RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

Info Note

Carbon prices, climate change mitigation & food security: How to avoid trade-offs?

Climate change mitigation policies in the agriculture sector must be designed to minimize trade-offs with sustainable development goals

Stefan Frank, Petr Havlík, Hugo Valin, Eva Wollenberg, Tomoko Hasegawa, Michael Obersteiner

OCTOBER 2017

Key messages

- Carbon price policies deliver cost-efficient mitigation across sectors, but can result in trade-offs with food security and other sustainable development goals.
- Scenarios for a 1.5 °C world based on carbon prices could increase the undernourished population by 80 - 300 million in 2050.
- Applying a uniform carbon price across geographic regions and economic sectors has inequitable effects on countries' agricultural competitiveness and food availability.
- Under higher carbon prices, regions with poor productivity – and consequently higher GHG emissions per unit of output – would experience increased agricultural commodity prices.

Way forward

- A full portfolio of policy and economic options that extend beyond carbon prices is needed to avoid food security trade-offs in developing countries. Options include international trade, climate finance, investments in agriculture, redistribution of carbon tax, and improved technologies.
- Mitigation options that reduce trade-offs between greenhouse gas mitigation and food security – such as soil organic carbon sequestration, sustainable intensification, diet shift towards less greenhouse gas-intensive foods, and reducing food waste and post-harvest losses – are key to achieving both food security and climate stabilization targets.
- Steering mitigation to land-rich countries that can mitigate more from land use change than agriculture can achieve both climate change mitigation and food security more cost efficiently.

Agriculture, climate change, and human welfare

Agriculture, climate change, and human welfare have numerous linkages. First, agriculture is among the sectors most sensitive to the impacts of climate change: changes in temperature, precipitation, pests, extreme weather events, etc., could impact future crop and livestock productivities significantly, especially in the tropics. Second, large-scale afforestation and increased biomass use for energy production to decrease greenhouse gas (GHG) emissions from fossil fuels, as well as population and income growth, is exacerbating the competition for fertile land, and raising challenges about how to provide sufficient food and biomass for a growing and richer world population characterized by evolving dietary and energy demands. Third, agriculture is an important contributor to climate change, accounting for up to 24% of anthropogenic GHG emissions (IPCC 2014), including indirect emissions from land use change mainly caused by deforestation.

Given these linkages, agriculture must be an integral part of any global strategy to stabilize the climate. At the same time, climate change mitigation policies must be designed carefully to minimize trade-offs with food security and farmers' livelihoods.

Potential trade-off with food security

A major concern in implementing stringent mitigation policies in agriculture is how much the policies would limit potential for increasing food and biomass supply and how they would affect rural livelihoods. Mitigation policies can affect food production via several channels:

- Diverting land from food to energy uses;

- Limiting land for agricultural expansion due to the need to preserve high carbon landscapes such as forests; and
- Shifting towards less GHG-intensive agricultural commodities, for example away from rice and ruminant production toward pig, poultry or cereals.

Mitigation efforts across regions and sectors are typically distributed in integrated assessment models by pricing GHG emissions. Even though a global carbon price delivers cost-efficient mitigation across sectors and regions, such mitigation policy would lead to substantial impacts on food availability if applied to agriculture. For example, if direct emissions from livestock or crop production were taxed, product prices, especially of ruminants and rice, could significantly increase due to the high GHG emission intensity (GHG emission per output of unit produced) of dairy, beef, and rice.

Figure 1 shows the relative product price changes on agricultural commodities driven by a global carbon tax on direct GHG emissions across world regions and without consideration of adjustments in production, such as shifts to more GHG efficient systems or other dynamics.

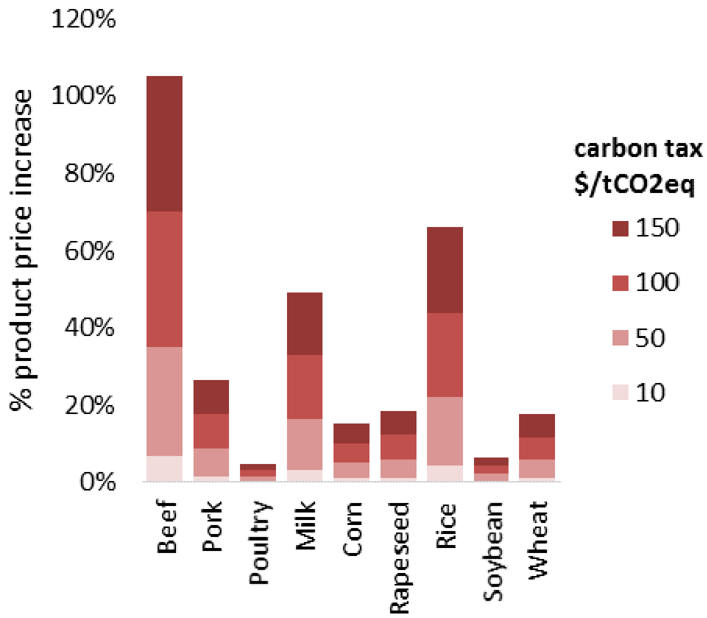

Figure 1. Relative price impact of a carbon tax (0 – 150 \$/tCO_2eq) on global commodity prices. *The carbon tax covers methane (CH_4) and nitrous oxide (N_2O) emissions from crop and livestock production (Frank et al. 2017).*

Geographically, changes in the food price index would be least impacted in regions characterized by efficient agricultural production systems, such as in North America and Europe. However, regions with poor productivity and consequently higher GHG emission intensity, would likely experience a significant increase in agricultural commodity prices if current inefficient production systems continue. Expected price increases would be most notable in the livestock sector in Sub-Saharan Africa, South Asia, and Southeast Asia.

Climate change impacts vs. mitigation efforts

Both the impacts of climate change and efforts to mitigate climate change affect agricultural prices and food consumption. A recent study commissioned by the World Bank (Havlík et al. 2015) examining the food security impacts of climate change and mitigation policies found that – depending on how mitigation policies are implemented for the agricultural sector – the negative effects of mitigation could be even worse than the negative effects of climate change itself in the medium term. The analysis of the impact of climate change vs. climate change mitigation on calorie consumption per capita shows that a mitigation policy designed to stabilize the climate with a maximum of 2 °C warming uniformly applied to all regions as a carbon tax would result in a 6% reduction in food availability by 2050, which exceeds the related calorie impacts of climate change itself.

Figure 2 presents the trade-offs between global and regional agriculture, forestry, and other land use (AFOLU) mitigation targets and global average calorie loss by 2050. The convex line represents global climate stabilization scenarios, emulated by a uniform global carbon price up to 190 \$/tCO_2eq by 2050 to achieve the indicated radiative forcing values, with the 1.9 W/m^2 scenario corresponding to the 1.5 °C target. The figure shows that low levels of land use GHG mitigation can be cost-efficiently achieved at relatively little cost in terms of calorie loss per capita, but increasingly ambitious stabilization targets lead to increasing trade-offs with food security, indicated by increasing calorie loss.

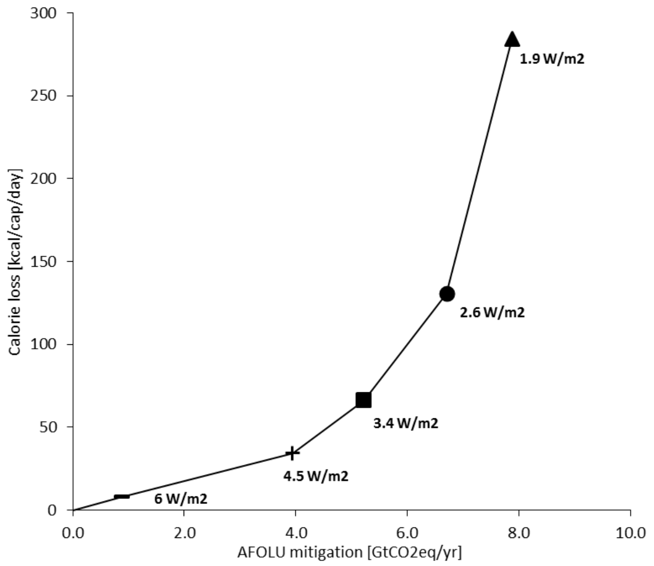

Figure 2. Mitigation and calorie cost curve for the AFOLU sector

Increasing calorie loss results from rising food prices driven by the adoption of GHG mitigation strategies in the land use sector. The carbon price policy limits agricultural land expansion into carbon-rich land cover such as forests, and increases production costs for farmers by taxing emissions of methane, nitrous oxide and carbon dioxide from land use change. Farmers would need to shift towards production systems with lower emission intensity per unit of output produced and possibly abandon GHG-intensive cropping areas and livestock production systems as a result of the carbon price policy.

While in developed countries agricultural demand is unresponsive to price increases, food insecure countries experience a significant reduction of calorie availability due to higher price responsiveness. Calorie availability could drop by up to a global average of 285 kcal per person and per day in a 1.5 °C scenario. Applying the FAOSTAT methodology, this translates to an increase of 300 million chronically undernourished people in 2050. Assuming less responsiveness of consumers in a sensitivity analysis results in less pronounced impacts of the 1.5 °C scenario, but still yields global average calorie losses of 110 kcal per capita and per day and an increase of 80 million chronically undernourished people.

Policy implications

Applying a uniform carbon price across regions and sectors without accompanying (social) policies has inequitable effects on countries' agricultural competitiveness and food availability. Modelling results indicate a food calorie loss of 110-285 kcal per capita and per day on global average in 2050 in a scenario that limits global warming to 1.5 °C. This corresponds to an increase of 80-300 million chronically undernourished people. Hence, mitigation efforts for the agricultural sector must consider aspects beyond cost-efficiency to avoid trade-offs with other sustainable development goals.

Win-win mitigation options that reduce trade-offs between GHG mitigation and food security are necessary in order to avoid achieving ambitious climate stabilization targets at the expense of food security in the most vulnerable regions of the world. Such options exist on both the supply and demand sides and include soil organic carbon (SOC) sequestration, sustainable intensification, shifting diets towards less GHG-intensive products, and reducing food waste and post-harvest losses. For example, the 1.5 °C target can be met at considerably lower costs in terms of calorie loss (-65%) if SOC sequestration measures on agricultural land are promoted (Frank et al. 2017).

Analysis of regional mitigation hotspots and sensitive mitigation pathways (Frank et al. 2017) show that targeting countries with high emissions from land use change minimizes trade-offs with food security and so should also be prioritized when designing mitigation policies. Steering mitigation efforts to countries that are land rich and are thus able to mitigate proportionally more from land use change, rather than agriculture, achieves mitigation and food security more cost-efficiently.

In addition, climate change mitigation policies focused on different emission sources affect agricultural commodity prices very differently. For example, a carbon price on land use change emissions hardly impacts agricultural commodity prices due to intensification possibilities on existing agricultural land that partly offsets forgone area expansion and production decreases. Similarly, large-scale bioenergy production was found to have little impacts on food prices (Havlík et al. 2015) and hence is a promising option for climate change mitigation.

Mitigation policies should encourage GHG-efficient agricultural development in emerging regions, while at the same time not penalizing highly efficient agricultural production systems. International trade may also buffer food security impacts. Together with climate finance, targeted redistribution of carbon price revenues, and additional investments in agriculture, the options presented above could ensure that all countries can contribute to mitigation efforts without jeopardizing food security or other development objectives.

Further reading

- Frank S, Havlík P, Soussana J-F, Levesque A, Valin H, et al. 2017a. Reducing greenhouse gas emissions in agriculture without compromising food security? *Environmental Research Letters*.
- Frank S, Havlík P, Soussana J-F, Wollenberg E, Obersteiner M. 2017b. The potential of soil organic carbon sequestration for climate change mitigation and food security. CCAFS Info Note. Available from: www.ccafs.cgiar.org
- Frank S, Havlík P, Valin H, Wollenberg E, Obersteiner M. 2017c. Regional mitigation hotspots and sensitive mitigation pathways. CCAFS Info Note. Available from: www.ccafs.cgiar.org
- Havlík P, Valin H, Gusti M, Schmid E, Forsell M, et al. 2015. Climate change impacts and mitigation in the developing world: an integrated assessment of the agriculture and forestry sectors. Policy Research working paper. Washington, DC: World Bank Group. Available from: http://documents.worldbank.org/curated/en/866881467997281798/pdf/WPS7477.pdf
- Havlík P, Valin H, Herrero M, Obersteiner M, Schmid E, et al. 2014. Climate change mitigation through livestock system transitions. Proceedings of the National Academy of Sciences 111. Available from: http://doi.org/10.1073/pnas.1308044111
- IPCC 2014. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Available from: http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf
- Riahi K, van Vuuren DP, Kriegler E, O'Neill B. n.d. The Shared Socio-Economic Pathways (SSPs): An overview. Available from: https://unfccc.int/files/science/workstreams/research/application/pdf/part1_iiasa_rogelj_ssp_poster.pdf

Research led by IIASA Science for Global Insight www.iiasa.ac.at

This series of briefs summarizes findings from the project "Identifying low emissions development pathways" *(https://ccafs.cgiar.org/identifying-low-emissions-development-pathways), undertaken by researchers from the International Institute for Applied Systems Analysis in collaboration with the CCAFS Low Emissions Development flagship. Using IIASA's integrated assessment modelling, the project team developed scenarios to identify pathways and priorities for mitigation in the agriculture and land use sector. It is hoped that these results will bring attention to policymakers, donors, and other stakeholders, thereby contributing to the design of AFOLU mitigation policies around the world. The briefs are:*

- *Carbon prices, climate change mitigation & food security: How to avoid trade-offs?*
- *Potential of soil organic carbon sequestration for climate change mitigation and food security*
- *Regional mitigation hotspots and sensitive mitigation pathways*

***Stefan Frank** (frank@iiasa.ac.at) is a research scholar in the Ecosystems Services and Management Program at IIASA. This brief is based on Frank et al. (2017) "Reducing greenhouse gas emissions in agriculture without compromising food security?"*

***Petr Havlík** is a senior research scholar, **Hugo Valin** is a research scholar, and **Michael Obersteiner** is program director of the Ecosystems Services and Management Program at IIASA. **Eva Wollenberg** leads Low Emission Development research for CCAFS. **Tomoko Hasegawa** is a guest research scholar at IIASA from Japan's National Institute of Environmental Studies.*

CCAFS and Info Notes

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a strategic partnership of CGIAR and Future Earth, led by the International Center for Tropical Agriculture (CIAT). CCAFS brings together some of the world's best researchers in agricultural science, development research, climate science and Earth System science, to identify and address the most important interactions, synergies and tradeoffs between climate change, agriculture and food security.

CCAFS Info Notes are brief reports on interim research results. They are not necessarily peer reviewed. Please contact the author for additional information on their research.

www.ccafs.cgiar.org

CCAFS is supported by:

CGIAR Fund · Australian Government Australian Centre for International Agricultural Research · Irish Aid · Ministry of Foreign Affairs of the Netherlands · New Zealand Ministry of Foreign Affairs & Trade Manatū Aorere · Swiss Agency for Development and Cooperation SDC · UKaid · USAID From the American People · IFAD