Executive summary

Almost all economic activities are supported by the use of scarce land, water or energy, either directly or indirectly. Nexus is a useful label to describe how these resources are closely interlinked. To avoid negative side effects and to create synergies through policy, efficient management of the nexus resources needs to account for the direct and indirect effects of changes in various resources within the full biophysical and economic systems.

The report addresses the following question: What would be the global and regional biophysical and economic consequences by 2060 because of policy inaction regarding the limited availability of land, water and energy, given their interlinkages? The most direct linkages in the nexus are at the biophysical level, such as in the production of crops; however, it is vital to look at the consequences of the bottlenecks on different economic activities and on different policy objectives: welfare, environmental quality, food, water and energy security.

This report focusses on a dynamic, integrated, and disaggregated analysis of how land, water and energy interact in the biophysical and economic systems. In the modelling analysis that combines the IMAGE and ENV-Linkages models, a set of carefully chosen scenarios reflects on bottlenecks in water supply, land supply and energy supply. The water supply bottleneck scenario examines the consequences of the depletion of selected deep groundwater reservoirs before 2060. The land bottleneck scenario considers the impact of increased urban sprawl and of expanded protected natural areas on the access to land for agriculture. The energy bottleneck focusses on reducing the reliance on increasingly scarce fossil fuels through a partial shift in energy supply towards biofuels. The combined bottlenecks scenario aims to show how the three bottlenecks interact and add-up. The report also examines the sensitivity to the changes in biophysical conditions from alternative assumptions of climate change. This report, a part of the "Cost of Inaction and Resource scarcity: Consequences for Long-term Economic growth" (CIRCLE) project, compares the system-wide performance with selected nexus bottleneck scenarios to a baseline projection without bottlenecks. The top-down assessment carried out in this report complements more fine-grained analysis of the nexus in specific hotspots and provides essential context for such hotspot analyses.

Key findings

- There is no clear evidence to suggest an absolute scarcity of land-water-energy (LWE) resources globally. The impacts from LWE bottlenecks, however, vary significantly across regions and time periods. Therefore the main problem is having the resources at the right time in the right place.
- The multiple nexus interactions imply that the impact of the combined bottlenecks in land-water-energy resources may significantly differ from the summed effects of the individual bottlenecks. In around half of the regions the key results for the

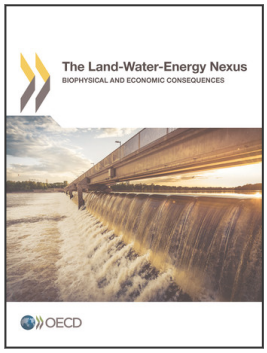
combined scenario are close to the sum of the individual three bottlenecks. In the most fragile regions, the interactions from combining the bottlenecks are more pronounced; this suggests that adding an overarching nexus vision to policy making has clear benefits. The quantitative analysis illustrates how in some regions the exploitation of the least critical (or scarce) resource can overcome the negative economic consequences of the other resources.

- Bottlenecks appear to have a relatively modest negative welfare effects at the global level, depressing GDP and consumption levels somewhat below the baseline level. In contrast, countries that rely heavily on the scarce resources, such as India and the People's Republic of China (hereafter China), could be more severely impacted. Other countries, such as the ASEAN economies and countries in Latin America, might benefit from the changes in international competitiveness of countries.
- Although difficult to quantify, the increasing food prices from the three nexus bottlenecks suggest that the welfare of the poorest households may be particularly vulnerable.
- The nexus bottlenecks combined triple the loss of pristine forest cover from baseline projections driven by demographic and economic trends between 2015 and 2060. Many core environmental services provided by pristine forests are thus seriously affected.
- All bottleneck scenarios lead to deteriorations in food security, as reflected in increasing food prices and increased budget shares spent on food. Furthermore, in most regions the import share of food increases, indicating increased pressure on self-sufficiency. The consequences are especially pronounced in India. The combination of all bottlenecks further amplifies the increase in food prices, while climate change adds to rising food budget shares and reliance on food imports with aforementioned social repercussions in equity issues.
- Even though the projected increase in total irrigation water demand is very moderate, the depletion of non-renewable sources reduces future water security. The combined effect of increasing demand for non-agricultural uses, and depletion of aquifer stocks for irrigation, will have serious implications for water security in many regions and countries, including India, Middle East, North Africa, Mexico and the Caspian region and specific arid parts of other regions. This in turn can also affect food and energy security.
- The implications of the nexus bottlenecks for energy security are much less clear. While energy is a key resource with economic importance, the large traded volumes of energy and the availability of alternative energy sources imply that supply risks are fairly low. A bioenergy policy could improve energy security at the national level, but the quantitative analysis shows that this comes at a trade-off with the other nexus resources, especially land, and can thus threaten other policy objectives such as food security.

Key policy conclusions

- At the global level, the biophysical and economic impacts of bottlenecks in the LWE nexus are moderate. International trade can help spread the risks and limit the worst regional impacts.

- Negative economic consequences of the nexus bottlenecks tend to concentrate in hotspots: countries with strong bottlenecks in economic activities that cannot be substituted or imported, as well as regions with strong decreases in crop yields and higher production costs. North Africa, the Middle East and parts of Asia, not least India, are projected to suffer the most from bottlenecks in the LWE nexus. Policy-makers of these areas can potentially gain a lot from more integrated policy approaches.
- The LWE bottlenecks threaten food security in all regions and water security especially in already water-stressed regions; this could disproportionately affect the poor as their share of income dedicated to food, water and energy tends to be largest.



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