Agriculture: costs and benefits of adaptation

Key Messages

- Agriculture has the potential to be impacted by a large number of risks associated with climate change, positive (e.g. CO2 fertilization or extended growing season,) and negative (e.g. increased rainfall variability and extensive periods of drought).
- The literature has moved from considering a narrow set of technical options (e.g. irrigation) to a broader range including diversification, shifts to other crops or other regions, conservation agriculture, sustainable soil and water management.
- More attention is given to uncertainty, co-benefits and conflicts, and capacity barriers, with a shift in terms of timescales considered, and approaches examining low regret options, robust strategies and iterative risk management.
- The distribution of costs e.g. between farmers, or between the public and private sectors is also increasingly integrated to account for affordability and equity issues.

Context

Agriculture is expected to see both positive effects, such as CO2 fertilisation or extended growing seasons, as well as negative effects, like lower rainfall and increased variability. Changes in extremes and increased range and prevalence of pests and disease will impact all agricultural sectors. It is fairly well established that the impacts on yield will be negative above a 2°C rise in tropical and temperate regions, however short-term impacts are uncertain and gains in yield may be possible particularly in colder climate regions.

A number of adaptation measures exist including: changing planting dates, using new varieties, diversification (and other risk reduction strategies) and sustainable soil and water management techniques. Many options exist specifically in the realm of soil and land management, such as: no-tillage techniques, de-compaction, buffer strips, agroforestry, cover and catch crops and residue management. Additionally, improving irrigation schemes is seen as a good option to address potential water scarcity but the cost of the systems may be prohibitive.

Policy and methodological developments

Global and national assessments

A UNFCCC study (McCarl, 2007) estimated global adaptation costs for the agriculture sector at USD 14 billion annually by 2030, which half of this coming from developing countries. Using various models and projections, another study estimated the cost for developing countries at only USD 2.5-3 billion annually (EACC, 2010); in part due to welfare restored through trade. A number of similar studies exist for developing countries, such as crop modelling studies in Bangladesh, Bolivia, Ethiopia, Ghana, Mozambique, Samoa and Vietnam (World Bank, 2010a, b, c, d, e, f, g); India (Markandya and Mishra, 2010); and Brazil (Margulis and Dubeux, 2010). Additionally, there are studies on sector investment and financial flows in Bangladesh, Colombia, Ecuador, the Gambia, Liberia, Namibia, Niger, Paraguay, Peru, Togo, Turkmenistan and Uruguay (UNDP, 2011). Other comprehensive overview include Mendelsohn et al. (2009) and Antle (2008).

In the past, constraints and cross-sectoral concerns were rarely taken into account. These older studies had optimistic assumptions about the substitution of domestic production for international trade, and did not include externalities associated with lower food security levels. Lastly, uncertainty was not factored into analyses, co-benefits and conflicts were ignored, and capacity barriers were left out. Recently, studies have attempted to address these issues (e.g. Iglesias et al., 2012). Timescales have shortened and the idea of decision making under uncertainty has become more prominent.
There are more sophisticated assessments being undertaken at various levels which include consideration of global food markets, trade, and the cost of climate adaptation (FAO, 2015). These studies may link crop models and global trade models to explore climate change impacts and adaptation policies (Mosnier et al., 2014). Some studies have also begun to incorporate uncertainty and robustness, as well as transformational adaptation (Leclère et al., 2014), or stochastic modeling (Fuss et al., 2011; 2015). Recently work has also been started to integrate crop growth models in integrated assessment models to account for the feedback between land use, crop choices and climate change.

**Studies on climate smart agriculture**

While some earlier impact assessment based crop modelling studies focused on very specific, narrow options (in particular irrigation and fertiliser use), more recent studies have broadened their consideration of adaptation options. The idea of climate smart agriculture has become especially prominent recently, focused on sustainable agricultural land management practices including agroforestry, soil and water conservation, reduced tillage and the use of cover crop (FAO, 2013). Studies include a qualitative cost-benefit analysis of various options in Canada (British Columbia, 2013), as well as a cost-benefit analysis of low tillage in Germany (Tröltzsch et al., 2012). Climate smart options are particularly attractive in developing countries because of the benefits from rain-fed agriculture; various studies have been carried out in this area (McCarthy, Lipper and Branca, 2011; Branca, 2011; ECA, 2009; Lunduka, 2013). These studies mostly report high benefits for climate smart options and even significant co-benefits in some instances. However, McCarthy, Lipper and Branca (2011) point out that there can be high opportunity or transaction costs associated with some of these adaptation options.

**Studies on low-regret options**

Similarly to climate smart agriculture approaches, there are numerous promising early low-regret options. In OECD countries, such strategies include increasing water supply through on-farm storage reservoirs and incentivizing efficient water management, introducing soil conservation measures and increased expenditures on research and development (Wreford and Renwick, 2012; Moran et al., 2013). One study in Germany determined that crop switching had a high benefit to cost ratio (Tröltzsch et al., 2012). In Australia, Howden et al. (2003) noted high benefit to cost ratios for increased research and development.

In developing countries, many of the emerging low-regret adaptation strategies overlap with existing agricultural development strategies. Some of the promising options include: climate information, agro-meteorological information, seasonal forecasting and early warning; research and development; agronomic management; pest and disease management; soil and water management; ecosystem based adaptation; and insurance (Ranger and Garbett-Shiels, 2011; ECONADAPT, 2015). These options generally work best when implemented as a portfolio, and not individually (Di Falco and Veronesi, 2012).

Main implications and recommendations

Studies in the agriculture sector are beginning to undergo changes in the approach to climate change adaptation. There is an increased attention to uncertainty, co-benefits and conflicts, and capacity barriers, and iterative risk management. In the United Kingdom, Frontier Economics (2013) developed adaptation pathways to identify early options to improve adaptive capacity. Similar ideas were applied to the Ethiopian Climate Resilience Strategy (FRDE, 2015), and real options analysis was used to assess agricultural irrigation in Mexico (World Bank, 2009). A shift in terms of timescales considered can also be observed, with newer studies focusing on more immediate options, but also greater consideration to opportunity costs (e.g. estimation of income foregone that may be experienced if options are implemented). A larger range of adaptation options is considered, including efficient water use and climate smart agriculture. There is also increased attention to the role of international trade and its limitations, as well as externalities associated with lower food security levels. Finally, there is greater consideration of the distribution of costs...
and issues of affordability and inequalities. It is recommended to pay more attention to awareness raising of the impacts of climate change on the agricultural sector in order to adapt in early stages, particularly in the planting of perennial crops and trees.

Bibliography


ECA (2009), Shaping climate-resilient development. A Framework for a decision making


FDRE (2015), Ethiopia’s Climate-Resilience Strategy Agriculture, Federal Democratic Republic of Ethiopia, Environmental Protection Authority.


McCarl, B.A. (2007), Adaptation Options for Agriculture, Forestry and Fisheries, a report to the UNFCCC Secretariat, Financial and Technical Support Division.

McCarthy, N., L. Lipper and G. Branca (2011), Climate-Smart Agriculture: Smallholder Adoption and Implications for Climate Change Adaptation and Mitigation, Mitigation of Climate Change in Agriculture Series, No. 4, FAO, Rome.


Moran, D. et al. (2013), Research to assess preparedness of England’s natural resources for a changing climate: Part 2 - assessing the type and level of adaptation action required to address climate risks in the ‘vulnerability hotspots’, Report to the Adaptation Sub-Committee of the Committee on Climate Change, United Kingdom.


World Bank (2010b), Mozambique – Economics of adaptation to climate change, World Bank, Washington, DC.

World Bank (2010c), Ghana – Economics of adaptation to climate change, World Bank, Washington, DC.

World Bank (2010d), Samoa – Economics of adaptation to climate change, World Bank, Washington, DC.

World Bank (2010e), Ethiopia – Economics of adaptation to climate change, World Bank, Washington, DC.

World Bank (2010g), Bangladesh – Economics of adaptation to climate change, World Bank, Washington, DC.


Further Information
Overview of costs and benefits of adaptation at the national and regional scale
Using cost and benefits to assess adaptation options [pdf]
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