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Making the Case:

# How Agrifood Firms are Building New Business Cases in the Water-Energy-Food Nexus

# About REEEP

REEEP is an international non-profit organization that advances markets for clean energy in developing countries. There, we build scale by connecting funding to projects, practice to knowledge and knowledge to policy.

REEEP uses donor funding to support a portfolio of high potential ventures that create energy access and combat climate change, often attracting private finance. REEEP monitors and evaluates projects within their policy, financial and commercial environments to gain insight into opportunities and barriers. REEEP feeds this knowledge back into the project, the portfolio and the policy framework to continuously advance markets for clean energy.

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Cover image: Terraced rice fields at dawn, Yuangyang, Yunnan Province, China

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## About this Study

This study was commissioned by the Food and Agriculture Organization of the United Nations (FAO) to complement its comprehensive work on a Water-Energy-Food Nexus Assessment approach and funded by the OPEC Fund for International Development (OFID). This study analyzes several existing business cases specifically addressing the nexus. In looking at commonalities and variances across large and small enterprise approaches, the report identifies several model pathways for nexus-related business cases, and showcases real life business examples.

The large enterprise business case analysis draws on research and interviews with representatives of Coca-Cola, ITC limited and SABMiller, among others. In looking at small and medium enterprise (SMEs) approaches, the study focuses on nine REEEP projects using clean energy in food production and water management. The SME cases range from solar-powered irrigation and decentralized power distribution to post-harvest processing and use of agriculture waste for energy generation in Asia, Africa, and Latin America.

The business case is primarily based on desk review and a number of interviews with representatives of both large and small enterprises in the agrifood sector. Due to the short timeframe for research, the information, data and statements provided by the different sources could not be validated in detail. Hence, it is not the intention of this paper to comprehensively evaluate case study results, activities and approaches of both large and small enterprises according to specific nexus related evaluation criteria.

# Executive summary

It has long been known that water, energy and food systems are inextricably interconnected. Water and energy are needed to produce food; water is needed for almost all forms of power generation; energy is required to treat and transport water. The relationships and trade-offs within this triangle of resources are known collectively as the water-energy-food nexus.

The agrifood sector is one of the most prominent single subsectors within the nexus, accounting for some 80% of total freshwater use, 30% of total energy demand, and 12-30% of man-made greenhouse gas emissions worldwide. With global food production expected to increase 70% by 2050, the agrifood sector

is facing unprecedented resource pressures, with more on the horizon.

Understanding water-energy-food inter-linkages and managing them holistically is critical to sustainability in the sector. But while some private enterprises in the agrifood sector understand the significance of the nexus – and some have already seen competitive advantages in nexus-driven solutions for sustainable crop management, processing, distribution and retailing – most do not.

A study of agrifood business cases incorporating nexus concepts reveals important lessons both for enterprise as well as for governments.

## Key Findings

### For Enterprise:

- **The nexus adds value:** Firms in the agrifood sector can mitigate risk, reduce costs and raise productivity through nexus thinking.

Ultimately, an enterprise's engagement in the water-energy-food nexus hinges on value. Both large and small enterprises can often reap significant value in the form of (particularly environmental) risk mitigation, reduced costs and increased productivity. But large and small enterprises vary considerably in their ability and readiness to act on positive value propositions.

- **Discovering nexus value:** Firms must be able to assess risks, quantify returns and monitor progress. This requires upfront investment and long-term thinking, often leaving small and medium-sized enterprises on the sidelines.

Understanding nexus value hinges on how well a company can analyze problems amid increasingly complex market conditions, identify measures to address them, and implement timely action. While managers in large companies often enjoy freedom to engage in long-term strategic thinking, as well as the financial and technical capacity to invest in assessments and planning, small and medium enterprises are often focused on managing immediate and short-term issues.

At the same time, nexus value is often difficult to quantify in terms of economic returns on investment (ROI), the primary driver of private sector activity. Such returns are often held in long-term and/or life cycle cost reductions, necessitating protracted investment timeframes aggregation across supply chains. Much nexus value comes in the form of positive externalities for the environment and society at large, and does not yield financial returns.

- **Trust and partnerships are key:** Large enterprises can generate nexus value across supply chains and SMEs can reduce up-front risks and costs through mutually beneficial business partnerships and trusted, verified technologies and services.

Large enterprises can develop strategic long-term partnerships and multi-stakeholder forums to leverage capacity, resources and tailored solutions. Because so much sustainable value is found within precompetitive arenas, joint work on creating standards, processes and protocols of measurement and reporting are critical.

Vertically-integrated enterprises with close connections to sourcing areas may also be able to generate nexus value unilaterally, while those downstream may need to rely upon upstream actors to take the lead, or focus on collaborative strategies and networks with other businesses and NGOs.

Risk-averse SME's will be more able to implement nexus solutions when those make use of reliable technologies and are offered by trusted service providers. In some instances, collaborations between multiple small enterprises may lower risk perception by joint investments into technologies and services.

## For Governments:

- Private enterprise cannot be expected to finance public benefits alone – governments must take steps to promote and “monetize” nexus returns.

Large enterprises are making strides in quantifying benefits and incorporating into accounting and strategic decision-making. For instance, greater environmental stewardship from nexus strategies can translate into improved reputation or better water quality into lower water treatment costs over the long term.

But large and small companies alike generate significant co-benefits for communities by engaging in sustainable nexus practices, such as improved air and water quality, public health, and food security. To ensure that businesses have incentives to invest in sustainability, governments must create incentive schemes and price instruments that account for positive environmental and social externalities.

- Firms, especially SMEs, must have access to finance in order to make long-term investments in sustainability.

Limited access to finance is often a key barrier for both large and small enterprises. Banks often refuse lending for unconventional technologies or business models, particularly ones with long-term return periods. Large enterprises with cash on hand, multinational parent companies, or low-risk status with financial institutions are at an advantage, while small and medium enterprises are often constrained by limited access to finance. SMEs tend to be risk-averse, with financial assessments focused on loan conditions and payback periods rather than investment returns. Governments should promote lending through specific targeted financial instruments and incentives.

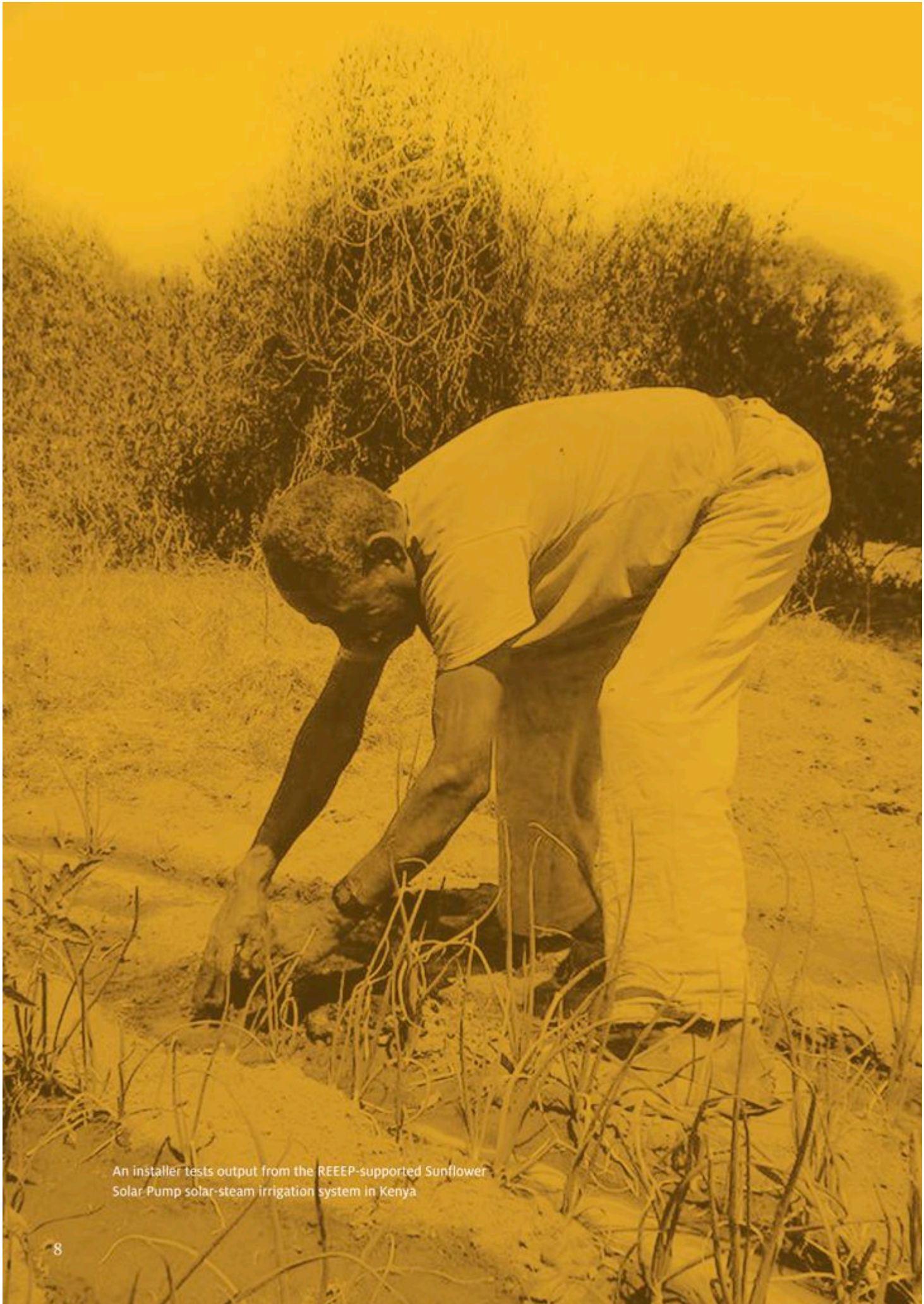
- The nexus is little-known among SMEs – governments must do more to promote awareness among small and medium enterprises.

Large companies are largely aware of the significance of the nexus for their business, even if they do not use this precise language, and the concept of sustainability has shifted from a peripheral PR concern to a core element of corporate strategy. SMEs are usually not familiar with nexus terminology, but are generally aware of climate change and potential impacts on their business. But lack of access to finance and information are holding many back from action. While technological developments are progressing at lightning speeds, SMEs are at risk of being left farther behind large enterprises with greater access to both finance and information.

- Better policy making on food-water-energy issues demands cohesion among government agencies and inclusion of SMEs in consultation processes:

Large companies use market power to engage with governments and influence policy development. Even so, they must often navigate a confusing policy landscape. Most countries do not have cohesive food-water-energy strategies; rather, interconnected issues are handled by multiple agencies with unclear lines of responsibility and decision making processes, each working on the basis of proprietary data. SMEs in most cases lack strong representation among decision makers. Governments can do more to ensure that policy frameworks and incentive schemes, government-funded research and development, and national standards for services and technologies are tailored toward SMEs.






An installer tests output from the REEEP-supported Sunflower Solar Pump solar-steam irrigation system in Kenya

# Table of contents

Acknowledgements	3
Executive summary	5
Table of contents	9
<b>The water-energy-food nexus</b>	<b>11</b>
Interactions between water, energy and food systems	12
Climate change and the nexus	13
The water-energy-food nexus in action: Global illustrations	14
The water-energy-food nexus and the agrifood sector	16
Defining a water-energy-food nexus approach	20
Holistic conceptual nexus approaches	20
Business-driven nexus approaches	21
<b>Business cases in the water-energy-food nexus</b>	<b>23</b>
Large enterprises	24
Case study: SABMiller plc	24
SABMiller Example Bogotá, Colombia	27
SABMiller Example South Africa, George	28
(Micro), small and medium enterprises	31
Case study: Solar-steam irrigation pumps in Kenya and Ethiopia	32
Case study: Energy Efficiency and Biogas Production in the tofu and tempeh SMEs in Indonesia	38
<b>Nexus business cases: Potential pathways for the agrifood sector</b>	<b>45</b>
Commonalities and differences among large and small agrifood enterprises	46
Large enterprise pathway for a business case inside the nexus	48
Small and medium enterprise pathway inside the nexus	49
<b>The role of governments</b>	<b>51</b>
Ensuring predictable, stable and inclusive government policies	52
Removing barriers to investment	53
Creating enabling conditions for business	54
Imperatives for concerted action government, business and civil society working together	54





As part of a REEEP-supported program by RONGEAD, entrepreneurs in the Lake Victoria region of Tanzania receive training on how to use compact biogas systems, helping to relieve strain on over-used water resources.

# The water-energy-food nexus

It has long been known that water, energy and food systems are inextricably interconnected. Water and energy are needed to produce food; water is needed for almost all forms of power generation; and energy is required to treat and transport water. The relationships and tradeoffs within this triangle of resources are known collectively as the water-energy-food nexus.

Despite broad consensus on basic human rights to security of water, energy and food in a world of 7 billion people there is considerable overlap between the 1.1 billion poor people lacking adequate access to water, the 1 billion who are undernourished, and the 1.3 billion who are without access to electricity.

And the world is not standing still: By 2030, the global population will have grown to over 8 billion people, and with current trends in urbanization and

economic growth each one will have on average a greater impact on their environment, and in particular greater demand for water, energy and food. One of the greatest challenges of the coming decades will be meeting that demand amid increasingly depleted resources. The United Nations estimates that by 2030 we will need 30 percent more water, 45 percent more energy and 50 percent more food<sup>1</sup> –climate change will exacerbate the stress on resources even further.

Current policies and business models often treat water, energy and food security separately. They are not separate, but rather inextricably interdependent. Any effort to address sustainability in one of these sectors must begin with the understanding of this interdependence, and seek holistic solutions to address the water-energy-food nexus.

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<sup>1</sup> United Nations Secretary-General's High-level Panel on Global Sustainability (2012): Resilient People, Resilient Planet: A future worth choosing. New York: United Nations.



## Interactions between water, energy and food systems<sup>2</sup>

The water-energy-food nexus describes the interdependent relations between water, energy and food systems. At first glance, it may appear that not all pieces of the nexus are equal. Water security, for instance, is often stressed - as we cannot create or grow more water, nor is water substitutable<sup>3</sup>. However, an overemphasis on water risks sidelining the other elements of the nexus, thereby contradicting the idea of cross-sectoral perspectives and response options that holistically integrate all three dimensions – water, energy and food.

### Water and Food:

The amounts of water required for food and animal feed production and processing are immense. At the global level irrigating crops account for 80–90% of consumptive use of blue water - freshwater in rivers and lakes - plus a large fraction of green water – rainwater stored in soil<sup>4</sup>. Accordingly, food production is a main driver of resource over-exploitation. Water productivity in kcal per m<sup>3</sup> varies widely among crops, cropping systems, agricultural management methods and climates. But as rule of thumb, it takes on average about one liter of water to produce one calorie of food energy<sup>5</sup>.

Irrigation competes with other water uses, such as municipal drinking water, power plant cooling, and fossil fuel production. When parts of a country face drought, water sources can become strained, creating problems not only for farmers, but also for the drinking water supply and power plant operators.

Reverse links from food production to water include land degradation, and changes in drainage and run-off, impacts on groundwater recharge, water quality and ecosystem services, such as carbon sequestration. Land degradation and erosion not only reduce soil water storage capacity, but often also cause siltation in downstream reservoirs, which can reduce water availability and energy production from hydropower. Reversal of such land degradation is generally very energy and water-intensive.

### Water and Energy:

Energy is required for lifting, moving, distributing, and treating water. Irrigation is generally more energy-intensive than rain-fed agricultural techniques and drip irrigation. Groundwater – which provides close to half of total consumptive irrigation water use – is generally more energy-intensive than surface water; in some countries up to 40% of total energy use goes toward pumping groundwater<sup>6</sup>.

Large amounts of water are required for conventional power production, primarily for cooling. Non-conventional water sources, such as reclaimed wastewater or desalinated seawater, are often highly energy-intensive. Energy intensities per m<sup>3</sup> of clean water produced vary by a factor of 10 between different sources (e.g. about 0.4 kWh from locally produced surface water up to more than 4 kWh from desalinated seawater)<sup>7</sup>. Also water imports to cities become more energy intensive as the distance from the source grows.

### Food and Energy:

Food production and energy have always been connected; modern technology, mechanization and industrialization have helped to increase yields and to make agricultural labor more bearable. In response, however, energy inputs have increased significantly, in particular for land preparation, fertilizer production, irrigation, the sowing, harvesting and transportation of crops - the full food production and supply chain is

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<sup>2</sup> Adjusted after Hoff, H. (2011): Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm.

<sup>3</sup> SABMiller (2014): The water-food-energy nexus; animation film, available on <http://www.sabmiller.com/index.asp?pageid=2338>, accessed 19.5.2014

<sup>4</sup> FAO (2009): Growing more food, using less water, [http://www.fao.org/fileadmin/user\\_upload/newsroom/docs/water\\_facts.pdf](http://www.fao.org/fileadmin/user_upload/newsroom/docs/water_facts.pdf), accessed 8.5.2014

<sup>5</sup> FAO (2009): Growing more food, using less water, [http://www.fao.org/fileadmin/user\\_upload/newsroom/docs/water\\_facts.pdf](http://www.fao.org/fileadmin/user_upload/newsroom/docs/water_facts.pdf), accessed 8 May 2014

<sup>6</sup> World Economic Forum Water Initiative (2011): Water Security: The Water-Food-Energy-Climate Nexus, Island Press

<sup>7</sup> Hoff, H. (2011): Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm.

responsible for around 30% of total global energy demand<sup>8</sup>. While energy productivity varies widely between food products, food production systems and regions, the strong energy dependence of agriculture is reflected in the close correlation between crop and oil prices.

The energy sector itself can also negatively impact food production (and other vital ecosystem services) by reducing available land through mining for fossil fuels or deforestation for biofuels. Biofuel development has also been identified as a direct contributor to higher cereal prices on world markets<sup>9</sup> and increased demand for water. While it is difficult to disentangle the various contributing factors, it is assumed that first-generation biofuels – along the entire production cycle from growing irrigated crops on a farm to pumping biofuels into the car – can consume up to 20 times more water per mile covered<sup>10</sup> than gasoline and have accounted for about a third of the recent increases in agricultural commodity prices<sup>11</sup>.

## Climate change and the nexus

### Drivers of climate change:

Energy and food production and provisioning are major drivers of climate change. Electricity and heat production alone contribute 27% of global greenhouse gas emissions. Agricultural energy use, methane emissions (from livestock and rice cultivation), and nitrous oxide emissions (from fertilized soils) account for 15% of global emissions. Land use changes for energy and food contribute a further 14%<sup>12</sup>.

### Climate change impacts:

Climate change is likely to aggravate pressure on resources and so add to the vulnerability of people and ecosystems, particularly in water scarce and marginal regions. Agriculture is among the most climate-vulnerable sectors, subject to impacts such as further drying of already water-scarce regions, loss of glacier water storage, effects of extreme weather events, and region-specific changes in crop productivity. The repeated food crises in the Horn of Africa illustrate the vulnerability of food production to drought.

Power production can also be severely impacted by climate change. Low surface water levels can leave power plants without access to cooling water, forcing them to shut down, or droughts can starve the hydropower production sources. Other ecosystem services are also threatened by more intense droughts, as illustrated by reductions in carbon storage associated with recent droughts in Amazonia.

Climate policies themselves may also feedback on water, energy and food security. Climate change mitigation measures must be “water smart”, and take land requirements into account. Adaptation measures (e.g. irrigation in response to drought) must also be “energy smart” to avoid maladaptation and negative externalities such as ground water depletion and damaging consequences for vital ecosystem services. Climate change mitigation via carbon sequestration, expansion of biofuels, or hydropower can create significant new water demands. For example, forests – such as those used for biofuel production or carbon sequestration – can consume more water than most other indigenous vegetation.

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<sup>8</sup> Hoff, H. (2011): Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm.

<sup>9</sup> Rosegrant M.W. (2008): Biofuels and Grain Prices: Impacts and Policy Responses. Testimony for the U.S. Senate Committee on Homeland Security and Governmental Affairs.

<sup>10</sup> Webber M.E. (2008): “Energy versus Water: Solving Both Crises Together,” Scientific American, Scientific America, October 2008.

<sup>11</sup> Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm.

<sup>12</sup> World Resources Institute, UNDP, and World Bank: World Resources (2005): The Wealth of the Poor – Managing Ecosystems to Fight Poverty, Washington, DC



## The water-energy-food nexus in action: Global illustrations

Failure to recognize water, energy and food as an interlinked nexus can lead to flawed decision making in policy, business and consumer behavior. The specific implications of neglecting the nexus play out very differently in different economic, policy and development contexts. The availability of resources within the water-energy-food nexus is determined by the climatic and physical conditions in a country as well as the country's ability to make use of its natural resource base, its development status and whether "resilience thinking" informs development planning<sup>13</sup>.

At the same time water, energy and food security have become global issues, no longer contained within national or river-basin boundaries. As the human population grows, economies develop and globalization accelerates, the countries and regions are becoming more and more interdependent. This can lead in one of two directions: to more resource competition and potential conflict, or to increased collaboration and co-management.

Developing economies with low levels of industrial and infrastructure development often focus primarily on resource exploitation (extraction and agricultural production), improving livelihoods, ensuring food security and developing commodity driven exports. This requires prioritization of investment to overcome the infrastructural and other constraints on the use of water-energy-food resources. The following examples highlight the importance of water management regionally, and the negative impacts upstream resource management decisions can have on downstream food security and economies:

**Chad**<sup>14</sup> has substantial oil reserves in the Doba Basin in the southern part of the country, and is at the same time an exceedingly water-scarce nation, with low average annual rainfall. Lake Chad is the only permanent freshwater source in the country but has diminished more than 90% over the past 30 years. This phenomenon has been driven mainly by increased demands on the water that feeds the lake, largely by upstream countries. High water stress has translated into severe food insecurity and poor agricultural production potential. Almost a third of Chad's population is considered to be at risk of food insecurity and a mere 0.03% of the country's land area is permanent cropland. Constraints on transporting its oil to shipping have curtailed Chad's ability to earn foreign exchange and import food.

**Vietnam**<sup>15</sup> is a country rich in water resources; it is one of the world's highest-rainfall countries with favorable conditions for agricultural production in most areas. The government of Vietnam has prioritized agricultural production to achieve food self-sufficiency. For instance, the government has made significant investments in irrigation infrastructure to lengthen growing seasons. Currently, approximately 42% of all agricultural land is irrigated, with the majority of irrigation water (as well as fish protein) coming from the Mekong River. However, increased pressure – primarily through dam building for energy generation – on the Mekong River Basin by upstream countries is likely to have profound impacts on both water flow and fish productivity for Vietnam. Under these circumstances, maintaining food self-sufficiency may become more challenging in the future.

Emerging economies grow rapidly by shifting toward secondary manufacturing, leading to improved human development indices, increased urbanization and development of economic and social infrastructure, often with considerable remaining rural poverty. The development focus is usually on ensuring sustained investment, diversification and bringing value-add to economic activity and trade, while addressing livelihoods in rural and peri-urban areas. Water and air quality may be rising up the political agenda. Environmental challenges are also coming into focus, partly because of growing middle-class expectations of environmental quality, and partly

<sup>13</sup> WWF & SABMiller (2014): The water-food-energy nexus – Insights into resilient development.

<sup>14</sup> WWF & SABMiller (2014): The water-food-energy nexus – Insights into resilient development.

<sup>15</sup> WWF & SABMiller (2014): The water-food-energy nexus – Insights into resilient development.

because of trade-offs made during earlier infrastructure development. Two examples illustrate the importance of coherent energy, agriculture, water and social policies:

**India** relies heavily on groundwater for agriculture due to short monsoon seasons and variable river discharge<sup>16</sup>, and irrigation is crucial. Farmers often over-irrigate – leaving pumps on all the time – due to unreliable electricity supply, leading to aquifers degradation. Irrigation pumping is energy-intensive, making up ¼ of India's total electricity consumption, helped by low (or free) tariffs. In response to acute crises in 2003, the Gujarat State government introduced strategies to support massive rainwater harvesting, micro-irrigation and groundwater-recharge schemes. An example is the innovative "Jyotigram" (lighted village) scheme to redistribute and "intelligently" ration electricity, covering nearly all of Gujarat's villages<sup>17</sup>, a key element of which is a strict schedule for full-voltage irrigation pumping. This has benefited utilities by reducing loss, thefts and agricultural consumption, and improved peak load management and revenues. Still, financial gains alone were not enough to cover up-front investments<sup>18</sup>. The state has benefited from reduced subsidies, and groundwater levels are recovering. Livelihood gaps between rural villages and cities have narrowed and reliable power supply for agricultural processing enterprises helped to create new jobs. But effects on small rural farmers remain unclear. While farmers appreciate improvements; they are concerned about rationing. Farmers in water-abundant areas, who once operated pumps to sell water to other small farmers, have lost income. As groundwater markets have shrunk, water buyers are facing 40%-60% increases in water prices, pushing many small farmers out of irrigation practices, and creating adverse effects on agricultural yields, income and livelihoods<sup>19</sup>.

**South Africa's** developmental challenges posed by the Water Energy Food Nexus are already evident<sup>20</sup>. The country has substantial coal reserves but is significantly constrained by water and agricultural land availability. Coal accounts for 86% of electricity generation, which contributes to water pollution and climate change and has thus negative impacts on crop production. South Africa's coal deposits coincide with the country's best agricultural land and major river-systems, which adds spatial complexity to the task of effective management of water, energy and food resources. 98% of South Africa's current total water supply is already allocated and the Department of Water already estimates a 1,7% shortfall in the water supply as early as 2015, while at the same time the National Development Plan (Vision for 2030) proposes an increase of more than 50% of land to be irrigated. Water scarcity has implications for both energy generation and agricultural production. Increasing energy demand for accessing new water resources, pumping and desalination reinforces water demand for water-intensive coal-based electricity under the current scenario – demonstrating the strong need and opportunity for efficient clean energy solutions. Important political issues are emerging around the constraints and opportunities for rural black farmers. New rural jobs have to be created in a currently stagnant agricultural economy without overextending scarce water and energy resources. 50% of South Africa's population doesn't have enough food and with the prospect of a rising population increasing food imports will make the country more vulnerable to volatile commodity prices on global markets.

Developed economies have shifted to a consumption-based, service-dominated economy supported by trade and specialization in manufacturing and commodities, and have high rates of urbanization. The focus in developed economies is on promoting growth through trade, sometimes seeking improved environmental quality, while maintaining employment, welfare and aging infrastructure. Putting in place effective regulatory and economic instruments to achieve this is often a major challenge, along with the maintenance and adaptation of aging infrastructure and human resources to meet changing global conditions.

The transition to services and trade-based economies implies a degree of uncoupling of the economy from domestic resource constraints. National energy and food security are interwoven with trade and foreign policy, with increasing awareness of the risks associated with sourcing resources from other countries and the volatility of global markets. Given the global power of these economies, shifting energy policy decisions, such as increasing self-sufficiency and growing renewables, could have profound impacts on global energy and

<sup>16</sup> Hoff, H. (2011). Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm.

<sup>17</sup> Bonn2011 Conference The Water, Energy and Food Nexus (2011): "The Water, Energy and Food Security Nexus – Solutions for the Green Economy", Conference Synopsis (February 2012).

<sup>18</sup> World Bank (2013): Lighting rural India: Experience of rural load segregation schemes in states. Washington, D.C.: World Bank.

<sup>19</sup> Swain, A. K. & Charnoz, O. (2012): In pursuit of energy efficiency in India's agriculture: Fighting 'free power' or working with it? AFD Working Paper 126. Paris: Agence Française de Développement.

<sup>20</sup> Von Bormann, T. and Gulati, M. (2014): The Food Energy Water Nexus: Understanding South Africa's most urgent sustainability challenge. WWF-SA, South Africa.



agricultural markets. In the United States and Australia, policy makers have struggled to develop nexus-based policy frameworks that maintain economic and national resource resilience while avoiding perverse incentives:

**California** in the United States – with a variety of climates, geographies, and population centers – is a major producer of food, which is exported for consumption elsewhere. In the early Twentieth Century, water and energy were primary ingredients for jumpstarting the state's economy, especially in the southern regions. However, vast amounts of water (and energy) are required to accommodate these demands – arguably more than California can sustainably support. Some of the state's largest population centers are on the arid, southern coast, which requires water to be brought from wetter, northern parts of the state, as well as from the Colorado River. Moving and treating this water takes almost 20% of the state's total electricity usage<sup>21</sup>. In addition, California has competing interests its water resources: As a major agricultural producer, farms need water for irrigation, while continually growing metropolitan areas need drinking water. The water and energy inter-linkages in California are pronounced; coherent management of these will become increasingly important in the future as climate change exacerbates existing problems. The government of California has established regulatory mechanisms and economic incentives to alleviate some of these constraints, but whether these will be sufficient to maintain economic and natural resource resilience in the future is unclear.

**Vietnam** is an example where national climate legislation, specifically the Carbon Credits Act, did not rigorously regulate water impacts, leading to perverse outcomes. While tree planting in Australia is regarded as unequivocally good (in particular, well-planned restoration of indigenous tree cover can contribute to biodiversity conservation, salinity control and even increase crop and livestock yields) there are also possible negative externalities. Besides taking up prime agricultural land and diminishing biodiversity, some carbon farming practices may also increase evapotranspiration, which, together with over-abstraction (e.g. for irrigation), can exacerbate water scarcity. For specific catchment areas it has been calculated that replanting 10% of the watershed with trees could reduce river flows by 17%, which would lead to further contraction of major wetland ecosystems. This could have knock-on effects for carbon storage if wetlands dry out. Given today's enormous demands for water, a restoration of natural vegetation and the associated 'natural' hydrology is no longer an option. A wise approach would need to explicitly address and manage the costs, benefits and trade-offs between the goals of carbon sequestration and increased water availability.

## The water-energy-food nexus and the agrifood sector

One of the most important single subsectors within the water-energy-food nexus is the agrifood sector. Indeed, in combining water and energy to create food, the sector is itself an embodiment of the nexus. Key characteristics of the agrifood sector in the context of the water-energy-food nexus can be described as follows :

**Growing demand:** The global beverage and food industries are rapidly growing sectors. The beverages industry, for example, grew by 15% in 2010 alone. Total global food production is expected to increase by 70% by 2050 (and nearly 100% in developing countries)<sup>23</sup>.

Despite this growth, producers face unprecedented pressures, such as scarcities of critical resources – especially water – climate change, and associated potential supply disruptions from extreme weather conditions.

**Increased water scarcity:** Given that the world will face a gap in fresh water demand of 40% in 2030<sup>24</sup>, water scarcity is the single most critical resource risk for the beverage sector. Beverage producers depend on ready access to fresh, potable water as a key ingredient and for irrigation, processing and packaging. Large water demand is putting the sectors at risk of conflicts with other stakeholders. Until recently the beverage sector has had relatively easy access to water in developing economies. But the industry's primary growth targets – Asia, Africa and Latin America – include some of the most water-endangered regions on Earth.

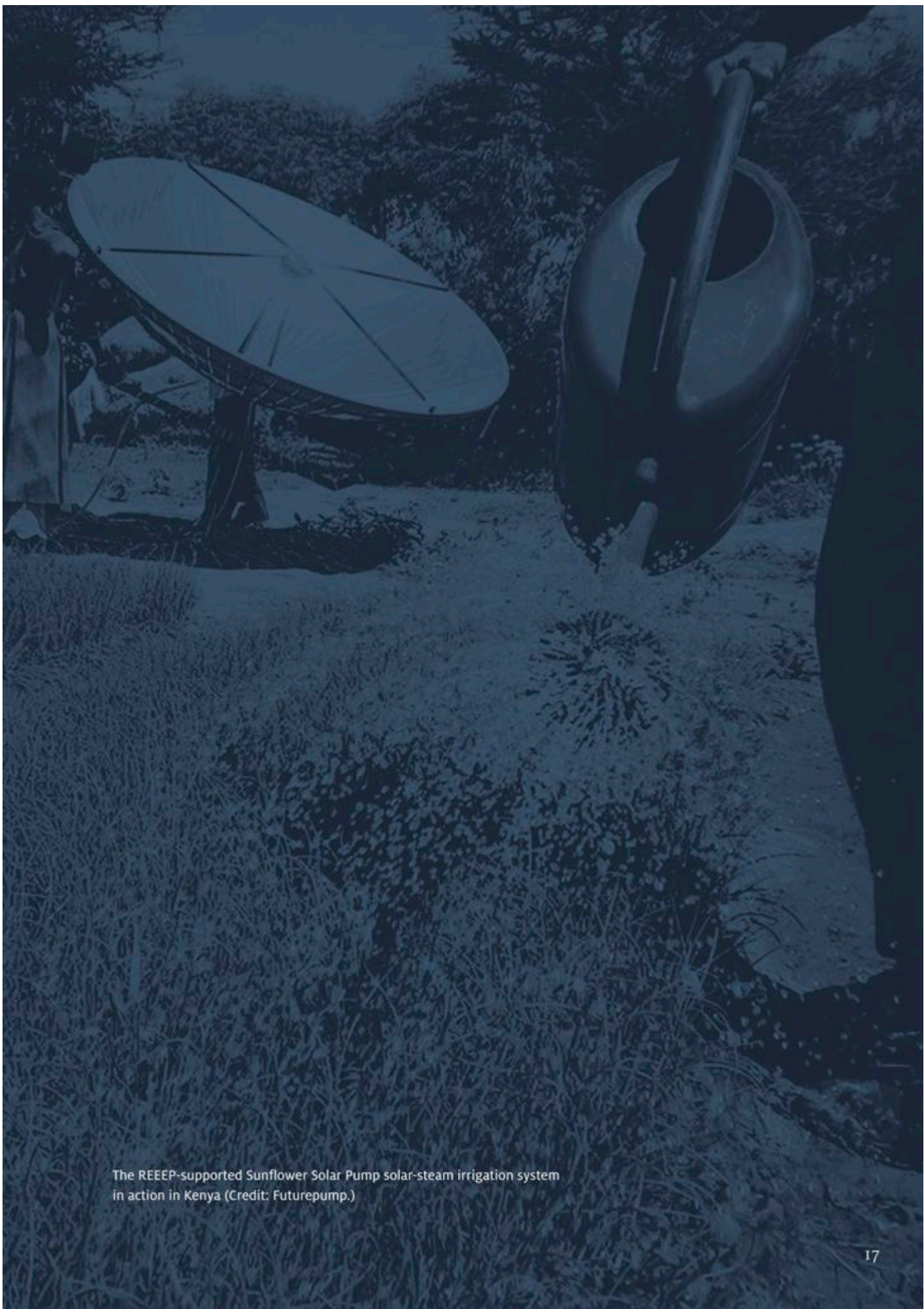
<sup>21</sup> Klein, G. (2005). California's Water – Energy Relationship. California Energy Commission.

<sup>22</sup> Adapted after KPMG International (2012): Expect the Unexpected: Building business value in a changing world.

<sup>23</sup> KPMG International (2012): Expect the Unexpected: Building business value in a changing world.

<sup>24</sup> KPMG International (2012): Expect the Unexpected: Building business value in a changing world.





The REEEP-supported Sunflower Solar Pump solar-steam irrigation system in action in Kenya (Credit: Futurepump.)



Additional water requirements for agricultural production to meet future demand are estimated, under different climate change scenarios, at some 40–100 % of total extra water requirements in the absence of global warming<sup>25</sup>. Water demand increases not only due to population growth, but also due to the rise of the middle class in developing countries, which leads to changes in food consumption patterns, as people eat less staple carbohydrates and demand more luxury food products such as milk, meat, fruit and vegetables. These changes will increase demand for water, as these products require more water in the production process.

**Water pollution:** Water quality is critical to avoiding contamination issues. Increased scarcity of high quality water supplies will increase the costs of avoiding contamination. Food producers directly affect the quality of freshwater in the regions in which they operate. Nitrogen and phosphorus fertilizers leach into waterways, causing “dead zones” – low-oxygen areas incapable of supporting aquatic life.

**Scarcity of raw materials and dependency on fossil fuels:** The supply of raw materials (e.g. sugar, barley, corn and hops) to the beverage sector is likely to be affected. Sugar production is especially susceptible to drought and water scarcity. Raw materials like these are the largest cost category for beverage companies, accounting for more than 50% of revenue for soft drink and water producers and around 35% of revenue for beer producers. Price volatility and shortages expose firms to physical, reputational and regulatory risks as communities realign priorities for survival. Multinational food companies are already facing price pressures and volatilities that were unimaginable years ago, and that are expected to intensify in the coming years.

Modern agrifood value chains significantly depend on fossil fuels – as they are the main energy used for manufacturing chemical inputs such as fertilizers, for input and product transportation as well as for processing. Agrifood value chains are therefore exposed to fuel price volatility risks.

**Increased climate change impacts on agriculture:** Higher temperatures and increased numbers of extreme weather events threaten to impact ecosystem health and land productivity across the globe, and may alter growing conditions in key agricultural regions. Food producers are dramatically impacted by the effects of climate change, such as reduced yields in warmer regions due to heat stress, extreme weather events leading to damage of crops, droughts affecting land degradation and soil erosion, and higher sea levels leading to salinization of irrigation water.

Coffee and tea producers in particular are already witnessing changes – in addition to increased erosion and infestation by pests, shifts in rainfall and harvest patterns are impacting food security of farmers’ communities and shrinking the usable land for coffee production.

**Agrifood product environmental footprints:** The agriculture and food sector at a global level has a massive carbon footprint, generating up to 30% of all man-made greenhouse gas emissions<sup>26</sup> (including direct agricultural emissions, emissions due to the production of agricultural inputs as well as land use change caused by some agricultural practices).

At a deeper level, the environmental footprints of agricultural products – and the inter-linkages of the water-energy-food nexus – can best be illustrated by looking at specific examples. For instance, a simple slice of pizza, made using dough, tomato sauce and cheese, can tell a long story about the energy and water consumption along its production and processing chains. Water is directly added to the flour and yeast to make

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<sup>25</sup> FAO (2008): Climate change, water and food security.

<sup>26</sup> El-Hage Scialabba, N.; FAO (2010): Organic agriculture and climate change, *Renewable Agriculture and Food Systems*: 25(2); 158–169

the dough in the final stage before cooking, but that is not all: "hidden water" was used in growing the wheat that was milled into flour for the dough. The global average water footprint of one Pizza Margherita (725 gram, topped with tomato, mozzarella and basil) is 1,260 liters of water. Mozzarella represents about 50% of the total water use, wheat flour 44%, and tomato puree about 6%<sup>27</sup>. Looking at the energy going into the pizza slice we see the direct energy that goes into warming the pie, but we do not see the "hidden energy" that goes into the farming of crops (tractors and fossil fuels required to produce fertilizers and pesticides), processing and distributing the ingredients and even the energy that was required to manufacture the pizza oven.

**Wasteful production:** Roughly one-third of food produced for human consumption is lost or wasted. In more developed countries food is mostly wasted in consumption stages, while in lower-income countries food is lost in mainly the early and middle stages of the food supply chain. Global food waste represents 1.5% of total energy demand and 20%–30% of total land and water demand<sup>28</sup>. Beverage containers are an important sub-set of all packaging waste and include mainly glass, plastics, aluminum and liquid paper board.

**Reputational and regulatory risks:** Regulatory and reputational risks are high for the beverage, food and agriculture sector as a whole. The sector is a high emitter of CO<sub>2</sub>, and as such will be disproportionately affected by expected government regulations on climate change and sustainability challenges. There is likely to be increasing political pressure over the next 20 years for the pricing of resources, products and services to reflect the full cost of their production – including the cost of environmental impacts. Possible scenarios include removals of fossil fuel and water subsidies and the expansion of carbon pricing systems. Governments are already taking decisions and setting priorities on water access, a trend that is likely to become the norm as water becomes scarcer. For example, a major soft drink bottling plant in India recently lost its social license to operate amid accusations that it was depleting the water table<sup>29</sup>.

**Opportunities and synergies:** The increasing demand flows between resources (e.g. water for energy, energy for water, etc.) also points to the opportunities and synergies for increasing total resource use efficiency, and possibly also substitutions between resources.

At the upstream end of the food production chain, irrigation plays a central role in the nexus. Introducing irrigation increases land productivity, but generally also increases energy intensity compared to rainfed agriculture. Solar pumping solutions can reduce carbon footprints of irrigation systems; precision irrigation generally improves energy productivity but may not save much water. There is large potential for sustainable and inclusive or pro-poor intensification in rainfed agriculture, which can reduce the demand for irrigation and associated blue water and energy inputs.

Further downstream in the food production chain, there are ample opportunities for reducing wastage, introducing renewable energy technologies and increasing efficiency through improvements in processing, distribution and retailing.

Changes in lifestyles and consumption patterns can also reduce pressure on water, energy and land, and enable more equitable benefit sharing.

The role of governments in addressing sustainability in the food sector will become more important as food insecurity increases and impacts of climate change become more apparent. Policymakers will focus on farmers,

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<sup>27</sup> Water Footprint Network (2014): Water Footprint Product Gallery: Pizza Margherita; Retrieved from <http://www.waterfootprint.org/?page=files/productgallery>

<sup>28</sup> Briefing paper submitted by McKinsey and Co., the OECD and the World Economic Forum for "Managing the Nexus for Green Growth", Hot Topic 12, Bonn2011 Nexus Conference, 16-18 November 2011.

<sup>29</sup> J. Singh, India Coca-Cola compensation law is passed in Kerala, BBC, 24 February 2011.



food processors and on consumers: the competitive opportunity for food companies lies in preparing for, and actively supporting, the process of finding these solutions.

## Defining a water-energy-food nexus approach

There are several concepts of the water-energy-food nexus that vary in objectives, scope, and approach, but which generally fall into one of two categories: holistic and business-driven.

### Holistic conceptual nexus approaches:

Several institutions have developed holistic conceptual frameworks and specialized assessment tools to support management of the water-energy-food nexus and the inter-linkages of sectors and policy objectives. A comprehensive overview of these frameworks is provided in the “nexus in practice” section of the web-based nexus resource platform hosted by the German federal government<sup>30</sup>.

The Food and Agriculture Organization of the United Nations (FAO) has developed its own holistic conceptual Water-Energy-Food Nexus approach<sup>31</sup>, which aims to help policy makers and practitioners:

1. Improve understanding and systematic analysis of dynamic cross-sectoral interdependencies and the growing demand for water, energy and land resources,
2. Explain and weigh different and often competing social, economic, environmental and development goals
3. Identify and manage trade-offs among water, energy and food security, and
4. Design, appraise and prioritize response options and interventions.

According to this framework, water-energy-food interactions are influenced by global drivers such as demographics, globalization, international and regional trade, urbanization, technology and innovation, changing lifestyles and diets and climate change, as well as more context-specific drivers, including governance structures, sectoral policies, vested interests, cultural and societal beliefs and behaviors.

The FAO nexus approach targets decision makers and involves a wide range of stakeholders from local to national governments, regional organizations, development banks and agencies, international organizations, research institutes and universities, NGOs, civil society and the private sector. The nexus approach also encourages intra-organizational collaboration across divisions, sectors, countries and regions.

FAO highlights two pre-conditions for decision makers that are required to manage water-energy-food interactions effectively, namely (a) the capacity to identify, assess and analyze nexus inter-linkages and implications that any action may have beyond the intended objectives, and (b) the capacity to develop and prioritize response options.

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<sup>30</sup> Federal Ministry for economic cooperation and development – BMZ(2014): Webpage, The water-energy-food nexus resource platform; Nexus assessment tools, available at <http://www.water-energy-food.org/en/practice/assessment.html>, assessed 19.5.2014

<sup>31</sup> FAO (2014): The water-energy-food nexus; A new approach to support food security and sustainable agriculture – June 2014.

In order to address these two pre-conditions for decision makers, FAO has identified four areas of work:

- Evidence (access to and development of accurate, pertinent and timely data of the current state of natural resources and of future scenarios),
- Scenario development (using quantitative models and qualitative, participatory approaches),
- Response options (planning and implementation of new activities as well as nexus proofing of already ongoing action), and
- Stakeholder dialogue throughout the above areas of work (establishing participatory processes with relevant stakeholders and experts to build consensus on analysis, response options and policies).

## Business-driven nexus approaches

Meanwhile, the private sector has developed business-driven approaches to looking at the nexus.

Large agrifood enterprises in particular have in many cases already adopted nexus thinking, highlighting opportunities and potentials to harness positive feedback loops for their business – such as generating renewable energy from reclaimed agricultural waste and waste water, improving farming systems to increase yields and supply chain resiliency, reducing water use for processing and packaging, and cutting energy required for heating and cooling<sup>32</sup>.

The World Economic Forum<sup>33</sup> identifies the water-energy-food nexus as one cluster of risks that is particularly important for stakeholders to address in the coming decade, and highlights four levers to address<sup>34</sup>:

- Integrated multi-stakeholder long term resource planning (to help governments and other stakeholders in understanding the real impact of policies and actions across the nexus),
- Regionally-focused infrastructure development (to enhance resilience by cooperative investments and resource use),
- Market-led resource pricing (to include environmental externalities), and
- Technological and financial innovation (to provide financial resilience for those engaged in resource production, such as poor farmers).

According to the synopsis of the Bonn 2011 Water-Energy-Food Nexus conference<sup>35</sup> a nexus approach can be seen in the context of economic transition to a Green Economy, which aims at increased resource use efficiency and policy coherence. According to the United Nations Environment Programme (UNEP), the Green Economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities; carbon output and pollution are low and resource use efficiency is high; natural capital is valued as a critical economic asset and as a provider of benefits for the poor. The Green Economy concept seeks to unite the entire suite of economic policies that are of relevance to sustainable development under a single banner. A Green Economy concept in its truest form – by going beyond sectoral solutions, addressing water-energy-food inter-linkages and taking into account human rights based perspectives – could be seen as a nexus approach *par excellence*.

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<sup>32</sup> SABMiller (2014): The water-food-energy nexus; animation film, available on <http://www.sabmiller.com/index.asp?pageid=2338>, accessed 19.5.2014.

<sup>33</sup> World Economic Forum (2011): Global Risks 2011, Sixth Edition, An Initiative of the Risk Response Network.

<sup>34</sup> World Economic Forum (2011): Global risks 2011 – the water-food-energy nexus; animation film available on <http://www.youtube.com/watch?v=LPVIG2sKGIA#t=122>, accessed 19.5.2014.

<sup>35</sup> Martin-Nagle, R et al. (2012): The Water, Energy and Food Security Nexus – Solutions for the Green Economy”, Conference Synopsis (February 2012).



A dam at Heidekruin, a hop farm in South Africa.  
(Credit: Stephanie Mountifield, SABMiller)



# Business cases in the water-energy-food nexus

Many companies in the agrifood sector have begun to recognize the importance of water-energy-food inter-linkages, and for some it is vital for businesses to identify synergies and solutions that reduce nexus trade-offs and take advantage of nexus opportunities – e.g. by reducing risks and securing supply chains, improving productivity and resource efficiency, improving resilience planning and long-term investment returns, and enhancing brand and reputation.



## Large enterprises

Large enterprises in the food and beverage sector are already responding to the water-energy-food nexus through sustainability efforts in global supply chains. Those companies that have already started to take steps to address these issues are seen to have a marked advantage in the near future<sup>36</sup>.

For a majority of food companies the business imperative of sustainability programs is in differentiating their brand. According to KPMG (2012) the agrifood sector needs to better demonstrate how sustainability integrates with core business, and also to improve reliability and accountability in sustainability reporting. Food companies often operate within a long and complex chain of growers, producers, processors and marketers – yet supply chain issues are barely reflected in detail in sustainability reports (e.g. details about the management of sustainability codes to monitor supplier adherence to sustainability practices or the business value of sustainability initiatives, whether through cost savings or actual financial gains in revenues or market opportunities).

Two case studies from SABMiller on how a multinational brewing and beverage company is adopting a water-energy-food nexus approach are described in more detail below. The case studies reveal typical patterns for business case development inside the water-energy-food nexus.

### Case study: SABMiller plc<sup>37</sup>

SABMiller is one of the world's largest brewers and has brewing interests and distribution agreements across six continents. In 2012 group revenue was USD 1.388 billion with lager production of 229 million hectoliters. SABMiller's business growth depends on developing and emerging markets, where beer volume growth is expected due to the growth of middle class consumers with improved incomes.

**Risks:** SABMiller recognizes that increased production will place further demands on finite resources, and simply focusing on internal operations is not enough to secure adequate water, energy and agricultural supplies for their breweries. Specifically changes in water quality and quantity translate into water-related business risks. And these risks are often shared with the local community, in which SABMiller's businesses operate, generating a set of secondary risks as water scarcity increases; tensions concerning the allocation of water may arise, creating reputational risks for the company. Given the geographic distribution of SABMiller's operations, it has a global perspective on water availability and quality. Water availability and quality are increasingly of importance at the operational and strategic level. SABMiller identified the following challenges as critical to address through an integrated approach to water management:

- Water scarcity
- Competition for water resources
- Declining water quality
- Social dimension of water – interaction of local communities with business

**Sustainability framework:** At a global level, SABMiller seeks to generate so-called "inclusive growth," creating long-term returns by building value-chains that drive on economic growth and stimulate social development, while using scarce natural resources efficiently. As a result, underpinning SABMiller's operations is their "Ten Priorities: One Future" framework for sustainable development. The framework brings clarity to local operations

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<sup>36</sup> KPMG International (2012): Expect the Unexpected: Building business value in a changing world.

<sup>37</sup> Kissinger (2013): SABMiller case study. Reducing Risk: Landscape Approaches to Sustainable Sourcing, Washington, DC. EcoAgriculture Partners, on behalf of the Landscapes for People, Food and Nature Initiative.

on how to address sustainable development issues, while at the same time flexibility in the approach is encouraged for local operations to invest their resources in the issues most relevant to them in their own local markets. Two overarching goals guide those priorities at regional scales:

- Reduce water use per hectoliter of beer by 25% from 2008 levels by 2015—a goal of using 3.5 liters of water to make 1 liter of beer. As a result of interventions, by the end of 2012 the business had reduced its water consumption by 8% per hectoliter of beer.
- Reduce fossil fuel emissions from the en-suite energy use per hectoliter of beer by 50% from 2008 levels by 2020.

**Governance:** The group corporate accountability and risk assurance committee (CARAC), a sub-committee of the SABMiller plc board, is responsible for overseeing progress against the 10 sustainable development priorities. Twice a year, each business is required to provide both qualitative and quantitative data relating to each of the 10 priorities. This is done through the SABMiller Sustainability Assessment.

**Partnerships:** At international level SABMiller, WWF and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH created the Water Futures partnership in order to:

- Facilitate a wider discussion with local stakeholders to look beyond the boundaries of SABMiller's own operations.
- Establish technical skills, capacity and resources from globally recognized leaders (WWF and GIZ) to help find solutions at local levels.
- Craft collective approaches to a problem that cannot be solved by one actor alone - as a lack of water security presents risks that are shared by other businesses, civil society, ecosystems and governments.

At local level the company has prioritized developing partnerships with governments, non-governmental organizations and academic institutions to tackle the sustainable development challenges that they face.

**Risk-based management:** SABMiller chose to address these challenges and risks through a range of mitigation strategies and operational changes. SABMiller developed a water strategy across its operations based on a 5R model (pRotect, Reduce, Reuse, Recycle and Redistribute), a comprehensive, risk-based approach to managing water in its business and in the value chain.

**Risk assessment tools:** The risks to SABMiller breweries and bottling plants have been evaluated by using a combination of tools including:

- Water footprint analysis: to provide an overview of the water use in the value chain from crop production to distribution of products, strategic information to assess the risk associated with the water use, and equip senior managers with a basic knowledge set for further action. While footprints showed considerable variation between different countries the largest portion (over 90%) of water used was always related to the cultivation of raw crops<sup>38</sup>. As this element of the water footprint in the supply chain is not directly under SABMiller's control, it is the most challenging to address.

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<sup>38</sup> WWF & SABMiller (2009): Water footprinting: Identifying and addressing water risks in the value chain



- Watershed Risk and Sustainability Assessments (WRSA) to enable each local business to assess its own specific risks (state of the watershed, groundwater, water infrastructure, water management institutions, water policy, supply and demand in the water shed; risks for the business and surrounding communities and ecosystems; and how climate and social change may affect these risks over the next 20 years) and develop tailored strategies and action plans to address them.
- Business Water Risk Assessment (BWRA) to establish the costs of the risks to SABMiller's business (considering the likelihood of the risks and the cost of the consequences) and examining the cost-benefit of risk mitigation options (business priorities for taking action and understanding of the return on investment).

The WRSAs and BWRAs form the first stage of the development of a business case to address water risks. Many causes of business-specific risks are also drivers of risks shared by communities—such as lack of regulation of land and water use, pollution discharge, climate change, and the behavior of other water and land users. Assessing the risks from a financial perspective provided the rationale and evidence base for SABMiller's businesses to support interventions in water management beyond their breweries or farms.

**Landscape approach:** Recognizing it never faces these risks alone, SABMiller identified the need to look “beyond the breweries” to the broader landscape and communities it operates in. The rationale for the company to engage a landscape approach was fundamentally driven by the company's intention to foster an inclusive way of addressing water risk, in order to identify shared responsibilities and craft shared solutions together with local communities, stakeholders and businesses involved in the water catchment and ecosystem.

## Example Bogotá, Colombia

Bavaria – SABMiller's Colombian subsidiary – operates six breweries and two malt houses for the Colombian market and serves a population of 7.5 million people living in Bogotá. Over 80% of the city's water comes from the Chingaza watershed (Chingaza and Sumapaz National Parks) and 7% comes from the Tunjuelo river basin.

Bogotá's water quality is impacted negatively by deforestation and degradation of the water catchment by clearing for livestock grazing and agriculture. Declining water quality created additional energy demand and costs for the Sewage Company of Bogotá, which was passed on to water users.

Bavaria recognized the solution to escalating water costs lay in addressing unsustainable agricultural practices in the water catchment. To address this risk, partnerships were promoted to identify shared risks and collaborative solutions to address them.

### Key Points: SAB Miller, Colombia, Bogota

- SABMiller Colombian subsidiary Bavaria operates six breweries and two malt houses serving a population of 7.5 million people living in Bogotá.
- Over 80% of the Bogotá's water comes from the Chingaza watershed (Chingaza and Sumapaz National Parks).
- Water quality in Bogotá is impacted negatively by deforestation in the water catchment area related to livestock farming and agriculture. Declining water quality created additional energy demand and costs for water purification.
- Bavaria identified operational risks related to water quality concerns and reputational risks due to potential conflicts with other industrial and municipal water users.
- A multi-stakeholder platform was established consisting of the Nature Conservancy, the National Parks System, and the Sewage Company of Bogotá.
- Bavaria invested in water efficiency within its own operations, leading to estimated reduction of 22,000 m<sup>3</sup> of fresh water used per month.
- Bavaria has contributed USD 240,000 (by 2013) to the establishment of a water fund and supports a payment for ecosystem services (PES) scheme, led by The Nature Conservancy, supporting upstream land users in watershed protection and sustainable land management practices.
- Bavaria is supporting efforts to raise USD 60 million to restore 60,000 hectares of cloud forests over 10 years.
- Actions will prevent 2 million metric tons of sediment per year from entering the water catchment leading to estimated USD 35 million water treatment cost savings over the next 10 years.
- Future conflicts will be avoided by improved quality and price stability of water consumed by residents in Bogotá and improved yields for local farmers in the water catchment areas.

### Risk assessment:

A basin mapping (with a 20-year projection on water supply and demand, including source supply forecasts, ecological flow, demand required by Bavaria plants based on production needs, and projections on other user demands based on industry requirements, population growth, irrigation, and other demands) identified risks and mitigation opportunities. Among identified risks are:

- Operational risks from increased costs due to higher levels of required water treatment by the municipal supplier;
- Operational risks due to water quality concerns;
- Reputational risks due to potential conflicts between municipal and industrial users.

### Partnerships:

- A multi-stakeholder platform was established - consisting of the Nature Conservancy, the National Parks System, and the Sewage Company of Bogotá - to prevent two million metric tons of sediments entering the Bogotá River in order to halt the escalation in water costs to Bogotá residents and businesses.
- Farmers in the catchment area receive payments for improved practices.

#### Modes of investment:

- Bavaria has invested in water efficiency within its own operations.
- Bavaria has so far (2013) contributed USD 240,000 to the consolidation of a water fund. It is hoped this investment will directly improve the quality of water to the brewery, decrease operational risks and maintain reputational capital.
- Bavaria supports a 'payment for ecosystem services' (PES) scheme, led by The Nature Conservancy, which will focus on paying land users upstream for watershed protection and land management changes. Farmers would receive payments for improved practices. Cattle ranchers are to be given better pastures for their herds to improve milk yields but also move them off the steepest slopes. Farmers will agree to give over certain areas of land and plant native species that protect the soil and use less water than alien species. The payments are expected to begin (and better land use practices to occur) once the program has been consolidated within the national parks.
- Bavaria is working in partnership to restore 60,000 hectares of cloud forests and raise USD 60 million for conservation projects over the next 10 years.

#### Value proposition

- Avoided costs for water: Bavaria's investments into water efficiency have resulted in a reduction from 5.1 liters of water for every liter of beer produced in 2008 to 4.1 liters by 2011 and an estimated reduction of 22,000 m<sup>3</sup> of fresh water used per month<sup>39</sup>.
- Avoided water treatment costs: Bavaria's investment and leveraged contributions from the partnership will prevent 2 million metric tons of sediment entering the water catchment. Reducing sediment loads is projected to save on average USD 458,000 per year in treatment costs in the supply area. Across the entire water supply system, these projections equate to around USD 3.5 million per year in treatment cost savings, and USD 35 million if maintained over the 10 years.
- Avoided conflict by improving the quality and price stability of water consumed by Bogotá residents and improved yields for local farmers in the catchment areas.

#### Lesson Learned:

- Using a business risk assessment approach identifies, quantifies and prioritizes risks, providing the framework for building a business case for addressing water issues. However, some risks are difficult to quantify, such as reputational risks.
- Use a brief qualitative risk assessment to discount risks that are of very little or no importance to the business (or are already being tackled), then focus the detailed quantification on risks required for the business case.

#### Example: South Africa, Southwestern Cape Province

South African Breweries (SAB) operate seven breweries and 42 depots with an annual brewing capacity of 3.1 billion liters per year. The company owns a hops production company, a barley farm and a barley malting company. SAB's hops production is derived from about a dozen commercial hop farms, of which three belong to SAB, located in the foothills of Outeniqua, near George, Southwestern Cape Province (in an area of high water quantity risks).

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<sup>39</sup> Kissinger (2013): SABMiller case study. Reducing Risk: Landscape Approaches to Sustainable Sourcing. Washington, DC. EcoAgriculture Partners, on behalf of the Landscapes for People, Food and Nature Initiative.



#### Key Points: SABMiller, South Africa, Southwestern Cape Province

- South African Breweries (SAB) operate seven breweries with an annual brewing capacity of 3.1 billion liters per year.
- SAB's hops production is derived from a dozen commercial hop farms near George, Southwestern Cape Province (in an area of high water quantity risks).
- A water footprint assessment carried out by SAB demonstrated that more than 98% of SAB's water footprint is related to the production of barley, maize and hops.
- Based on water risks assessments and future scenarios the Water Futures Partnership (WWF, GIZ, SABMiller) in South Africa identified the hops farms as the most at-risk landscape in SAB's production.
- The Water Futures Partnership identified three drivers of water availability risks to SAB hops farms: Climate change (potential USD 200,000 per year in additional costs); spread of invasive vegetation (potential USD 700,000 in additional costs); increasing competition from neighboring municipalities.
- In partnership with local stakeholders and municipal governments, SAB created a Water User Association to implement an integrated landscape management approach based on recognition of shared risks and responsibilities.
- Apart from SAB investments in improving water efficiency by 20% in its own operations, SAB leveraged resources through its partnerships to restore the hydrological functionality of the catchment area (by removing invasive alien species) and supports extension programs for sustainable farming and water management in the region.
- SAB improves reputation by creating 50 new jobs per year (removal of invasive species, water management, and farming) in a region faced with high unemployment and avoids future conflicts by establishing monitoring systems for ground water abstraction and recharge in the region.

SAB increasingly views water as a potential risk, and believes there is a clear business case for water stewardship – based on the need to secure an adequate supply of good quality water, as well as increased interest by consumers, regulators and investors in water risks and quality issues.

South Africa was identified as a priority country for the Water Futures Partnership, given future projections on water quantity. A water footprint assessment was carried out, which demonstrated that 98.3% of SAB's water footprint is in the production of barley, maize and hops (including locally cultivated and imported grains). Given the importance of hops and the relatively small size of the hops industry, it was a logical choice for the first project for the Water Futures Partnership in South Africa.

#### Risk assessment and link to the water energy food nexus:

To identify the ultimate drivers of water risk to SAB hops farms, a conceptual model of this integrated system as well as scenarios of future change were developed to understand the nature of the risks and its impacts over time at a more detailed level.

- Water availability risks due to Climate Change impacts: through change in temperatures and to a lesser extent, rainfall patterns. The projected cost over twenty years to SAB to access groundwater to replace water loss through plant and soil evaporation is estimated at USD 200,000 per year.
- Water availability risk from water-intensive alien tree species: Despite the hops farm catchments are highly valued for ecological integrity, connectivity and ecosystem-based adaptation to climate change the spread of invasive alien trees posed one of the greatest threats to ecological integrity and water resources. Their annual water usage is predicted at 3 million m<sup>3</sup>, significantly more than indigenous vegetation. This reduces the annual mean runoff by 15%, and if unchecked, would reduce surface water yield by 41% by 2032. It directly competes with farm water requirements, potentially resulting in expected costs of over USD 700,000 per year — a conservative figure given rising energy prices and increased evaporation.
- Community opposition risk: The main driver for competition for water is expected from the municipalities of George and Oudtshoorn. The increasing competition for ground water from municipalities is expected to impact water availability and the cost of irrigation. This means that water levels in boreholes must be monitored on a systematic basis to understand the impact of extraction from the shared aquifer.

#### Partnerships:

- The SAB, WWF and GIZ partnership focused on the most at-risk landscape in SAB's production: the hops farms in the Southwestern Cape. The partnership brought together key stakeholders to undertake a water risk assessment and future scenarios based on modeling hydrology, climate change patterns, water policy context, socio-economic development, and agronomic variables. The water footprints were used to develop a matrix of water risk for each business covering blue water, green water and grey water, and to develop local action plans to mitigate these risks.
- Creation of a local Water User Association: In partnership with local stakeholders and municipal governments SAB started to implement an integrated landscape management approach based on the recognition of shared risks and responsibilities. The coordinating body receives specialist support from the Water Futures Partnership, the Department of Water Affairs, catchment management agencies, and local municipalities in order to manage the comprehensive catchment rehabilitation and stewardship program.

#### Modes of investment:

- SAB invests in water efficiency within its own operations.
- SAB invests as part of its partnerships in the restoration of the natural hydrological and ecological functionality of the catchment, primarily through the removal of invasive alien trees and through engagement in formal biodiversity stewardship agreements.
- SAB works in partnership with WWF and the South African government's Working for Water Program to pilot the "water neutral" concept in two water-scarce regions where it has breweries. The scheme allows SAB to voluntarily monitor and reduce its operational water consumption and then potentially offset the residual by investing in projects that clear alien vegetation. This in turn releases equivalent volumes of water back into natural aquatic ecosystems.
- SAB set up the Better Barley, Better Beer initiative, bringing SAB agriculturalists and selected SAB barley contract farmers together to develop a set of criteria, indicators and verifiers for sustainable barley farming, and to implement these practices. SAB employs agricultural extension workers who engage with farmers on issues such as yield management and water efficiency and appoints a Local Catchment Coordinator to support farmers with legal compliance on water use and to engage the government on new water regulations.
- SAB invests into a multi-year partnership with WWF and the Department of Environmental Affairs aiming at a multi-year budget of USD 1.1 million for projects to systematically clear alien species vegetation (detailed alien species mapping as basis for a multiyear plan and funding model for alien species clearing and job creation).

#### Value proposition:

- Avoided costs for water: SAB improved its average brewery water efficiency by 20% between 2008 and 2013, and seeks to reduce water use to 3.5 liters per liter of beer by 2015. It is estimated that the removal of invasive alien trees will off-set about 30% of the 100m hector liter of water used annually in SAB breweries. The economic benefit of clearing invasive species would be roughly equal to the averted additional costs for water, in dollar amounts.
- Reputational benefits: SAB could contribute to the creation of 50 jobs per year, benefitting 900 people in a region faced with high unemployment. This brings reputational benefits and also bolsters SAB's ability to nurture a local workforce that it depends on for training hops vines and harvesting. Further, the biodiversity stewardship agreements will make a significant contribution to the ecological integrity of the catchment.
- Avoided conflict: Ten water loggers have been installed, based on hydrological analysis, and will measure detailed water levels and ensure sensitivity by farmers and local government to ground water abstraction and recharge. Working with farmers on improving on-farm water management – i.e. reducing pipe leakages and improving irrigation efficiency - could potentially save 5% of water. A key cost benefit is electricity costs.



## (Micro), small and medium enterprises

In developing countries, micro, small and medium enterprises (MSMEs) play a key role in as major sources of employment generation, domestic and export earnings, and economic growth – and are thus a driving force for innovation and adoption of new technologies, tax revenue generation, poverty reduction and socioeconomic change.

MSMEs in the food and beverage sector are in some cases already becoming more sustainable by using clean energy solutions in food production and processing, as well as in water management. Yet MSMEs face much greater hurdles in pursuing a nexus approach due to the complexity of the nexus, the lack of direction from governments and the day-to-day pressures of the marketplace.

Still, as a survey of nine REEEP clean energy projects carried out for this study shows, even simple shifts can have both broad impacts on nexus sustainability and on economic returns for SMEs in the agrifood sector, allowing the development as well of model pathways for SME business case developments inside the water-energy-food nexus.

Some examples of SME-level nexus solutions in the agrifood sector include:

### On-farm productivity

Futurepump Ltd.<sup>40</sup> and the International Development Enterprise (IDE)<sup>41</sup> offer solar steam irrigation pumps for smallholder farmers in Kenya and Ethiopia, enabling them to access irrigation water in a low-cost, low-labor and sustainable manner (detailed description in case study below).

### Cold storage

Contained Energy Indonesia<sup>44</sup> is opening off-grid solar powered cold storage facilities in small remote fishing ports in Indonesia, creating financially and energy self-sufficient “cold chains”, and helping increase income in local fishing communities by 50%.

### Waste processing

Innovation Energie Développement (iED)<sup>42</sup> is retrofitting rural diesel-powered mini-grids in Cambodia with renewable energy (from rice production waste) and energy efficient technology. Risk husk gasifiers allow re-use of waste water from the gasification. Ash byproduct is used for making bricks or fertilizers. After implementation, electricity generation costs decreased substantially and service reliability and customer numbers have increased - delivering energy services not just for household use but also for productive uses to earn a living.

### Waste processing

EDS Sustenergy<sup>43</sup> targets micro and small enterprises in the cassava and dairy industries in northeast Brazil. In the cassava flour industry EDS offers biogas technology and efficient ovens to reduce firewood consumption. Biogas technologies offer treatment of manipuera (cassava processing effluents with highly toxic cyanide content), production of organic fertilizers, water re-use, and electricity generation. For the dairy industry, Upflow Anaerobic Sludge Biodigesters (UASB) treat dairy industry effluents, re-use water, and produce organic fertilizers and biogas in conjunction with cattle manure.

<sup>40</sup> <http://www.futurepump.com/>

<sup>41</sup> <http://www.ideo.org/>

<sup>42</sup> [www.iied-sa.fr](http://www.iied-sa.fr)

<sup>43</sup> <http://www.eds-sustenergy.com.br/site/empresa-en.php>

<sup>44</sup> <http://www.containedenergy.com/>



## Examples of SME-level nexus solutions in the agrifood sector (continued):

### Waste processing

Rongead<sup>45</sup> is using organic waste to produce biogas and organic fertilizer with compact biogas systems (CBS) for small and medium agrifood processors in peri-urban areas in the Lake Victoria region of Tanzania.

### Waste processing

Mercy Corps<sup>46</sup> and the Agency for the Assessment and Application of Technology (BPPT)<sup>47</sup> promote energy efficiency and biogas technology for micro, small and medium enterprises in the soybean processing sector in Indonesia to reduce firewood consumption, greenhouse gas emissions, smoke and illnesses in the workplace, as well as improve treatment of waste water (detailed description of case study below).

### Waste processing

Global supply solutions Ltd.<sup>48</sup> is setting up a large-scale briquetting plant to convert pineapple waste into biomass briquettes to provide energy for large-scale industrial use in the agrifood sector in Kenya. The briquettes are competitive to timber (increasingly scarce in the country) and more than two times cheaper than furnace oil (currently one of the main energy carriers in the industry).

## Case study: Solar-steam irrigation pumps in Kenya and Ethiopia

This case study draws on experiences of two projects supported by the Renewable Energy and Energy Efficiency Partnership (REEEP).

- Building a distribution network of the Sunflower Solar Pump in Kenya (2013 – 2015)<sup>49</sup> implemented by Futurepump Ltd. (developer and supplier of Sunflower Solar Pumps)<sup>50</sup>.  
Contact: Toby Hammond, Managing Director, Futurepump Ltd
- Developing a supply chain for the solar-steam irrigation pump in Ethiopia (2011 – 2013)<sup>51</sup>; implemented by International Development Enterprise (iDE)<sup>52</sup>, international nonprofit organization which creates income and livelihood opportunities for poor rural households.)  
Contact: Ryan Weber, Irrigation Engineer, iDE

Development of the Sunflower Solar Pump began at the PRACTICA Foundation in 2004, and is based on research by inventor Gert Jan Bom dating back to 1983. Support from International Development Enterprises (iDE) began in 2007, with the advent of field tests in Ethiopia thanks to funding from the Bill & Melinda Gates Foundation and REEEP. In 2011, Futurepump Ltd joined the partnership, tasked with mass manufacturing, marketing, sales and distributing the product. Supported by a wider range of partners and funders (including REEEP co-funding), all three organizations are now working towards the common goal of making low cost solar pumping available to smallholder farmers across the world<sup>53</sup>.

<sup>45</sup> <http://www.rongead.org/>

<sup>46</sup> <http://www.mercycorps.org/>

<sup>47</sup> <http://www.bppt.go.id/>

<sup>48</sup> [www.globalsupply.co.ke](http://www.globalsupply.co.ke)

<sup>49</sup> REEEP webpage: <http://www.reeep.org/projects/building-distribution-network-sunflower-solar-pump-kenya>

<sup>50</sup> <http://www.futurepump.com/>

<sup>51</sup> REEEP webpage: <http://www.reeep.org/projects/developing-supply-chain-solar-steam-irrigation-pump-ethiopia>

<sup>52</sup> <http://www.ideorg.org/>

<sup>53</sup> <http://www.futurepump.com/history.html>

## Background

In recent years, the important question of reducing poverty in the poorest parts of Africa has often been answered by a call for increased irrigation, helping to improve food security and nutrition. But with increased irrigation and a growing population, water use is set to rise markedly, resulting in an increasing reliance on groundwater. At the same time, there is evidence indicating the enormous unexploited groundwater resource in Africa, and showing that groundwater can provide a critical buffer against variable rainfall<sup>54</sup>. Still, if lessons are to be learned from parts of Asia, where water has become highly scarce as a result of human activity, that resource must be managed carefully. Further, climate change poses a threat to the replenishment of groundwater, with the uncertainty of future rainfall patterns.<sup>55</sup>

### Key Points: Futurepump Ltd., International Development Enterprise – iDE; Solar steam irrigation pumps, Kenya and Ethiopia

- The Sunflower solar thermal pump (STP) technology consists of three main parts: a collector captures and focuses sunlight to produce steam; an engine converts pressurized steam into mechanical movement; a pump draws water from a well.
- Water yield: 5-20,000 liters/day; pumping depth: 0-15m; lifetime ~20 years, initial capital costs ~USD 400 (as of 2013), nominal running costs (compared to diesel engines).
- The main target customers for the Sunflower solar thermal pump are commercial smallholder farmers in loose value chains with access to land (generally less than a hectare), growing staples during rainy seasons. The pump allows irrigation in the dry season to grow high-value vegetables.
- A feasibility study in Kenya concluded that the solar thermal pump provides a sustainable rate of groundwater abstraction (below the groundwater recharge rate).
- A business case analysis in Ethiopia (2010) indicates that gross annual revenue (about 1,000 USD) through irrigation farming exceeds the estimated production cost (250–300 USD) to pay-off investment costs (400 USD) within one year and suggests the solar thermal pumps are a financially attractive proposition for smallholder farmers.
- The value proposition for small holder farmers is increased income, resilience and food security in the dry season and decreased manual work (compared to manual pumps) and long term operating costs (compared to diesel engine pumps).
- Among the barriers for uptake of the technology by smallholder farmers are slightly higher upfront costs (compared to engine pumps), the technology risk (compared to manual and engine pumps) and the lack of access to finance.

## Pumping technologies

Recent years have brought irrigation systems within financial reach of nearly all farmers, especially where micro-credit is available. Micro-irrigation systems, as they are known, are relatively cheap and easily installed and do not require high pressure pumps to drive them. Smallholder farmers are already investing in small-scale irrigation. For example, in Asia about 14% of cultivated land is irrigated with groundwater and an estimated 7 million small engine irrigation pumps are currently used in India. In contrast, in Sub Saharan Africa only about 4% of arable land is irrigated.

The choice of pumping technology is heavily determined by the characteristics of the farmland and the farming activities – i.e. the size of the holding, water resources, amounts of manual labor available, types of crops grown – all affect overall irrigation requirements.

- **Manual pumps:** Human power has been used to pump water for millennia, and still is in many parts of the world. Two technologies have evolved that surpass all others, in terms of their performance and simplicity: the manual rope and washer pump (bucket irrigation) and the foot-powered treadle pump. But manual pumps are applicable only for very shallow water tables and require exhausting manual work (irrigating half an acre manually is equivalent to climbing a 1000m mountain)<sup>56</sup>.

<sup>54</sup> Paul Pavelic, Karen G. Villholth, Yunqiao Shu, Lisa-Maria Rebelo & Vladimir Smakhtin (2013): Smallholder groundwater irrigation in Sub-Saharan Africa: country-level estimates of development potential, *Water International*, 38:4, 392-407.

<sup>55</sup> Simmons, N. (2013): Groundwater in Kenya and the solar thermal pump: a feasibility study, Project document by Futurepump Ltd.

<sup>56</sup> Futurepump Ltd. (2014): The Sunflower - low cost solar irrigation, power point presentation.



- Petrol and diesel powered pumps are prevalent throughout sub-Saharan Africa, and offer the simplest option for delivering a large amount of water, from almost any depth, in a short period of time. Engine pumps dramatically reduce pumping labor and high volumes of water can be pumped up to a suction limit of 7 meter depth. But there is a cost: the initial purchase price is high (but at a minimum cost of 200 USD increasingly affordable), skilled maintenance is expensive and not always available locally, fuel (at fluctuating and increasing costs) is required and the lifespan of pumps maybe less than 5 years. On a wider scale, there are environmental costs: fossil fuels are strongly linked to climate change, and over-use has led to groundwater depletion in many parts of the world.

#### Proposed Technology:

The challenge is to develop a renewable-powered alternative to the fuel-powered pump that is economically viable, technically feasible, and desirable to the customer. It should pump enough water to support a garden of 1,000 square meters, from a water depth of 12 meters. Customers should be able to pay it off in one year or even better in a single growing season.

Based on a long-established technology the Sunflower solar thermal pump (STP) uses the power of the sun to drive a steam powered water pump. The pump has three main parts: the collector - a reflective dish to capture and focus sunlight to produce steam; the engine, a carefully designed engine to convert pressurized steam into mechanical movement; and a reciprocal piston pump to draw water out of a well. The design is built around principles of appropriate technology - in other words it is low cost, simple to operate and easy to maintain and repair locally<sup>57</sup> (similar to a bicycle) and thus may, combined with relatively low capital costs of about USD 400 and nominal running costs, provide a viable irrigation pumping technology (water yield 5 – 20,000 liters/day; Pumping depth 0 - 15m) with a design life of about 20 years for smallholder farmers in Africa.

Advantages of a solar pump compared to a conventional engine pump:

- 1 year payback time possible: Payback of the investment costs for solar pump and drip irrigation system (about 400 USD) is possible after one year of income generation by crops grown with irrigation
- No fuel costs: Take home income for the farmer can increase after the second year of use (no recurring fuel costs as with engine pumps – estimated at 1 USD per day to irrigate 1,000m<sup>2</sup>).

Disadvantages of a solar pump compared to a conventional engine pump:

- Higher capital costs for solar pumps: Engine pumps require lower capital costs (minimum of 200 USD) resulting in less need for financing and making the pump more accessible of a technology.
- Technology risk for solar pumps: Farmers see engine pumps as proven technology (as they are selling in big numbers) compared to solar pumps that are seen to be still in design stage.
- Difficult to expand irrigation with solar pumps: The solar pumper can expand irrigation only by additional investments in solar energy sources (PV panels, etc.) and drip irrigation equipment while the fuel pumper can expand irrigation with the existing pump to 8-10,000m<sup>2</sup> with investment just in fuel - assuming enough water and land<sup>58</sup>.
- Solar pumps can only be used during the day (when sun power is available): But farmers often prefer to use pumps early in the morning and late in the evenings, not during the daytime when they have other commitments and work.
- Limited transportability of the solar pump: Smallholder farmers' plots are often scattered several kilometers away from each other and from their homes.

<sup>57</sup> Futurepump Ltd (2014): Webpage, <http://www.futurepump.com/how-it-works.html>, assessed 5.5.2014

<sup>58</sup> IDE (2014): Product Specifications - Solar-powered individual-use irrigation pump for small holder farmers, power point presentation.



#### Target group – smallholder farmers

At global level: Currently, there are approximately 2.5 billion people living in 500 million smallholder households in developing countries. Based on a segmentation framework to better characterize the financial needs of smallholder households there are

- Noncommercial smallholders (approximately 300 million households), typically considered subsistence farmers,
- Commercial smallholders in loose value chains (approximately 165 million households), slightly better off than noncommercial smallholders and
- Commercial smallholders in tight value chains (approximately 35 million households) that usually produce more higher-value crops, although they also grow some staple crops.

Potential target group in Kenya - commercial smallholder farmers in loose value chains:

As for Kenya it is estimated that about 80% of the population live in rural areas relying on agriculture for primary income. There are about 3 million smallholder households with farms smaller than two hectares and plots for irrigation as small as 500 – 700 m<sup>2</sup>. Based on the segmentation framework outlined above there are an estimated 1.8 million smallholder households in the noncommercial, subsistence sector, 0.8 million households in the commercial sector in loose value chains and about 0.7 million households in the commercial sector in tight value chains<sup>59</sup>. While selling crops is assumed to be the best opportunity for increasing the households' income only 6% of the farmland in Kenya is estimated to be irrigated currently.

The main target group for the Sunflower solar thermal pump in Kenya is commercial smallholder farmers in loose value chains. Target customers have access to land (generally less than a hectare), which they use to grow staples during the rainy seasons. If they could farm a fraction of this land in the dry season, they could improve their families' health and earn extra money from high value vegetables. But, they need reliable access to water and an understanding of how to farm in the dry season. Without a pump in the dry season, many farmers are attempting to irrigate using a bucket and rope. This is back-breaking work and yields very little water, severely limiting the size of the irrigated plot. Treadle pumps bring much more water up to the surface for a farmer, but they still entail drudgery. Treadle-pump farmers are generally saving up for an automated alternative for pumping. Current off-grid motorized options are petrol or diesel pumps, which are usually over-sized for customers' wells and fields, and have recurring fuel costs.

Commercial smallholder farmers in tight value chains might already be using engine pumps – the Sunflower pump could only be attractive when engine pumps are broken or were rented at high costs or farmers find themselves locked into on-going fuel costs and maintenance requirements. For subsistence smallholder farmers it will be unlikely to afford a Sunflower pump unless economies of scale help to decrease the upfront capital costs dramatically.

Farmers who are using a grid connected pump are not a target group (example Nicaragua where grid connected farmers have very low investment for pumps at about 50 – 70 USD).

#### Water availability in Kenya:

A feasibility study was conducted by Futurepump Ltd. in Kenya to gain an understanding of the potential impact the Sunflower solar thermal pump could have upon the groundwater resource - mapping out the land areas suitable for irrigation, modeling the performance of the pump based on local climatic and hydrogeological conditions, and assessing its impact on the hydrological basin level. The key findings indicated that the solar thermal pump offered an improved performance over its manual and foot powered counterparts. The diesel

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<sup>59</sup> Futurepump Ltd. (2014): The market for solar irrigation and why Africa offers huge potential, power point presentation.

<sup>60</sup> Simmons, N. (2013): Groundwater in Kenya and the solar thermal pump: a feasibility study, Project document by Futurepump Ltd.

pump offered a considerably higher output but was seen to cause a depletion of the resource, while in the majority of cases the solar thermal pump provided a sustainable rate of groundwater abstraction (below groundwater recharge rate). The main conclusions drawn from the research were that, in most cases, the pump offered a sustainable solution to the Kenyan smallholder, so long as irrigation practices did not intensify beyond set limits (which were shown through a series of scenarios in which the intensity of cultivation was progressively increased).

#### Link to the Water-Energy-Food Nexus

- Water – Food: Ground water irrigation for smallholder farming to grow high value vegetable during the dry season on growing areas up to 1000 m<sup>2</sup>.
- Food – Water: potential risk of depletion of ground water resources and need for efficient pumping and (drip) irrigation schemes.
- Energy – Water: A Renewable Energy Technology (Solar steam irrigation pump) is used to replace manual pumps or engine pumps for irrigation.

#### Business Model developed for small-holder farmers in the Ethiopian context<sup>61</sup>

Based on the economic analysis conducted in 2010 in one Ethiopian project area located in the Oromia Region (around the market town of Ziway approximately 150 km south of Addis Ababa) it was shown that - by considering daily water production and typical crop water requirements - annual revenue projections allowed a payback time well below the conditions of local microfinance institutions.

Potential buyers are risk-averse and micro-finance institutions limit payback period for loans to one year - thus it was assumed that farmers will not buy technology that requires more than 1 year to payback. Annual revenue has been estimated by considering a hypothetical farm with a 600m<sup>2</sup> growing area, this is the average size encountered across the 8 test farms. The crop mix was chosen based on observations of existing growing practices and current market demands. The analysis produced the following economic variables.

- Investment costs to purchase the Sunflower pump were estimated at about 400 USD.
- Potential annual gross revenue through irrigation farming: 1,077 USD
- Annual production cost estimate: 250 -300 USD
- Potential annual net revenue: 780 – 830 USD

The analysis indicates that the gross annual revenue exceeds the estimated production cost to pay-off investment costs within one year and suggests the solar pumps as a financially attractive proposition. Although the analysis is based on a hypothetical plot of land, the estimated revenue is realistic compared to the income of farmers who had been using solely manual irrigation methods.

The analysis indicates that the gross annual revenue exceeds the estimated production cost to pay-off investment costs within one year and suggests the solar pumps as a financially attractive proposition. Although the analysis is based on a hypothetical plot of land, the estimated revenue is realistic compared to the income of farmers who had been using solely manual irrigation methods.

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<sup>61</sup> Jeffries, N.T. (2010): Viability of a new low power solar thermal irrigation pump for smallholder farmers in low income countries; Master Thesis; Centre for Alternative Technology; Wales



#### Value proposition for smallholder farmers

- Increased income
- Increased resilience and food security in the dry season: Income generating opportunity by complementing staple food production in the rainy season with high value crops production on irrigated plots in the dry season
- Increased area of arable land
- Decrease of manual work (compared to manual pumps) which often frees children and women from the onerous task of lifting water
- Lower operating costs in the long run (compared to engine pumps)
- Catalyzed creation of small businesses in manufacturing, assembly, repairs, sales etc.

#### Barriers and Constraints

- Slightly higher capital costs upfront compared to engine pumps (but no fuel costs).
- Clients (smallholder farmers) are generally risk adverse (evidenced by numerous attempts to promote and scale up the distribution of different types of irrigation technologies)
- Technological risks: Clients have to take the risk of a technology that has not been proven on large scale (as compared to engine pumps)
- Lack of conducive policy environment - incentives, taxation schemes – that help reduce investment and operating costs
- Financial risks: The viability of the business model for Sunflower pumps needs to be tailored and demonstrated in the local smallholder farmer context as a reliable alternative that can perform as well as a diesel pump, but is cheaper in the long run as it has no operating costs to pronounce the relative advantage of the system
- Financial risk: additional investments might be required in efficient distribution system (e.g. drip irrigation systems) and (elevated) water storage (allowing for convenient water distribution) to fully benefit from the Sunflower pump
- Financial risk: Access to micro-finance institutions is often limited for smallholder farmers and payback schemes, terms and conditions offered often not conducive to finance irrigation technologies
- Smallholder farmers need to have entrepreneurial skills to realize the additional income through irrigation farming on the market and payback the investment costs
- Maintenance and repair (over the projected lifetime of 20 years) require good training and manuals for the farmers, financial capacity as well as reliable support infrastructure, supply chains for spare parts and local partners
- The value attributed to time-saving and reduction of manual work is not so high, particularly if the families are large and there is an abundant labor pool and thus labor costs are perceived to be low and not an issue
- Labor and time requirement might not be totally eliminated as farmer presence might be required on the pumping site – and Sunflower pumps are in many cases slower than engine pumps
- Behavioral barriers due to specific local farming techniques and traditions that do not comply with the irrigation schemes. E.g. slower flow of solar pump mandates change in irrigation methods. Water should feed either into a drip system, or into a bin for periodic use
- Inconvenient timing for usage: Farmers might not want to pump and use the water during the daytime when there is enough sun
- Limited transportability of the Sunflower pump: Smallholder farmers' plots are often several kilometers away from their homes
- Safety issues related to potential increase in mosquito breeding habitats



## Case study: Energy Efficiency and Biogas Production in the tofu and tempeh SMEs in Indonesia

The case study is drawing from experiences of two independent projects supported by the Renewable Energy and Energy Efficiency Partnership (REEEP):

- Scaling up energy efficiency in tofu and tempeh SMEs in Indonesia (2013 - 2014)<sup>62</sup> implemented by Mercy Corps<sup>63</sup> which is an international development organization that helps people around the world survive and thrive after conflict, crisis and natural disaster.  
Contact: Jenny Hanley; Senior Program Officer- South & East Asia; Mercy Corps
- Planning and policy support for producing RE biogas in the Indonesian tofu industry (2011 - 2012)<sup>64</sup> implemented by the Environmental Technology Center which is a technical unit of the Agency for the Assessment and Application of Technology (BPPT)<sup>65</sup>.  
Contact: Widiatmini Sih Winanti

### Background

In urban Jakarta and the surrounding cities in Java, Indonesia, tofu and tempeh are fundamental staples of the Indonesian diet and an important source of protein and other critical nutrients, especially for low-income households. Tofu and tempeh are produced locally throughout Indonesia by approximately 85,000 informal micro, small, and medium enterprises (MSMEs), which collectively employ 285,000 workers and generate around USD 78 million per year<sup>66</sup>.

Java represents a significant fraction of total production with approximately 68,000 small factories, 9,000 of which are located in the Jakarta metropolitan area (and about 700 in the Banyumas cluster). These factories are organized in local cooperatives of 300 to 1,800 members. A single factory can produce anywhere from less than 50 kg soybeans per day to more than 1,000 kg. Tofu and tempeh are sold by producers in local markets throughout the city, or fried and sold as snacks in roadside snack stalls.

So far, Indonesia has not been self-sufficient in soybeans. The demand for soybeans (2.56 million tons per year<sup>67</sup>) is in part satisfied by imports. Due to the reliance on the world market the price of soybeans is highly volatile. Sometimes the producers have to buy soybeans at very high prices.

Tofu and tempeh are traditionally produced using firewood to heat soybeans. Firewood is typically gathered in parks, forests around town, or from secondary sources such as furniture factories and construction sites. Soybeans can be cooked using direct heat or a steam boiler which is hand-made in house or by a nearby producer or cooperative. The lack of government regulation has led to poor sanitation, safety and health conditions, and high environmental impacts. For example soybeans are often boiled in repurposed oil drums, which contain harmful chemical residues, and producers may add other harmful chemicals, including formaldehyde, to extend shelf-life. At the same time, producers are experiencing economic and political pressure with rising fuel and soybean costs and expanding urban development.

In short, the tofu and tempeh sector is in need of suitable, scalable, and sustainable production technologies. At the same time the sector - with its vast conglomeration of Micro, Small and Medium Enterprises (MSMEs), inefficient processes, environmentally damaging production practices, inadequate waste disposal, lack of

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<sup>62</sup> REEEP webpage: <http://www.reEEP.org/projects/scaling-energy-efficiency-tofu-and-tempe-smes-indonesia>

<sup>63</sup> <http://www.mercycorps.org/>

<sup>64</sup> REEEP webpage: <http://www.reEEP.org/projects/planning-and-policy-support-producing-re-biogas-indonesian-tofu-industry>

<sup>65</sup> <http://www.bppt.go.id/>

<sup>66</sup> Environmental Technology Centre, The Agency for the Assessment and Application of Technology - BPPT (2013): Development of Planning and Policy Support for Improving the Potential Production of Biogas as Renewable Energy in Indonesia's Tofu Industries, REEEP project document.

<sup>67</sup> Environmental Technology Centre, The Agency for the Assessment and Application of Technology - BPPT (2013): Development of Planning and Policy Support for Improving the Potential Production of Biogas as Renewable Energy in Indonesia's Tofu Industries, REEEP project document.

hygiene, insufficient access to credit, low awareness of new technologies, and low-paid employees - offers an opportunity to have a significant impact on mitigating environmental damage in Indonesia while reducing urban poverty.

#### Key Points: Energy Efficiency and Biogas Production in tofu and tempeh SMEs in Indonesia; Mercy Corps, BPPT

- Tofu and tempeh are fundamental staples of the Indonesian diet and an important source of protein and other critical nutrients, especially for low-income households.
- Tofu and tempeh are produced locally throughout Indonesia by approximately 85,000 informal MSMEs.
- The industry is characterized by high diversity of production technologies and equipment, size of factories (from small workshops to large factories), and access to firewood. Liquefied petroleum gas (LPG) (a common fuel type used in production) is subject to large price fluctuations.
- Environmental impacts of the tofu and tempeh industry include air pollution from firewood combustion, high water consumption, and pollution and greenhouse gas emissions from untreated waste water.
- Fuel switch from firewood to LPG (requiring investment in new boilers and cooking equipment) substantially reduces air pollution and improves hygiene; introduction of biogas technologies provides relief from LPG price fluctuations, improves wastewater treatment, and reduces greenhouse gas emissions.
- For tempeh factories, fuel switch from firewood to LPG proved to be not economically viable (higher costs of about 208 USD higher per year for using LPG boilers and equipment compared to the use of old equipment and firewood) in part due to the significant price increase of LPG in 2013.
- For the tofu industry the fuel switch to LPG economically viable (resulting in annual savings of about 1,800 USD), but payback period for the investment costs of 2,240 USD is longer than one year.
- For biogas digesters in the tofu industry the cost benefit analysis indicates a payback period of 3 years at investment costs of about 6,170 USD.
- The value proposition for biogas use in the tofu industry is avoided fuel costs, avoided risk of LPG price fluctuations and firewood scarcity and avoided opposition from neighbors due to reduced pollution.
- Among the barriers for biogas in the tofu industry are relatively high investment costs and long payback periods (more 1 year for LPG equipment, 3 years for the biogas digester), lack of access to finance, and lack of government incentives.

#### Environmental impacts and link to the water-energy-food nexus

The Greater Jakarta Metropolitan Area suffers from high levels of air and water pollution, which are enhanced by firewood combustion and large injections of liquid effluent into waterways. The country's greenhouse gas emissions are expected to increase with rising population and living standards. At the same time, local small and medium enterprises often rely on energy-inefficient, environmentally damaging production techniques, of which the food and beverage industry is one notable example. Modernizing this industry can also improve consumer health and reduce local environmental pollution, a growing concern with expanding urban growth and increased proximity of factories to residential communities.

- High water consumption: Tofu production is a water-intensive process. It begins with washing soy beans and soaking them in water for 6 hours. After soaking, the beans are ground and mixed with more water to form slurry. This mixture is then boiled and filtered to separate the liquid starch from its dregs. Acetic acid solution is then added into the liquid starch, where it forms clumps of tofu. Using pressing equipment, these clumps of tofu are then pressed out, yielding liquid wastewater and tofu itself as a product. In the end, about 60 kg of soybeans and 2,700 liters of water are required to produce 80 kg of tofu. The vast majority of the water – approximately 2,610 liters - ends up as wastewater. Its main components include reductive sugar, sucrose, starch and volatile acid, making tofu wastewater a serious environmental pollutant.
- Water pollution: Currently, the wastewater from these enterprises is released to rivers and fields without being completely treated, producing odor, greenhouse gas emissions and pollution in both water and soil. Albeit government authorities recognize the problem current relevant regulations only target larger enterprises.
- High emissions from untreated waste: Based on Intergovernmental Panel on Climate Change (IPCC) calculation methodologies the emissions from untreated waste water from the entire Indonesian Tofu and Tempeh Industry would be at 976,374 ton CO<sub>2</sub> equivalents per year. This amount is quite large when it



compared to major industries such as cement, steel and paper industries, in which emissions reduction potentials are estimated at 3.3, 1.2 and 1.8 million tons of CO<sub>2</sub> per year, respectively. The potential reduction of GHG emissions in the whole sector is estimated at 80% (747,469 tons CO<sub>2</sub>e per year) - e.g. by the use of biogas technologies.

- Inefficient use of energy sources: such as firewood, compressed natural gas (CNG), liquefied petroleum gas (LPG).
- Food security: consumers need access to tofu and tempeh products that are affordable, safe and hygienic.

### Technologies

A variety of new technologies are available to meet the evolving needs of the tofu/tempeh sector in the Greater Jakarta Metropolitan Area, and these technologies vary widely in terms of their up-front cost, maintenance requirements, lifetime, ease of use, stage of development, and technical specifications. The following options are to be considered:

- Fuel type, including firewood and other organic materials, liquefied petroleum gas (LPG), biogas, compressed natural gas (CNG), and others.
- Heating type, including direct heat or steam boilers, and high-efficiency options such as vacuum cooking and advanced heat exchangers.
- Materials, including galvanized steel and stainless steel, and other devices, including temperature and pressure gauges, safety valves, fuel storage, and pipes.

At the same time, many of the technology options available are new and untested in the field, while others are in development and not ready to enter the market at scale. Producers, technology providers, and governmental and non-governmental organizations promoting modernization of the tofu/tempeh sector need to reliably evaluate technology options in this rapidly evolving, data-limited context.

### Biogas Technology:

In order to reduce fuel use and achieve significant reductions in CO<sub>2</sub> emissions, the Mercy Corps project is promoting LPG cook-stoves and biogas reactors mainly for peri-urban areas. The project has selected large and small scale fixed dome biogas technology provided by a local company (digesters made of fiberglass to be used for individual tofu and tempeh producers or groups up to four producer units, price at about USD 1,500 – USD 8,000 depending on the size of digesters; waste input requirements are 90% liquid waste plus 10% solid waste or kitchen garbage) and a new very simple biogas technology provided by a Swedish company which is however still at development stage<sup>68</sup>.

Independent from the Mercy Corps project (mentioned above) the project of the Agency for the Assessment and Application of Technology (BPPT) has promoted larger scale fixed bed biogas digester types (capacity at about 20 m<sup>3</sup>) used for larger communities of tofu and tempeh enterprises (up to 18 units) to collect liquid waste and distribute the produced biogas. In general, the fixed bed reactor technology has advantages, such as resistance to fluctuations of waste loads, shorter reaction time, less sludge production, relatively low operating costs, and a relatively high ratio of the biogas produced compared to the volume of waste. Disadvantages of this type are the need for rigorous treatment in starting-up the biogas process, the system must be completely anaerobic, large land requirements for the reactor, and investment costs are relatively high.

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<sup>68</sup> Mercy Corps (2014): Cost benefit analysis workshop report, REEEP project document.



The biogas reactors convert the liquid waste of tofu and tempeh production into methane gas (CH<sub>4</sub>) and are able to substitute the LPG usage in the production process by up to 30%. Additionally, the effluent (waste) produced by the biogas reactor can be used as fertilizers or fish feed without any treatment. This means that there is a potential income opportunity for selling the waste products to the farming sector.

#### Target Group:

Tempeh enterprises can generally be categorized as micro businesses while tofu enterprises are usually small and medium size.

Most tempeh factories are small scale workshops operated by one single producer in his kitchen. Traditional tempeh production is done with old oil drums using firewood fuel, while after the switch from traditional methods, producers use stainless steel vats and LPG. Tempeh production levels vary from producers processing 50kg of soybean to those processing 150 kg of soybean per day<sup>69</sup>.

There are different types of tofu factories, varying from small scale workshops of one producer who has a few helpers to larger factories owned by one producer who has many workers/employees, or a factory owner who rents out the facilities (space and equipment) to renter producers. Production capacity levels also vary significantly from 50 to 500/1,000 kg of soybean processed per day.

Producers are under increasing economic pressure with rising soybean and fuel prices, as well as public pressure to reduce air pollution and on-site firewood storage and improve the sanitation of their factories. Tofu and tempeh consumers need a product that is safe and hygienic, although willingness to pay for this product seems to be limited, particularly for low income consumers. Citizens are concerned about smoke and firewood storage in their community, and are becoming more vocal with expanding urbanization and increased proximity to tofu and tempeh production areas.

#### Business Model for fuel switch from firewood to LPG gas

Due to the diversity of the tofu and tempeh industry it appears to be very difficult to develop a business model for large scale roll out of fuel switch programs in this sector. There are several factors contributing to this diversity:

- Diversity of production processes: The tofu and tempeh industries are very different from each other in terms of production technologies and equipment.
- Differences in size: as mentioned above, factories vary from small scale workshops to larger factories.
- Diversity of ownership models: There are industry owners as well as rental producers in the market for whom business models would need substantially different set ups.
- Location specificity: The business case depends on the location and the specific conditions of firewood availability and costs.
- LPG price fluctuation: LPG price is subject to large fluctuations and different subsidies are available for different LPG volumes.
- Lack of comparable and viable data: Full production costs for using firewood are difficult to assess as certain cost factors are often neglected in calculations – e.g. cost of hiring extra workers for moving fire wood from warehouse to factory; cost of using electricity for the fan or exhaust blower to facilitate burning; cost of using and maintaining the tools for cutting the woods, etc.

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<sup>69</sup> Mercy Crops (2014): Cost benefit analysis workshop report, REEP project document.

In 2014 Mercy Corps conducted participatory Cost Benefit Analysis workshops in Jakarta, Bogor and Bekasi attended by over 170 producers. The workshops intended to promote efficient steam boilers and direct heat biogas digesters.

#### Tempeh factories:

This concerns mostly small scale industries operated by one single producer in his or her kitchen. In early 2014 the price of a 3 kg LPG tube was at about IDR 16,000 (USD 1.39) but significant price increase and fluctuations had been experienced in the previous two years – from IDR 12,000 in 2012 up to IDR 18,000 in 2013. These fluctuations have had significant implications for the cost benefit analysis for tempeh producers.

Tempeh production levels vary from producers processing 50kg of soybean to those processing 150 kg of soybean per day. In the 2014 scenario for a tempeh producer who processes 100 kg of soybean per day a producer actually would lose money when switching from firewood to LPG (resulting in about USD 208 higher costs per year for using LPG and equipment compared to the use of old equipment and firewood). This was not the case a year before, when the price of a 3 kg LPG tube was still IDR 12,000.

But despite the negative economics there would still be a couple of co-benefits such as:

- Time savings of 1.5 to 2 hours per day. This could have potential value because the producer makes very long days 7 days a week producing and selling tempeh. As per calculations new equipment and LPG technology USD 0.57 per day against a daily income profit of USD 9. Or it costs USD 17 per month against a monthly income profit of USD 208<sup>79</sup>. This is seen as an acceptable price to pay for the time gained. Producers may choose to use this opportunity time to rest or engage in other activities that may be important to the family.
- Reputational benefits based on the cleaner kitchen and end-products. Hygienic production also allows producers to obtain a government certification, which opens markets to new clients, such as restaurants, hotels, supermarkets, etc.
- Avoided risk of firewood scarcity: Cheap wood is becoming scarcer in the study area. Tempeh producers mostly use cheap recycled wood from destroyed buildings or used boxes at the market but there are fewer buildings made of wood and more market boxes made of plastic these days. Tempeh producers are spending more time on trying to find cheap wood. They foresee this will become a much bigger problem in the future.
- Increased health conditions in producer's kitchen: no more smoke from wood burning stove.

#### Tofu Factories:

The conducted participatory Cost Benefit Analysis shows that once the producer has been able to make the initial high investment of USD 2,240 to purchase energy efficient equipment and switch to LPG, the return on investment is significant as it allows the producer to save some 1,800 USD per year. These calculations are based on the current LPG price of IDR 16,000 per 3 kg canister and the economics was much better a year earlier, when the LPG price was at IDR 12,000 per canister and this same producer would have gained annual savings of USD 3,680.

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<sup>79</sup> Mercy Corps (2014): Cost benefit analysis workshop report, REEEP project document.

#### Business model for Biogas digesters

Mercy Corps did a cost/benefit analysis for the case of tofu producers with a production of about 300 kg soybeans/day and the use of 25 m<sup>3</sup> biogas digester.

- Investment costs: IDR 70,000,000 (6,171 USD)
- Design live time: 10 years (about 3,600 days)
- Cost estimate per day: IDR 19,444 (70,000.000/3,600)
- Maintenance cost: IDR 550/day
- Saving fuel costs:  
The digester can produce 25 m<sup>3</sup> methane/day equivalent with 12 kg LPG/day  
Price estimate of LPG 1 kg LPG = IDR 6,000  
Saving/day: 12 kg LPG = IDR 72,000/day  
Saving per day less maintenance costs: IDR 71,450
- Payback period (estimated with about 3 years):  
 $71,450 \times 3 \text{ years (estimated with 1080 days)} = 71,450 \times 1080 = \text{IDR } 77,166,000$

But a payback period of 3 years is considered too long for most of the tofu producers.

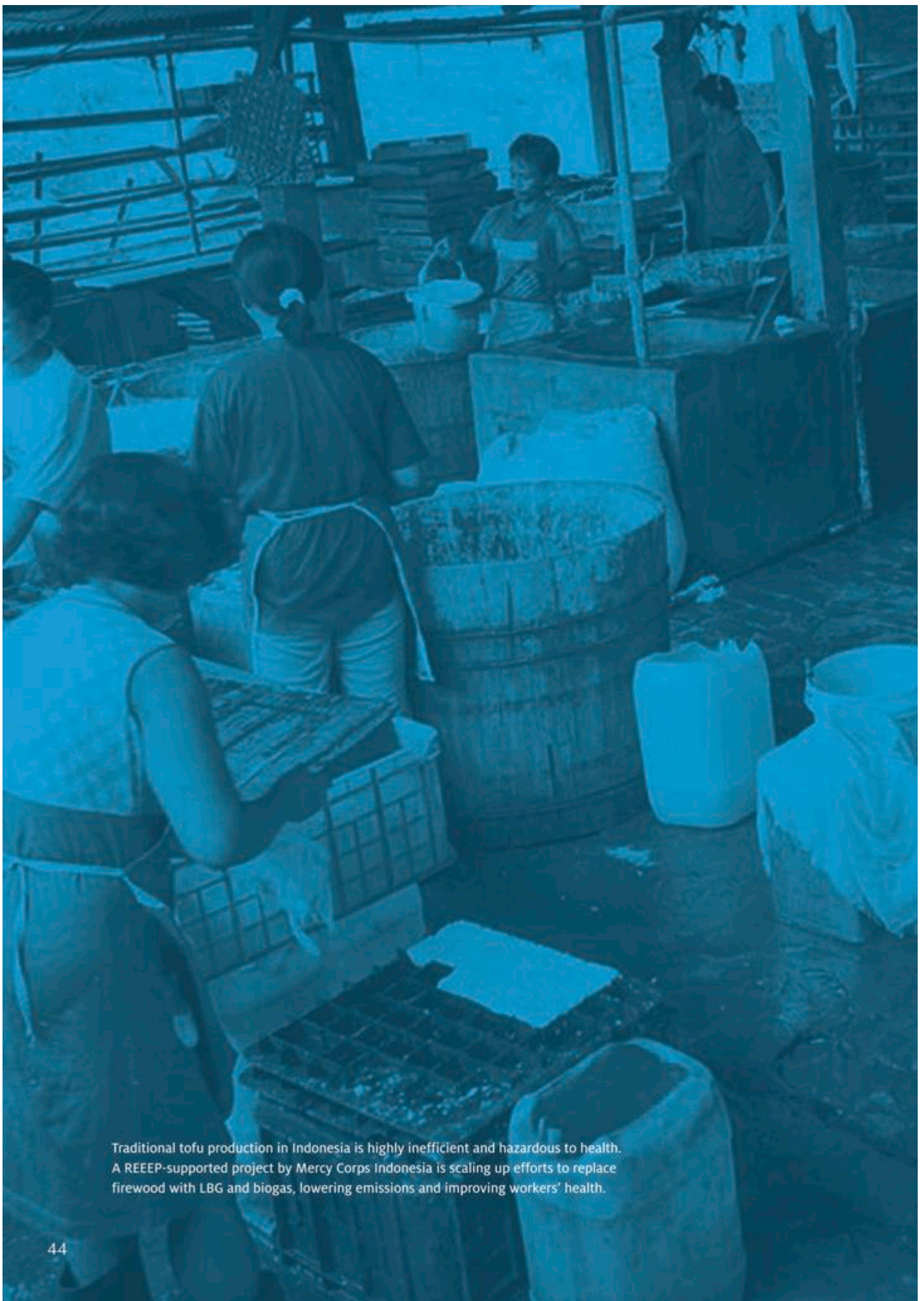
#### Value proposition for biogas use in the Tofu industry in peri-urban areas

- Avoided fuel costs for the Tofu industry in the long term (payback period for the fuel switch from fire wood to LPG gas and equipment of about 1 year, and about 3 years for the use of biogas).
- Avoided risk of LPG gas price fluctuations
- Avoided risk of firewood scarcity
- Avoided community opposition – due to reduction of smoke and water pollution
- Time savings and increased health conditions
- Potential option to produce electricity from biogas

#### Constraints for biogas use in the Tofu industry

- High investment costs and relatively long payback periods.
- Lack of incentives: While conventional energy (e.g. LPG) is subsidized (consumers pay below marginal costs) and negative externalities (water pollution, GHG emissions) are not considered in the energy pricing and taxation the positive impacts of biogas energy is not valued with incentives.
- Price fluctuations for the substituted firewood and LPG gas hamper biogas business models with a timeframe of 10 years
- Low financial capacity – specifically for smaller scale family enterprises. Also due to price fluctuations of soybeans.
- Lack of proper lending facilities, particularly for small-scale projects. Limited access to loans due to lack of collaterals such as land titles or houses. Also biogas digesters are in most cases not accepted as collaterals by banks.
- Technological risks: Clients have to take the risk of a relatively new technology that has not been proven at large scale. The technology is supplied by relatively new companies in the market, leaving clients vulnerable if companies cease to operate and cannot provide maintenance and repair.
- Usability risk: More complex technologies require training for the users. Tofu and Tempeh producers have low educational backgrounds and lack the knowledge of technologies and environmental considerations.
- Lack of information, familiarity and awareness of viable and affordable biogas technologies results in a generally high risk perception of this technology in the Tofu and Tempeh industries. The producers will only want to adopt the technology after watching other producers using the new technology successfully.
- No biogas production possible in urban areas due to land requirements for the digester.
- Scattered location of micro, small and medium businesses hamper efficient roll out and maintenance service for biogas digesters.





Traditional tofu production in Indonesia is highly inefficient and hazardous to health. A REEEP-supported project by Mercy Corps Indonesia is scaling up efforts to replace firewood with LBG and biogas, lowering emissions and improving workers' health.

# Nexus business cases: Potential pathways for the agrifood sector

In an analysis of the case studies above, commonalities and differences emerge in how large and small companies in the agrifood sector are addressing nexus-specific opportunities and challenges. From these it is possible to discover model pathways for business case development (business rationale, modes of investment, value proposition) inside the water-energy-food nexus (Please see table 1 and table 2 below).



## Commonalities and differences among large and small agrifood enterprises

**Value proposition:** Ultimately, for small and large enterprises alike, an assessment of the value proposition will determine and shape any engagement in a water-energy-food nexus approach. The value proposition is generally initiated by identifying the justification of the business case (the business rationale), based on assessment of risks and opportunities, which define the scope and scale of action. This is followed by assessing options (modes) for investment, largely informed by enabling conditions such as policy, structural and market aspects that influence success; and level of commitment at the company. Those factors combine to inform the value proposition.

**Risk assessment and opportunity analysis:** Business success will depend on how well a company can analyze problems (in an increasingly complex world of population growth, scarcity and environmental change), identify effective ways to address them, and implement appropriate action. In large companies there is most often strong awareness that a long-sighted approach can turn daunting risks and complexity into solid opportunities for partnerships, finance and growth.

While larger enterprises have the financial and technical capacity to invest in extensive long term assessment, planning and investments, small and medium enterprises tend to tailor solutions more to their immediate and short term needs.

**Mitigating priority risks:** If risks threaten survival of the business, large and small enterprises alike will immediately seek alternatives and opportunities.

**Increased productivity:** Productivity increases and cost avoidance are strong business arguments for both large and small companies. While larger companies have stronger financial capacities and internally-generated cash available for investments, small enterprises generally tailor business plans more towards short term perspectives and income opportunities.

**Access to finance:** Limited access to long-term finance is a primary barrier for both large and small enterprises, as banks often refuse long-term lending for unconventional or potentially riskier technologies. Larger companies, besides having greater access to internal resources, can often leverage increased access to financial resources through strategic partnerships and multi-stakeholder platforms. Large firm cost-benefit analyses tend to be focused on returns on investments as compared to alternative investments. Small and medium enterprises are often particularly constrained by limited access to finance. As any investment would have serious impacts on their acutely sensitive balance sheets, small and medium enterprises tend to be more risk averse and financial assessments often focused on loan conditions and payback periods.

**Quantifying benefits – money talks:** Apart from the various valuable co-benefits realized by small and large enterprise investments (e.g. improved ecosystem services resulting in reduced water treatment costs, reduced CO<sub>2</sub> emissions and air pollution, avoided conflicts, etc.) economic benefit and economic viability is always at the center of private sector considerations. Usually, companies quantify benefits based on costs avoided as compared to business-as-usual scenarios. Environmental, social, health and reputational risk mitigation are all difficult to quantify, but nevertheless often contribute to sustainable sourcing objectives, and ultimately, to sustainable growth.

**Trusted external partners:** Large enterprises can develop strategic long-term partnerships and multi-stakeholder forums to leverage additional capacity, resources and tailored packages of solutions. In fact large businesses might be competing on sustainability performance, but much of the essential work is most effectively done within pre-competitive arenas, in which standards, processes and protocols of measurement and reporting are agreed upon. Vertically-integrated large companies may have a clearer connection to sourcing areas and better ability to engage a water-energy-food approach – prioritizing investments that have the largest impact to make



the most of water-energy-food opportunities. Large companies farther downstream may have a harder time connecting to a sourcing area, and instead rely upon actors upstream with close ties to sourcing areas to take the lead, or focus on collaborative strategies and networks with other businesses, and between businesses and NGOs.

Smaller enterprises, with their attention to tailored solutions for immediate needs, tend to focus on trusted technology and services suppliers and seek successful showcase projects from businesses in similar situations.

**Internal decision processes:** For both small and large enterprises strong commitment at CEO level is crucial for decisions on new investments and production modes. Large enterprises specifically - depending on the scale of transformative actions - often need to set up strong internal governance structures to mainstream cultural shifts towards increased sustainability effectively into all relevant business entities and processes.

**Awareness and access to information:** Large companies in many cases already recognize the significance of the water-energy-food nexus for their business. For most brand manufacturers and retail companies in the agrifood sector the term “sustainability” has shifted over the past years from being a peripheral PR concern to a core element of corporate strategy.

Small and medium enterprises might not be familiar with water-energy-food nexus terminology, but are often aware of climate change and its potential impacts on their businesses. Small enterprises increasingly seek to deploy, for instance, clean energy solutions in food production and processing for economic reasons. SMEs are constrained in investing by limited access to finance, and relevant information. Reduced access to information often prevents SMEs from being fully aware of – or able to implement – new technologies, which are advancing at remarkable rates.

**Multiple co-benefits:** Large companies are able to create significant co-benefits and impact by working in multi-stakeholder platforms – e.g. with other water-intensive users in their supply chain, as well as government agencies, NGOs and research institutions. Adopting, for instance, efficient water management practices throughout a whole supply chain can trigger positive large-scale effects that are beneficial for all water users. Among the crucial co-benefits for large enterprises of such multi-stakeholder platforms is enhanced reputation and avoided conflicts. Pre-competitive alliances are also employed by beverage companies to counter campaigns against the industry.

Small and medium companies can also render substantial co-benefits in reducing air and water pollution, accrual of time savings and reduction of manual work, increasing health conditions for employees, hygiene of food products and food security during dry seasons. But these co-benefits can seldom be monetized – in large part due to lack of government incentive schemes and pricing instruments that would account for positive environmental and social externalities.

**Lobbying and policy influence:** Large companies can use their market power to engage with governments and influence policies for the benefit of their own business. But large firms still face challenges in working with governments resulting from unclear institutional responsibilities and decision making processes for cross-sector issues; lack of coherence among the different relevant sector policies; and lack of consolidated national water-energy-food nexus databases upon which they could build risk assessments and opportunity analyses. Small and medium enterprises often lack strong associations and strong representation among government authorities and other stakeholders. At the same time policy frameworks and incentive schemes, government funded research and development, and national standards for services and technologies are rarely tailored towards the needs and requirements of small enterprises or smallholder farmers.

## Large enterprise pathway for a business case inside the nexus

Table 1: Large enterprises: Model pathway for a business case inside the water-energy-food nexus.

Features	Large Companies: Key activities, questions and issues
Justification of the business case	<p>Risk assessment to create a comprehensive fact base for decision making:</p> <ul style="list-style-type: none"> <li>• What are sources of risk (resource scarcity, supply chain sustainability, community opposition, policy environment, reputation, shareholder and consumer pressure, etc.)?</li> <li>• What are relevant long term trends (population growth, industry development, resource requirements, etc.) and what will ensure competitiveness of the business in the long term future?</li> <li>• Where are data gaps to define long term trends?</li> <li>• What are priority risks for the business in the short and the long term?</li> <li>• What are the costs of these risks for the business?</li> </ul> <p>Analyzing opportunities to tailor strategies and action plans addressing the risks:</p> <ul style="list-style-type: none"> <li>• What are options to mitigate priority risks (e.g. for sustainable supply chains, increased productivity and efficiency; substitution; adaptation; new resources; new infrastructure; etc.)?</li> <li>• What is the cost-benefit and return on investment (ROI) of risk mitigation options and what are business priorities for taking action?</li> <li>• What are the risks associated with risk mitigation options (financial, technology and policy risks, etc.)?</li> <li>• What are reputational benefits for the company?</li> <li>• What is the value of interventions beyond the own business?</li> </ul> <p>Define entry points and solutions:</p> <ul style="list-style-type: none"> <li>• What are the corporate values of the business?</li> <li>• Are short term measures or systemic long term approaches needed (efficiency measures, renewable energy solutions, agricultural producer support, standard and certification systems, pre-competitive multi-stakeholder forums, supply chain and landscape approaches)?</li> <li>• Is strong commitment needed at director level?</li> <li>• Is a cultural shift of the whole company needed?</li> <li>• Who are the key stakeholders, industries and supply chain actors?</li> <li>• Who are potential partners, allies and trusted external parties (technology and service providers)?</li> <li>• Can risks be addressed through government policies and laws and market forces?</li> </ul>
Modes of investment	<ul style="list-style-type: none"> <li>• Strategy development and long-term resilience / scenario planning</li> <li>• Partnerships (to leverage capacity and resources to achieve the desired outcomes)</li> <li>• Multi-stakeholder platforms in pre-competitive settings (other businesses and users, governmental authorities, civil society and research institutions) and joint long-term resilience planning and resource use agreements</li> <li>• Long-term environmental stewardship commitments</li> <li>• Strategic investments in infrastructure, efficiency measures, large scale pilot projects etc.</li> <li>• Promotion of institutionalization and transformation of government frameworks, regulations and laws (subsidy schemes, access to capital, pricing of resources).</li> </ul>
Perceived barriers	<ul style="list-style-type: none"> <li>• Governmental institutions and private sector entities organized in silos and thus hampering development of solutions for cross sector challenges and interlinked problems.</li> <li>• Lack of consolidated and harmonized water-energy-food nexus knowledge and data base on country and local scale (e.g. availability of water sources, full life cycle analysis of water and energy use, etc.) to be used for monitoring and trade off analysis.</li> <li>• Difficulty in convincing farmers to reduce their water footprint.</li> </ul>
Value proposition	<ul style="list-style-type: none"> <li>• Mitigation of priority risks of the business</li> <li>• Avoided costs</li> <li>• Improved sourcing and secured value chains (quality and reliability)</li> <li>• Improved productivity</li> <li>• More stable agreements among the supply chain</li> <li>• Long-term sustainability and resilience of the business</li> <li>• Short term ROI success and long term investment benefits</li> <li>• Additional capacity, resources and access to capital through partnerships</li> <li>• Shared risks and a tailored package of solutions through pre-competitive agreements and cross-sectorial governance and management solutions through multi-stakeholder platforms</li> <li>• Avoided conflicts</li> <li>• Enhanced reputation and brand for the business</li> <li>• Technological and financial innovation; new products, services and markets</li> <li>• Enhanced dialogue and relationships to governmental institutions (potentially) resulting in more predictable and stable policies, enabling conditions for business and removed barriers to investment</li> <li>• Enhanced benefit from ecosystem services through valued natural infrastructure</li> </ul>



## Small and medium enterprise pathway inside the nexus

Table 2: Micro, Small and Medium Enterprises: Model pathway for the business case inside the water-energy-food nexus

Features	MSMEs: Key activities, questions and issues
Justification of the business case	<p>Assessment of factors that put the business at risk</p> <ul style="list-style-type: none"> <li>• Are there immediate risks that threaten survival of the business (e.g. access to water and energy, scarcity of raw materials, etc.)?</li> </ul> <p>Assessment of viable business opportunities that address risks of vital importance and/or immediately generate increased income at low costs and risk:</p> <ul style="list-style-type: none"> <li>• What are current supply chains, cost structures (labor, fuels, time, etc.) and revenue streams of the business?</li> <li>• What are market opportunities to generate additional income?</li> <li>• What are viable (technology) options to address priority risks or increase productivity and income?</li> <li>• What is the cost-benefit of these options (investment costs, operation and maintenance costs, payback periods, time-saving, reduction of manual work, etc.)?</li> <li>• What are the risks associated with these options (Cash flow, technology and policy risks; supply chain for technology, maintenance and repair)?</li> <li>• What are competitive advantages compared to business as usual (removal of priority business risks, avoided or reduced costs in the short term, increased income and wealth, etc.)</li> <li>• Are there trusted providers for technology, services and maintenance?</li> <li>• What are options and conditions for subsidies and access to finance?</li> <li>• Are there examples of businesses who successfully implemented these options?</li> </ul>
Modes of investment	<ul style="list-style-type: none"> <li>• Research of (technology) options.</li> <li>• Participation in information events and visits to demonstration sites.</li> <li>• Participation in low risk test runs of the (technology) options co-financed and guided by NGOs and/or Governments</li> <li>• Specific investment in technology options</li> </ul>
Perceived barriers	<ul style="list-style-type: none"> <li>• Lack of capacity to conduct a structured and holistic analysis of the business</li> <li>• Behavioral barriers and risk aversion impeding pro-active exploration of new opportunities</li> <li>• Long term nature of benefits to be reaped that require long term investments (e.g. payback periods longer than one year).</li> <li>• Lack of financial capacity for new investments</li> <li>• Lack of access to adequate finance services that enable investments</li> <li>• Lack of information, familiarity and awareness of new technologies and market opportunities</li> <li>• Lack of entrepreneurial skills to realize new market opportunities</li> <li>• Lack of capacity in business administration and technical operation and maintenance of new equipment</li> <li>• Weak supply chain for technology and maintenance and repair and lack of access to technical support</li> <li>• Lack of strong associations and powerful political representation to influence government frameworks</li> <li>• Lack of conducive policy frameworks that help overcome investment barriers and access to finance (incentive schemes, technology standards, etc.)</li> <li>• Fast technology developments at unprecedented scale bear the risk that SMEs, Governments and NGOs are being left behind</li> <li>• Lack of public funded research and development for solutions specifically tailored for SMEs, smallholder farmers, etc.</li> </ul>
Value proposition	<ul style="list-style-type: none"> <li>• Mitigation of priority (operational) risks - e.g. water scarcity</li> <li>• Sustainable reduction or avoidance of costs</li> <li>• Increased income</li> <li>• Increased productivity</li> <li>• Improved food security and access to resources (e.g. water in the dry season)</li> <li>• Time savings and reduction of manual work</li> <li>• Reduced social pressure and improved health (through e.g. avoidance of smoke).</li> </ul>





A REEEP-supported EDS Sustenergy biodigester facility catering to micro and small enterprises in the dairy industry in northeast Brazil.

## The role of governments

Businesses around the world have already begun to take action ahead of political processes and regulations on the nexus, chasing “quick wins” through efficiency measures or hedging against expected risks through systematic long term planning – as applied by selected large enterprises – pursuing both viable business opportunities and increased long-term industry resilience. But the necessary large-scale implementation of a holistic water-energy-food nexus approach will not only require enormous investment from the private sector, but also substantial, coherent support from governments.

Policy makers must play a much more active part in addressing the water-energy-food challenges, and adopt transparent and predictable long-term policies – in partnership with businesses, civil society and resource user groups – that promote patterns toward

a more sustainable future while respecting key drivers of economic activity, as well as human rights of vulnerable groups.

Unfortunately, both public and private financial institutions currently lack adequate analytical frameworks to adequately evaluate water-energy-food nexus inter-linkages, and rating agencies do not incorporate nexus risks in their evaluations of securities. There are still large gaps in knowledge on interactions, feedbacks and adaptation options across the water-energy-food nexus, and reconciling long-term and global policy objectives (climate change mitigation, ecosystem stewardship and equity goals) with immediate economic benefits and human rights is an ongoing challenge. Given the complex water-energy-food pressures ahead, business as usual is no longer an option, and the costs of inaction will vastly outweigh the costs of action.



## Ensuring predictable, stable and inclusive government policies

**Holistic, long-term water-energy-food nexus strategies:** Governments must take a close look at their existing policies, and begin thinking systematically about the long-term economic impacts of water-energy-food choices. The Stockholm Environmental Institute's background paper "Understanding the Nexus"<sup>71</sup> argues that "a coordinated and harmonized nexus knowledge-base, which would include database indicators and metrics that cover all relevant spatial and temporal scales and planning horizons, and full life-cycle analyses across the nexus, should ideally underpin new decision making and policy-making in a Green Economy framework." Hence a national Nexus Strategy Framework - based on long-term national water, energy and food outlooks and a clear understanding of the nexus inter-linkages - would have to provide measurable targets and national policy priorities, address relevant actors and design a consistent monitoring program for assessing achievements.

**The coherence gap:** Coherence is needed across the water, energy and food sectors - among not only public sector, but also private sector and civil society actors - to analyze and disseminate information on interconnectivity between sector policies. Institutional arrangements must be adapted to better cope with cross-sector challenges and interlinked problems. For example, government institutions with discrete responsibilities - such as water, agriculture, climate change, finance and urban development, etc. - should work more closely together to address nexus inter-linkages. A coordinating "nexus committee" (located in a ministry of planning or finance, for instance) would ensure that nexus-related constraints and opportunities are collectively defined together with private sector entities and relevant civil society and resource user groups (such as water user associations, forest committees and farmer groups). Based on collective assessments, the coordinating nexus committee would need authority to take tough decisions and guide fair and inclusive distribution of public goods, benefit-sharing and trade-off mechanisms.

Close cooperation between government authorities, private sector and user groups would allow communities to harness multiple co-benefits while minimizing required investment. For example, efforts to sustainably manage forests also work to improve resilience to climate change, address fresh water scarcity and protect agricultural ecosystem services. Policy schemes that increase electricity distribution efficiency help at the same time to reduce electricity demand for pumping ground water, in turn reinforcing responses to over-exploited aquifers and declined ground water tables. Similarly, actions to mitigate climate change call for improving energy efficiency, which in turn reinforces responses to energy price volatility and reduced availability of energy resources.

Not only coherence in policy making, but also in monitoring and evaluating nexus outcomes and results, is critical - horizontally as well as vertically (across local, national and international policies).

**Policy security and consistency:** Clear, well-planned and secure government policies with defined goals and consistent regulatory actions are key to scaling-up private sector investment and facilitating transition to a green economy that integrates the water-energy food-nexus. Conflicting policy signals confuse private sector investors and discourage confidence in sustainability. Examples of such conflicting signals are often found government policies that set expansion of renewable energy as a primary policy goal, while at the same time retaining heavy subsidies for fossil fuel-based energy generation.

**Reducing over-complexity:** Reducing regulatory complexity and improving transparency is another key area for action, as businesses frequently cite regulatory complexity as one of the main sources of risk and uncertainty surrounding investments in sustainability.

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<sup>71</sup> Hoff, H. (2011): Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm.

**Protecting vulnerable groups:** While governments pursue efforts to turn the water-energy-food nexus from a risk into an engine of economic opportunity, they must not forget rights to land, energy and water resources – particularly those of vulnerable groups, including women.

## Removing barriers to investment

Limited access to long-term finance for necessary investments is perhaps the most important barrier to sustainable solutions in the agrifood sector, as banks often refuse long-term lending for less conventional and potentially riskier technology. In addition to high interest rates, payback periods are often incompatible with revenue-streams of projects in line with the water-energy-food nexus. Measures to enhance access to finance and improve the risk-return ratio of projects range from financial incentives and tax credits to pricing of resources and environmental externalities.

**Financial incentives:** are designed to increase direct returns (e.g. feed-in-tariffs for renewable energy, tax credits for green investment). Financial incentives may also include market-based mechanisms that create additional income from the sale of emission allowances or other rights to the use of resource. However, there must be confidence around continuation of financial incentives by the government, as sudden changes (e.g. abrupt discontinuation of feed-in-tariffs) can have significant adverse impacts for investors and long-term investor confidence. Many countries provide financial incentives for energy-efficient equipment and price supports for renewable energy, to stimulate the diffusion of technologies. Taxation schemes can efficiently provide a “carrot” for influencing behavior and promoting new renewable energy and energy efficiency technology while raising revenue and providing a financial incentive to the marketplace.

**Public-private finance and loan guarantees:** Policy makers can also help to extend lending periods or reduce interest rates by, for example, providing blended public-private finance or guarantees. Government loan guarantees can allow private sector investors to borrow from commercial banks at lower rates.

**Resource and externality pricing:** Full environmental impacts and costs are most often not priced in the market. Instead, current policies and market incentives result in businesses providing significant positive social and environmental externalities, largely unaccounted for and unchecked. Incorporation of the full cost of externalities into the market price of resources is becoming increasingly important for scaling up investment in sustainable development. This is possible through a range of economic and fiscal instruments, including environmental taxation or removal of subsidies for water, food or fossil fuel based energy services to reflect the scarcity of resources.

Taking steps to promote sustainability will inevitably create both winners and losers among businesses. Consideration of these diverse economic impacts and gradual, rather than abrupt, transition to new policy instruments will be absolutely crucial for ensuring new policies are effective and long-lasting. To reduce disproportional costs to small farmers and SMEs, a steady reduction of subsidies for water, energy and fertilizers could go hand in hand with incentives for increased resource efficiency and waste avoidance that help farmers increase revenue streams. As farmers see improved margins for their products at lower production costs, they can gradually pay real prices for water and energy resources. Regional integration can enhance regional markets and trade, which would have the result of allowing for optimal resource use in that region.



## Creating enabling conditions for business

**Standards and regulations:** Standards and regulations can promote sustainable practices on the production and supply side, such as standards for pollution control or energy standards. On the demand side, they play a major role in directing markets towards demand for more sustainable and efficient products and reducing technological and financial risks for users.

**Capacity development and awareness:** Particularly on the demand side, increased awareness and understanding of nexus concepts and solutions would promote investments in sustainability. Governments can play a major role in training local workforces and in building capacity for new technology deployment, which in turn facilitates access to finance with a qualified local work force. The understanding of water-energy-food linkages can only be developed through providing access to information and raising awareness of resource use among all stakeholders. Therefore, all sector actors must be trained and qualified to implement nexus approaches, and youth must be educated from an early age to think of these issues as interlinked.

**Government incentives for Research and Development:** Public funding is critical for facilitating innovation and helping business scale-up investment in new and more sustainable products, technologies and resource substitutes. Governments have a wide range of measures available, including tax incentives or direct governmental funding.

### Imperatives for concerted action: Government, business and civil society working together

In the transition to water-energy-food nexus approaches, the success of government policies depends on the ability of policy makers to build effective partnerships with the private sector and civil society. As for the specific roles that businesses, governments, public-private partnerships, and the civil society could play, figure 1 maps out examples for both demand and supply interventions.

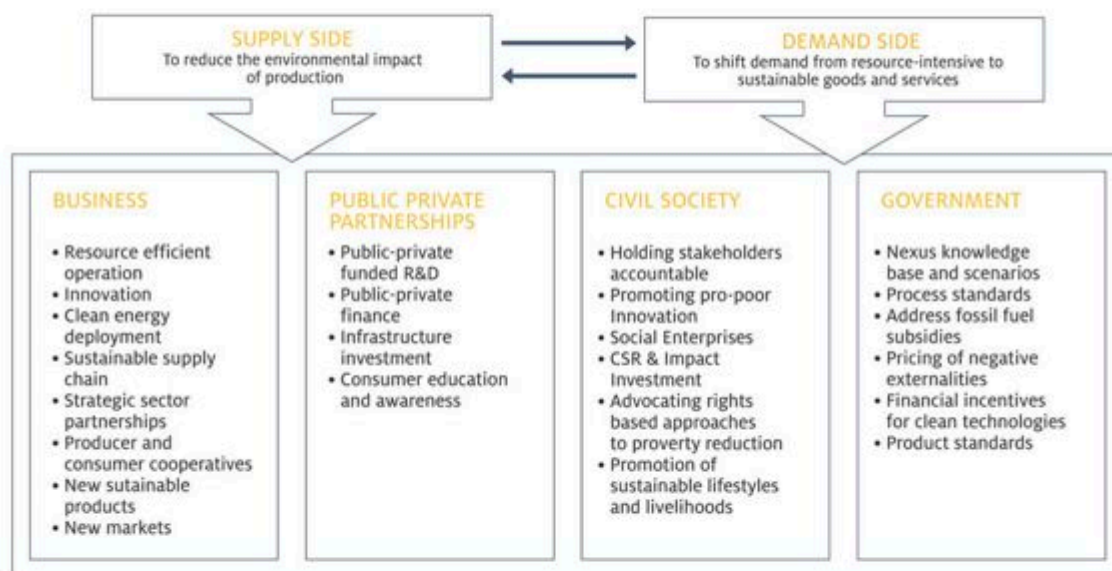


Figure 1: Concerted action between government, business and civil society towards a water-energy-food nexus approach .

<sup>19</sup> Adjusted after KPMG International 2012: Expect the Unexpected: Building business value in a changing world

Concerted action will require the understanding of partners' motivating factors, mutual interdependencies and long-term requirements. To achieve their strategies, governments need corporations to provide the necessary technology, the skills to deploy and operate it, and the finance to invest in delivering it. Given that many national budgets remain stretched in the wake of global financial crises, public-private partnerships can provide an effective architecture for mobilizing private sector investment in sustainability, rather than relying on public funding alone.

Public-private partnership architectures require thorough and inclusive planning with relevant stakeholders and user groups; legal structuring to ensure that responsibilities are clearly established and risks are mitigated.

A transition to a water-energy-food nexus approach requires solutions that address both how and which goods and services are demanded and produced and public, civil society and private sectors have a vital role to play. Regulatory government policies are needed to "push" the market by increasing resource efficiency with incentives and private sector voluntary measures are needed to "pull" the market forward by driving demand for new sustainable products. The inclusion of civil society and resource user groups is needed to ensure that the rights of less powerful and vulnerable groups are respected.



## Bibliography

- El-Hage Scialabba, N.; FAO (2010): Organic agriculture and climate change, *Renewable Agriculture and Food Systems*: 25(2); 158–169.
- FAO (2008): Climate change, water and food security.
- FAO (2009): Growing more food, using less water.
- FAO (2014): The water-energy-food nexus, A new approach in support to food security and sustainable agriculture – June 2014
- Federal Ministry for economic cooperation and development – BMZ (2014): Webpage: The water-energy-food nexus resource platform; Nexus assessment tools, available at <http://www.water-energy-food.org/en/practice/assessment.html>, assessed 19.5.2014
- Hoff, H. (2011): Understanding the Nexus. Background Paper for the Bonn2011 Conference: The Water, Energy and Food Security Nexus. Stockholm Environment Institute, Stockholm.
- Jeffries, N.T. (2010): Viability of a new low power solar thermal irrigation pump for smallholder farmers in low income countries; Master Thesis; Centre for Alternative Technology; Wales.
- Kissinger (2013): SABMiller case study. Reducing Risk: Landscape Approaches to Sustainable Sourcing. Washington, DC. EcoAgriculture Partners, on behalf of the Landscapes for People, Food and Nature Initiative.
- Klein, G. (2005). California's Water — Energy Relationship. California Energy Commission.
- KPMG International (2012): Expect the Unexpected; Building business value in a changing world.
- Martin-Nagle, R et al. (2012): The Water, Energy and Food Security Nexus – Solutions for the Green Economy”, Conference Synopsis (February 2012); Published by: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU); Federal Ministry for Economic Cooperation and Development (BMZ); OOSKANews, Inc
- McKinsey; OECD and the World Economic Forum (2011): Briefing paper submitted for “Managing the Nexus for Green Growth”, Hot Topic 12, Bonn2011 Nexus Conference, 16-18 November 2011.
- Rosegrant M.W. (2008): Biofuels and Grain Prices: Impacts and Policy Responses. Testimony for the U.S. Senate Committee on Homeland Security and Governmental Affairs.
- SABMiller (2014): The water-food-energy nexus; animation film, available on <http://www.sabmiller.com/index.asp?pageid=2338>, accessed 19.5.2014
- Simmons, N. (2013): Groundwater in Kenya and the solar thermal pump: a feasibility study, Project document by Futurepump Ltd.
- Singh, J (2011): India Coca-Cola compensation law is passed in Kerala, BBC, 24 February 2011.
- Swain, A. K. & Charnoz, O. (2012): In pursuit of energy efficiency in India's agriculture: Fighting 'free power' or working with it? AFD Working Paper 126. Paris: Agence Française de Développement.
- United Nations Secretary-General's High-level Panel on Global Sustainability (2012): Resilient People, Resilient Planet: A future worth choosing. New York: United Nations.
- Von Bormann, T. and Gulati, M. (2014): The Food Energy Water Nexus: Understanding South Africa's most urgent sustainability challenge. WWF-SA, South Africa.
- Water Footprint Network (2014): Water Footprint Product Gallery: Pizza Margherita; Retrieved from <http://www.waterfootprint.org/?page=files/productgallery>; accessed 19.5.2014
- Webber M.E. (2008): “Energy versus Water: Solving Both Crises Together,” *Scientific American*, Scientific America, October 2008.
- World Bank (2013): Lighting rural India: Experience of rural load segregation schemes in states. Washington, D.C.: World Bank.
- World Economic Forum (2011): Global Risks 2011, Sixth Edition, An initiative of the Risk Response Network.
- World Economic Forum (2011): Global risks 2011 – the water-food-energy nexus; animation film available on <http://www.youtube.com/watch?v=LFViG2sKGtA#t=122>, accessed 19.5.2014
- World Economic Forum Water Initiative (2011): Water Security: The Water-Food-Energy-Climate Nexus, Island Press.
- World Resources Institute, UNDP, and World Bank: World Resources (2005): The Wealth of the Poor –Managing Ecosystems to Fight Poverty, Washington, DC.
- WWF & SABMiller (2009): Water footprinting: Identifying and addressing water risks in the value chain.
- WWF & SABMiller (2014): The water-food-energy nexus – Insights into resilient development.