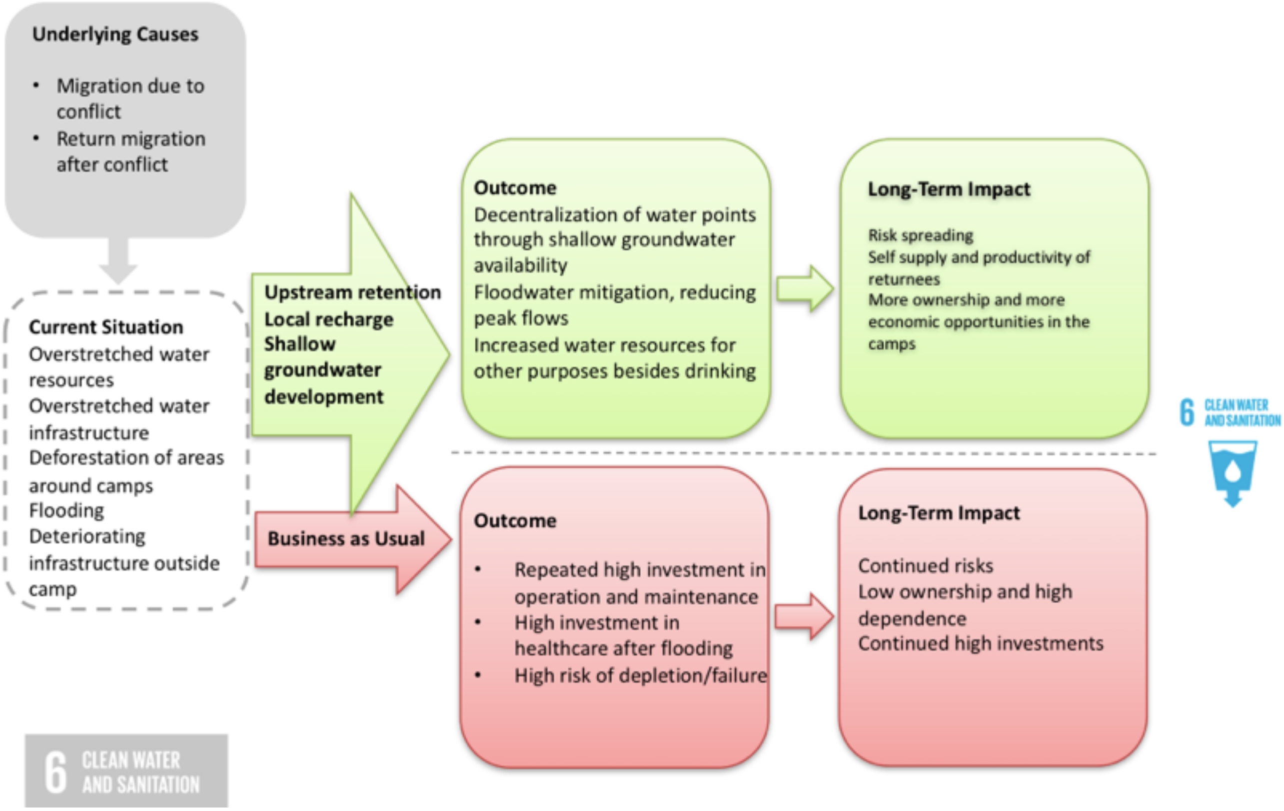

Figure 30. 3R versus business as usual scenarios

ment costs are higher, at about € 15,000, but the operational costs are € 500, a lot lower. Particularly when undertaken with community support, sand dams and other 3R structures have a much longer lifespan. Some of Kenya's first sand dams, built in the 1950s, are still in use. 3R measures are a relatively low-tech solution that allow people to participate in maintenance and to use water in an equitable way, rather than depending on a pump operator or a truck.

The urgency of action is clear. UNHCR reported in 2017 that access to water decreased in four locations where the rate of refugee inflow and insufficient funding inhibited the ability of the organisation and its partners to scale up water supply operations. All cases were related to the large-scale arrival of South Sudanese refugees in Ethiopia, Sudan, and Uganda. Although water trucks and boreholes might be needed in the short-term, 3R measures are best adopted rapidly to ensure cheaper water supplies after the rainy season. Investors and interested parties include UNHCR, other humanitarian organisations, and local governments. 3R saves money and lives in the long run and, most of all, it is a source of human dignity when people understand and manage their own resources.

Traditionally, humanitarian aid is very short-term oriented, focused on saving lives. However, to solve water challenges structurally, a medium-term horizon is needed. Sustainable water sourcing through 3R is crucial to prevent or mitigate water scarcity-induced conflict. This should be a central point of attention in post-conflict situations. Resettlement comes with many opportunities to improve water structures and farmland. When not planned with 3R measures, environmental degradation and social conflicts are usually the main challenge in resettlement areas.

CASE 1
The return to rural Darfur

After 15 years in IDP camps, the people of West Darfur have started to return to their former villages. Along the road from Geneina into the interior of West Darfur, donkeys carry poles and supplies used to settle in areas where small farming communities were once located. Some of the groups return to abandoned areas where bushes have come up, while others go on to live near the people with whom they were once in conflict. The situation is less volatile now, but sharing scarce water resources remains an issue.

The Sustain Darfur Partnership is developing strategies, sharing knowledge, and implementing measures to improve access to water in 13 catchment areas in South, North, and West Darfur. Among the strategies to improve the returnees' situation is the creation of awareness about the benefits of applying 3R measures, both in dry riverbeds and in fields.

It is clear that 3R measures like terracing and living fences reduce runoff and increase infiltration. They specify ownership and reduce livestock encroachment. Programmes are now being set up to make terracing conditional to qualify for water infrastructure like a shallow well. Subsurface or sand dams, check dams, and gully plugs further improve water availability and sometimes generate enough water to last throughout the year. Benefits include increased groundwater levels and a re-greening of the environment and small-scale irriga-

Figure 31. Returnees setting up a new village near Habila Kanare, West Darfur (Source: RAIN, 2018)

tion. Setting up small-scale water infrastructure close to returnee villages reduces the chance that people will need to rely on larger water schemes further away or return to the camps for water (as has happened in northern Uganda).

Darfur has 1.6 million registered IDPs living in camps (Reliefweb, 2016). In terms of unregistered IDPs living in rural settlements and urban areas, estimates vary considerably, especially as there is no systematic registration of displacement outside the camps. These people have started to return now or are already returning seasonally to plant and harvest. 3R, combined with robust water points, will encourage returnees to settle more permanently. The benefits of 3R start after year one but increase progressively as more people settle and more 3R is implemented at the village level.

Table 8. Business as usual versus 3R intervention

Business as usual		3R intervention	
Upfront costs: Boreholes for 2,000 people	€ 15,000	The same amount of money could provide two shallow wells and two small weirs but would serve only 500 people	€ 60
		Small community land and water management programme invested in village conditional incentives to increase terracing and agriculture	€ 20
Recurring costs: Food aid of € 0.55 per person per day. 2,000 people means 0.55x2000x365	€ 401,500	Self-supply (although often the situation in the returnee villages needs to be supplemented with relief food)	€ 0
Borehole operation	€ 1,500	Shallow well maintenance	€ 500
Externalities: Local markets flooded with cheap cereals from outside		Externalities: Local markets supported, internal economy strengthened, ownership strengthened	

CASE 2

Hospitality in times of climate change. Rhino camp, Uganda

In total, over 1 million refugees and asylum-seekers from South Sudan were located in Uganda in 2017 (UNHCR, 2018). The image of a refugee camp is one of tents and make-shift houses in cramped and fenced areas somewhere in the desert. Over the past decade, the government of Uganda debunked this image by opening large chunks of land for refugees to settle. Through the Refugee Law Project (2006) the government applies a self-reliance strategy. This means that refugees are expected to use agricultural land that is allotted to them to produce crops for their own consumption and for the market to obtain cash. For over 50 years, Rhino camp and other camps in northern Uganda have been hospi-

Figure 32. Infiltration pit filled with stones that allows floodwater to drain to more permeable layers (Source: RAIN)

table to refugees from neighbouring countries (Congo, Sudan, and South Sudan). The settlement was home to more than 120,000 refugees in January 2018.

Refugees who obtain land to farm for their own subsistence can potentially reduce costs of food aid. Unfortunately, insufficient rains have reduced their abilities to meet their own needs in the past. In addition, sprawling settlements have impeded the establishment centrally-managed water points, and the great depth of groundwater has also been challenging. This has resulted in a situation in which anything more than water for direct consumption and cooking is unavailable. Water shortages have created conflicts between settlers and the host community (Taban, 2014). Water shortages sometimes cause camp management to truck in water, and some people resort to polluted surface waters for bathing, leading to worm infections and other waterborne diseases.

A project was recently started to address water challenges through the establishment of three micro-catchment management committees and the piloting of five water user associations. These groups are a vehicle to implement 3R measures with the aim of increasing water availability at the local level. There is just one snag. Recharging shallow and deeper groundwater in highly populated areas needs to done carefully. Additional water purification may be required.

Establishing 3R measures at the micro-catchment level and working with water user associations has considerable advantages. They allow collectives of refugees to work together to manage the environment and increase water productivity. Through the user groups, boreholes and shallow groundwater pumps can be provided in exchange for unskilled labour to dig wells or trenches that improve water infiltration. 3R's success in this case will attract the attention of other countries. Benefits start after one rainy season but with progressive impact when more 3R is implemented.

Table 9. Business as usual versus 3R intervention

Business as usual		3R intervention	
Upfront costs: 1 borehole for 2000 people when functional, but in Rhino camp there are usually 2 others that do not work.	€ 45,000	Upfront costs: Recharging boreholes is possible; it requires a study on where water is coming from and how it can be recharged without getting polluted. Interventions can be 10.000 per borehole, and if it works, three boreholes have water instead of one.	€ 30,000
		Upfront costs: Small community land and water user program to support village conditional incentives to increase terracing and agriculture and enforce infiltration pits for 2000 users	€ 20,000
Annually recurring: borehole operation	€ 1,500	Annually recurring: Shallow well maintenance	€ 500
Annually recurring: trucking water for 2,000 people	€ 60,000	Annually recurring: Operation and Maintenance of the 3R infrastructure	€ 500
Externalities: No commitment of users required		Externalities: Commitment required, but people start to become owners of their resources and understand their environments.	

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Here are eight deals – where 3R can make a significant contribution – covering a large share of the SDG agenda:

» contribute to clean water and more secure WASH services through source improvement (SDG6);
» contribute to zero hunger and responsible food production through more reliable water supplies for farming (SDG 2 and SDG12);
» contribute to sustainable cities and communities by enhancing their water drainage and storage, and reducing flood risk (SDG11);
» contribute to resilient infrastructure by making roads instruments of water management (SDG 9);
» contribute to peace and justice by improving living conditions in settlements of displaced persons (SDG16);
» contribute to improved life on the land, in restored watersheds and in safer deltas (SDG15);
» contribute to climate action, by creating more favourable microclimates that buffer the adverse effects of global climate change (SDG13).

For this we call upon all investors – donors and grantors, charities, impact investors and private capital to combine efforts in a model of outcome payment.