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A Nexus Approach to the Post-2015 Agenda: Formulating Integrated Water, Energy, and Food SDGs

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While the MDGs aimed to lift people out of poverty, the SDGs aim to keep them out of poverty by ensuring that development is both socially and environmentally sustainable. To achieve this, a "nexus" approach that integrates goals across sectors, makes the SDGs more cost-effective and efficient, reduces the risk that SDG actions will undermine one another, and ensures sustainable resource use is necessary. This paper aims to support the SDGs' integration by showing how cross-sectoral interactions can be approached through examples from the water-energy-food nexus.

The Millennium Development Goals (MDGs) laid out an ambitious agenda to improve living standards in poor countries. Now, with the Sustainable Development Goals (SDGs), world leaders are aiming to set a broader agenda for 2015 and beyond: a set of universal goals that engages countries at all income levels to ensure the long-term well-being of humankind. Put another way, while the MDGs aimed to *lift* people out of poverty, the SDGs aim to *keep* them out of poverty by ensuring that development is both socially and environmentally sustainable.

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Long-term sustainability requires acknowledging that many of the resources that support development—water, land, materials—are finite and are also needed to support vital ecosystem services. Development can only be sustainable if it works within those constraints, over time, and across sectors and locations. This is where the MDGs fell short: they identified sectoral goals—and targets under them—with little consideration of how efforts to attain a goal in one sector would affect (or be affected by) efforts in another sector, or whether the total demand for key resources could be met by existing supplies without degrading the resource base and underlying ecosystems.

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A different approach would be to integrate goals across sectors to make the SDGs more cost-effective and efficient, reduce the risk that SDG actions will undermine one another, and ensure sustainable resource use. The UN Open Working Group on SDGs presented its proposed set of goals in July 2014. It explored these integration opportunities but their ultimate set of suggested goals fell short of using them.

This paper aims to support the SDGs' integration by showing how cross-sectoral interactions can be approached through examples from the water-energy-food nexus. Water, energy, and food have been identified as priority areas for the SDGs, both in the Rio+20 outcome document as well as in the Open Working Group outcome document.[1]

We show how to identify interactions among goals, and examine different types of interactions; for example, how the achievement of targets under one goal might affect targets under another goal, or how individual targets might serve multiple goals. We also propose "nexus targets"—targets that cut across sectors—as entry points for developing an integrated framework beyond water, energy, and food security.

The Water-Energy-Food Nexus

Most governments have separate agencies to oversee water, energy, and agricultural food production. They set policies and plan for each sector separately, although these sectors are closely linked through local, regional, and global water, carbon, and energy cycles. Moreover, the sectors all involve resources upon which all people depend, but which billions of people lack access to; they deal with constrained supplies and rapidly growing global demand, and they are subject to regional variations in supply and demand.[2]

Governments' and international agencies' "silo" approaches to these resources have often led to unsustainable policy and development choices. For example, a growing number of countries are increasingly relying on energy-intensive, fossil-fuelled desalination plants; others rely on energy-intensive inter-basin water transfers and groundwater pumping as solutions

to water scarcity. Another example is that bio-energy development has, to a great extent, focused on water- and land-intensive fuels such as maize-based ethanol and palm-oil biodiesel, rather than pursuing more efficient and sustainable solutions, such as generating energy from agricultural residues and waste.

A growing number of scientists and policy analysts in recent years have emphasized linkages between water, energy, and food, and encouraged an integrated "nexus" approach to planning in those sectors. The approach emerges from a long history of systems analysis and is backed by a robust body of scientific evidence, which is only beginning to take hold in policy-making and planning circles.[3] The guiding principles of the nexus approach are to ensure *access* to resources for the most vulnerable, especially the poor, to promote *efficiency* in resource use, and to ensure *sustainability*. In short, to maintain healthy and productive ecosystems.[4] Similar principles underpin the call for the SDGs.[5]

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Identifying Interactions within the SDGs

Preparation and consultation processes for the SDGs have so far encouraged a top-down process that begins with an overarching, aspirational goal—food security, for example—then sets actionable targets to support the achievement of that goal.[6] Such an approach makes it very difficult to address interactions across goals and the resources they involve. When goals are the starting point, stakeholders in different sectors have little occasion to interact, much less coordinate their efforts, and the discourse will favor single-sector goals. This process is therefore likely to lead to a long list of disparate goal proposals, with often redundant, and even conflicting, targets.

An alternative method is to start by identifying concrete targets without concern for overarching goal areas. Focusing on targets stimulates discussions on the scope of development issues, not sectoral challenges, and enables interactions to emerge. Consider, for example, a target on improved access to safe drinking water. It would certainly fit well under a goal of ensuring universal access to drinking water, but is likewise an enabler of health, education, food security, and growth. Taking targets as the entry point invites a broader range of stakeholders and perspectives to be included in the formulation of the SDGs, extending beyond traditional sectors.

In the end, targets must be grouped into goals if the SDGs are to be easily communicated. However, by starting with targets, goal definitions will follow from a process that recognizes complexities, interdependencies, and interactions, and will highlight that targets can be shared across several sectors.

Understanding such interactions supports more coherent decisions on goals, targets, and indicators. The fact that a trade-off has been identi-

fied does not mean that a target must be excluded. It just draws attention to the need to address the trade-off, weighing the options on the basis of common principles and priorities. By bringing interactions to light, we can avoid contradictions in the final SDG framework and can also identify potential synergies between targets that suggest joint solutions and make action more cost-efficient.

A key principle of the SDGs is universality. The goals will be relevant to all countries and all will contribute to achieving them, but through differentiated actions adapted to country needs and capabilities.[7] Countries will face different trade-offs and synergies, emphasize different targets, and find different ways to improve development outcomes. Thus, the targets can be seen as building blocks that each country will combine in its own way, balancing the needs for ensuring access to resources, efficiency, and sustainability to fit the local context and capabilities.

The SDGs alone cannot, of course, guide national or local policies. Decision makers need to take local resource characteristics, economic, and political realities into account. The formulation of targets must therefore take place at the scale where action will be taken and where data can be gathered. The SDG process offers opportunities to involve statisticians at an early stage in the formulation of targets, ensuring that selected targets and indicators are designed so they can be measured efficiently. Where data already exists, tools can be used to quantify relationships between sectors. Where data quality or accessibility is poor, integrated approaches can inform qualitative analyses and also help to identify data needs.

Exploring Interactions in the SDGs: Three Approaches

To illustrate how interactions between goals can be identified, we looked at the water, energy, and food-related goals of the proposed SDG framework of the Open Working Group through three complementary approaches.[8] First, we examined the targets under the proposed energy, water, and food or agriculture goals to identify ones that might relate to targets under the other two goals. We did this screening at a conceptual level, considering known water-energy-food interactions. Second, we examined *how* the targets interact, and where there are potential trade-offs and synergies among them. Third, we identified possible "nexus targets" that would be positioned between the three sectors, aiming to maximize overall efficiency and also looked beyond water, energy, and food.

Approach 1: Screening for Interactions Among Proposed Targets

The Open Working Group proposes 21 targets under the water, energy, and food goals. In summary, they include the following areas:

- Access to affordable, reliable, and modern energy services
- Energy efficiency
- The share of renewable energy in the global energy mix

- Access to safe, nutritious and sufficient food
- Ending malnutrition
- Agricultural productivity
- Sustainable food production systems and resilient agricultural practices
- Genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their related wild species, and access to fair and equitable sharing of the benefits from genetic resources
- Universal and equitable access to safe and affordable drinking-water
- Water quality, wastewater, recycling, and reuse
- Water-use efficiency, sustainable withdrawals and supplies of freshwater, and reduction of water scarcity
- Integrated water resources management
- Access to sanitation and hygiene
- Protection and restoration of water-related ecosystems

The proposed means of implementation under these goals focus on:

- Renewable energy, energy efficiency, advanced and cleaner fossil fuel technologies, energy infrastructure, and clean energy technologies
- Water harvesting, desalination, water efficiency, wastewater treatment, and recycling and reuse technologies
- Rural infrastructure, extension services, and technology development
- Trade restrictions and distortions in world agricultural markets
- Ensure proper functioning of food commodity markets, limit food price volatility

As is evident from the list above, some of the targets focus on ensuring access to resources, some on efficiency, and some on long-term sustainability. The three are linked: efforts to ensure access must be combined with efficient management and protection of the resource base and ecosystems in order for the outcome to be sustainable. For example, if we expand access to agricultural irrigation, over-abstraction must be avoided in order to ensure that the resulting productivity gains can be sustained in the long term. In line with the ambition of making the SDGs universally applicable but allowing for the differentiation of action, each country would emphasize the targets that best fit its priorities and needs. For example, a country with widespread hunger might focus on food security and nutrition, while a wealthier country might focus on making agricultural systems more sustainable. On a global scale, however, all three types of targets are essential to the success and sustainability of the SDGs.

Figure 1 shows the targets of the proposed water, energy, and food goals. The capital letters indicate what other goal or goals they directly relate to. Note that there are targets with implications for water, energy, and food in other goal areas than those we have included here for illustrative purposes.

Figure 1. Screening of Water (W), Energy (E), and Food (F) Relevance in Proposed WEF-Targets

WATER (W)

- By 2030, achieve universal and equitable access to safe and affordable drinking water for all. (F, E)
- By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and increasing recycling and safe reuse by X percent globally. (F, E)
- By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity. (F, E)
- By 2030, implement integrated water resources management at all levels, including through transboundary cooperation, as appropriate. (F, E)
- By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes. (E, F)

ENERGY (E)

- By 2030, ensure universal access to affordable, reliable, and modern energy services. (W)
- Increase substantially the share of renewable energy in the global energy mix by 2030. (F, W)
- Double the global rate of improvement in energy efficiency by 2030. (F, W)

FOOD/AGRICULTURE (F)

- By 2030, end hunger and ensure access for all people, in particular the poor and people in vulnerable situations including infants, to safe, nutritious, and sufficient food all year round. (W, E)
- By 2030, end all forms of malnutrition, including achieving by 2025 the internationally agreed targets on stunting and wasting in children under five years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons.
- By 2030, double the agricultural productivity and the incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, pastoralists, and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets, and opportunities for value addition and non-farm employment. (W, E)
- By 2030, ensure sustainable food production systems and implement resilient agricultural practices that: increase productivity and production, help maintain ecosystems, strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and progressively improve land and soil quality. (W, E)
- By 2020, maintain genetic diversity of seeds, cultivated plants, farmed and domesticated animals, and their related wild species, including through soundly managed and diversified seed and plant banks at national, regional, and international levels, and ensure access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge as internationally agreed.

It quickly becomes clear that most targets are inherently cross-sectoral when screening each target for their relevance to the other two goal areas. This reinforces the point that attention to target interactions and understanding their implications is critical to guiding action in regards to the SDGs.

Approach 2: Exploring the Nature of Interactions between Targets

A second approach looks at natural resources as enablers of development. For example, food production requires water, land, and energy. It is important to note that while in this case we only focused on a narrow set of targets and resources, there are many other enablers of development, such as health, education, good governance, equality, peace, and security. One strength of an integrated approach is that it encourages a broader discussion of how all these factors interact.

Our analysis of the water, energy, and food targets shows three main types of interactions. Some are *interdependent*—one target has to be realized in order for another to be viable, usually because access to water, energy, or land for food production needs to be ensured. For example, the target for increasing access to irrigation requires a steady supply of freshwater.

Other targets *impose conditions or constraints* on one another. For example, the target for efficient agricultural water use sets a condition for how access to irrigation can be provided. Arguably, targets that impose conditions or constraints are essential to the long-term success of a wide range of other targets, as they ensure that development is sustainable over time.

Some targets *reinforce* each other, highlighting potential synergies. For example, increasing water efficiency in agriculture can ensure that more of the irrigation water actually reaches plants, thereby helping to achieve the target for increased agricultural productivity. Critical trade-offs and conflicts may occur as targets interact. Such is the case when food and energy production compete for the same water resource, or when the expansion of one impedes the other.

Figure 2 illustrates interactions between the water, energy and food targets in the four SDG frameworks. Take access to energy services as an example. As shown in figure 2, achieving this target often depends on water access, while the targets on sustainable water withdrawal levels and the ambition to increase the share of energy from renewable sources impose conditions for how access to energy services can be ensured. Improved water efficiency and energy efficiency reinforces both the energy access and the sustainable water withdrawals targets.

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Ending hunger, in turn, depends on access to energy services and access to water (as energy and water are needed to produce food), while the targets on sustainable improvement of yields, addressing land conversion for agriculture, and sustainable food and agricultural systems set conditions for how hunger is to be eradicated.

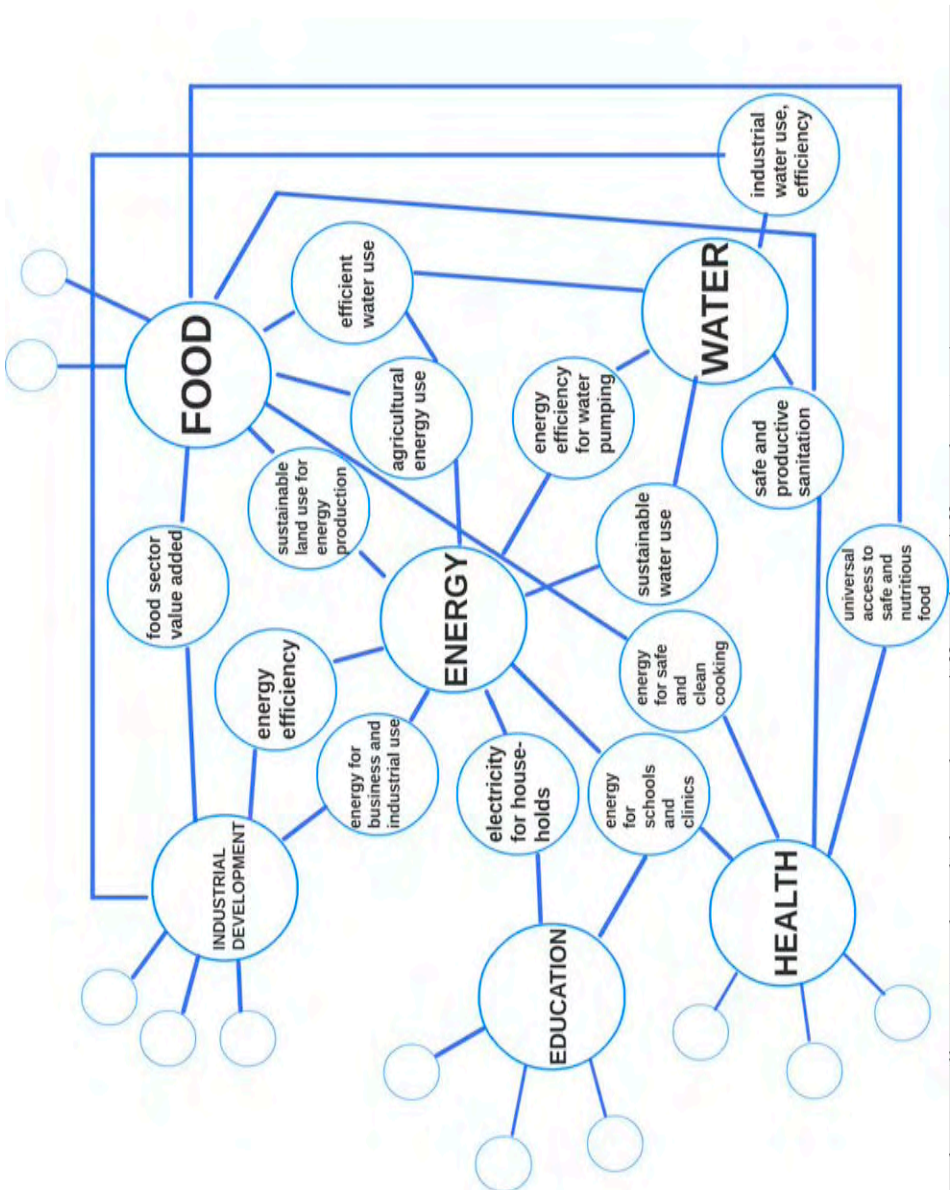


Figure 2. Interactions between Proposed Water, Energy, and Food Targets

(Note: These are illustrative only, as linkages play out differently in different locations.)

Figure 2 also highlights resulting potential trade-offs and opportunities for joint action. For example, there may be trade-offs between ending hunger and protecting forests from being cut down for agricultural land, or between ending hunger and increasing the share of renewable energy by producing biofuels (if food crops and biofuel crops are competing for the same land and/or irrigation water).

Targets focused on sustainability can help to avoid trade-offs. If agricultural yields are sustainably improved, and food and agriculture systems are made more sustainable, the pressure to expand into wetlands and forests will decrease. These conditions also reinforce one another in the long run, as higher yields and more sustainable systems will ensure that the gains made in ending hunger can be maintained over time, rather than being eroded by water scarcity and land degradation. Figure 2 shows many reinforcing interactions, emphasizing that many targets support one another and work in the same direction.

The different ways in which targets interact suggest potential for efficient solutions as well as tough political decisions between competing demands. A detailed assessment of the dynamics at the scale where action is to be taken would provide decision-makers with information that can support more efficient, equitable, and sustainable development pathways.

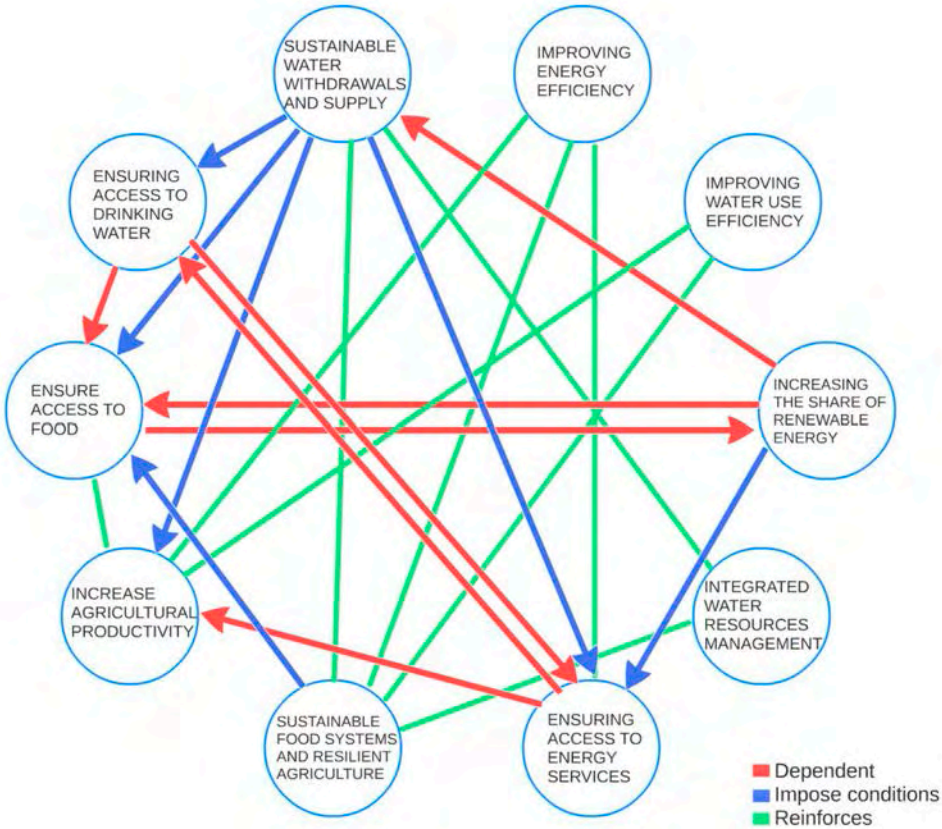
Approach 3: Identifying "Nexus Targets" between Sectors

A third way to address interactions between water, energy, and food targets is to map out the connections and identify linking targets at the nexus of different sectors. This approach clarifies how different sector objectives share interest in the same resources, hence enabling assessment of the total pressure that results from several targets. By enabling us to gauge whether the aggregate demand for human needs "adds up" within the limitations of ecosystems, this approach addresses sustainability. It also addresses efficiency by establishing targets for resource use across different sectors.

Like those in figure 1 and figure 2, this approach also starts from a nexus perspective, recognizing that the energy and water sectors are interdependent. For example, energy is needed for water pumping, and water is needed for both hydropower and thermal power production. Similarly, agricultural production depends on energy and water. Beyond water, energy, and food, Figure 3 also links these resources as enablers for social sectors. Energy is crucial to the attainment of both health and education targets, such as to provide electricity for schools and clinics, and light at home to do homework. Similarly, clean water and sanitation are also essential to achieving health targets.

Figure 3 is a partial illustration of this approach, starting from the energy domain, which could be extended to a comprehensive map of all SDG areas. The approach does more than illuminate interactions; it also highlights shared interests and common goals across sectors.

Figure 3. Mapping Targets at the Nexus between Goal Areas



The Nexus in Different Development Contexts

The many nexus interactions that have been illustrated in figures 1, 2, and 3 underscore why shared targets make sense, and why focusing on the targets rather than the goals would be helpful in developing an integrated SDG framework. To complement the conceptual-level discussion in the preceding sections, here we offer examples from Ethiopia, China, and the United States that illustrate how cross-sectoral interactions play out in different contexts.

Ethiopia: Rapid Growth to Alleviate Poverty

Ethiopia is one of the world's poorest countries, with a mostly rural population that often lacks access to safe water and modern energy sources. The government has embarked on a rapid economic growth trajectory. Its current five-year Growth and Transformation Plan (GTP) emphasizes rapid development of the agriculture and energy sectors, with a strong focus on exports. Crop productivity is to increase by 30 percent, power generation by 300 percent, sugar production by 600 percent, and meat export by 1,000 percent over five years.[9] The plan includes a significant expansion of irri-

gation for intensification of food and biofuel production, and large-scale hydropower development, particularly in the Blue Nile basin.

The GTP highlights the need for coordination among sectors and targets relating to food production, bioenergy, hydropower, and irrigation. Indeed, a nexus analysis of the Lake Tana/Upper Blue Nile suggests that agricultural intensification and commercialization can improve agricultural productivity, but could also compromise downstream aquatic ecosystems and agriculture around Lake Tana, and thus food security in the region.[10] Similarly, increasing biofuel production could bring new revenues from exports, reduce greenhouse gas emissions from fossil-fuel use, and potentially improve energy access. But large-scale biofuel production would require huge amounts of land, and also water for irrigation, potentially competing with food production and other ecosystems and their services.

China: A Nexus Approach in Ningxia

China's demand for water, land, energy, and food is increasing rapidly. While water is scarce in China, agriculture strongly depends on energy-intensive irrigation, and the energy sector depends on water-intensive coal. China has adopted so-called "red lines" related to water, energy, and land use. The Ningxia province in northern China exemplifies the need for improved coherence between the different targets.[11]

Ningxia is very water stressed; it has less than one third of China's already low average per capita water availability, and more than one million rural people lack access to safe water.[12] A provincial target only allows water withdrawals to increase by 20 percent by 2030, but more than 90 percent of Ningxia's water comes from the Yellow River, which already has all of its water resources committed.[13] Any increase in withdrawals for Ningxia would come at the expense of users downstream. At the same time, China's Grain for Green reforestation program has increased Ningxia's forest cover from 4.2 percent (1995) to 12.8 percent (2012), potentially reducing water availability due to the high water demand of trees.[14]

In terms of land resources, the national red line for land translates into an increase in cultivated land by 3.5 percent from 2010 to 2015 in Ningxia, whereas cities, industry, mining and transportation are to expand by about 2.5 percent yearly.[15] Consequently, more and more "unused land" is being put into productive use, which can come at the cost of ecosystem services such as carbon sequestration and resources such as water.

Ningxia holds about 3.5 percent of China's coal resources, and has large solar and wind power potential.[16] Within the current Five Year Plan, Ningxia aims to increase its total energy production yearly by 12.6 percent, wind power production by 45 percent and solar power production by 61 percent.[17] The current heavily coal based (95 percent) energy production and energy intensive industrial development brings growing tension with other targets to cap total consumption of coal and decrease the carbon-intensity of the economy.[18] It is not clear how much additional water will be required for the development of the energy sector, nor how that demand will be met.

In the short term, much can be gained by improving Ningxia's still very low resource productivity. Ningxia has a target to increase water productivity by 27 percent from 2010 to 2015.[19] Water quality improvement would also enhance the usability of water, and an ambitious action plan on soil erosion control—on almost half of cultivated land by 2015—would undoubtedly help increase land productivity. For long-term sustainable development of the region, there is a strong need for improved coordination and integration across sectors and supply and demand targets.

California: Grappling with Water Scarcity

Water security is a growing concern for California, the most populous US state and producer of nearly half of US-grown vegetables, fruits, and nuts.[20] Most of Californian produce is grown using water intensive irrigation. Only northern California has plentiful water, while the rest of the state relies on major aqueducts. Most notably, the State Water Project (SWP) delivers water to local water agencies that serve twenty-five million people and more than three thousand square kilometers of irrigated farmland in central and southern California.[21] Allocations from the SWP are reduced when water is scarce, and in January 2014, with reservoirs at historic lows due to severe drought, the SWP cut off allocations entirely for the first time in its fifty-four year history.[22]

California officials have long known that water supplies were being consumed faster than they could be replenished, and climate change projections show water stress will likely increase. Much of the state's surface water comes from winter precipitation and spring snowmelt, and over the last thirty years, winters have been getting warmer, the snowpack has declined, and spring stream flow timing has changed.[23]

In southern California, several utilities have been investigating seawater desalination as a way to improve water security. Desalination is very energy-intensive.[24] California's water sector already uses 19 percent of the state's electricity, including energy for pumping, transporting and treating water, and residential, commercial, and agricultural water end-uses. The SWP is California's single largest power consumer, with a net energy use of two million megawatt hours (MWh) per year.[25]

A nexus perspective thus raises the question: How would desalination affect energy use and efficiency in the state? Linked water and energy modelling tools, examined the implications of meeting roughly 5 percent of southern California's current urban water demand with desalinated seawater.[26] It found that desalination could reduce the need for water imports by about three hundred million cubic meters per year, on average, but it would also increase the water sector's electricity use by about three terawatt-hours (TWh) per year.[27]

Concluding Remarks

Many of the proposed SDG targets cut across and support multiple development objectives. In the past year the approach to formulating the SDGs has

been to set targets around pre-determined areas. The approaches presented in this paper could serve as a starting point for visualizing and jointly exploring a more integrated approach. Such an approach would aim to avoid a final SDG framework in which targets are conflicting or overlapping, and help identify potential synergies between goals that suggest win-win solutions and make the framework more cost-efficient.

Integrated approaches offer the potential of providing decision makers with the information needed to support sustainable development pathways. They can thus support action on the SDGs that is more equitable and benefit those who need it the most while respecting the needs of ecosystems. The approaches suggested here may also support more effective negotiations, by enabling countries and sectors to see more clearly where their interests coincide, where they diverge, and how they might reconcile their differences.

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Some might argue that a focus on interactions would add complexity to the SDG process. It is true that interactions are complex, but the approach merely exposes complexities that already exist, but are often overlooked. By proactively addressing those complexities in the formulation of the SDGs, we can produce a more concise SDG framework with more robust solutions, as redundancies and contradictions have been identified and addressed in the process.

Notes

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