Food and Agriculture Organization of the United Nations

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Climate change impacts and adaptation options in the agrifood system

Brief summary of the Intergovernmental Panel on Climate Change sixth Assessment Report

Highlights

- The Intergovernmental Panel on Climate Change (IPCC) sixth Assessment Report (AR6) gives more attention to health, nutrition, and migration; Indigenous knowledge; gender and other social inequalities; ecosystem-based adaptation; maladaptation; and non-crop systems and mixed systems, like crop-livestock systems, than previous Assessments.
- The Assessment confirms the significant impacts of climate change on agrifood systems. The authors state that 10 percent of the currently suitable area for major crops and livestock are projected to be climatically unsuitable by mid-century under high emission scenarios.
- Observed impacts are throughout the supply chain, from agricultural yields to supply chain disruptions, and climate impacts interact with other drivers to generate conflicts and migration.
- Extreme events are increasing, causing substantial direct economic damage, and reducing economic growth, up to 15 years after the event.
- Climate change increases the risk of hunger, malnutrition, and diet-related mortality, and is particularly problematic in Africa and south Asia, and disproportionately hits vulnerable groups.
- There are countless adaptation technologies and practices, many of them ecosystem-based. However, the Assessment notes that current options will be unable to deal with 2 °C+ global temperatures, and for many options there is lack of information on economic and institutional feasibility. Maladaptation is a problem.
- It is crucial to deal with the enabling environment if adaptation actions are going to reach the scale that is needed.

Working Group II (WGII) of the IPCC focuses on "Impacts, Adaptation and Vulnerability" and many of its findings in several chapters are relevant to the agrifood system (IPCC, 2022). This brief summary of WGII's contribution to the sixth Assessment Report (AR6) focuses on the Assessment's conclusions and their effect on agrifood systems.

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What are the new directions and themes in AR6?

WGII AR6 stands out from previous Assessment Reports by giving more attention to:

- Health, nutrition, migration
- Indigenous knowledge
- Gender and other social inequalities
- Ecosystem-based adaptation
- Maladaptation
- Non-crop systems and mixed systems

For example, AR6 has a much greater focus on Indigenous and local knowledge than earlier IPCC Assessments. It recognizes the important role of Indigenous knowledge in adapting to climate change, though also points to the need to bring in new knowledge. WGII AR6 also integrates knowledge more strongly across the natural, ecological, social, and economic sciences than previous Assessments, and thus gives considerable focus to gender and social inclusion. The Assessment pays more attention to ecosystem-based adaptation, variously termed and sometimes encompassing concepts such as nature-based solutions, agroecological approaches, diversification, land restoration, among others. The authors state that ecosystem-based approaches have the potential to strengthen resilience to climate change with multiple co-benefits, but trade-offs and benefits vary with socioecological context. There is increased evidence of maladaptation across many sectors and regions since the AR5. Maladaptation exacerbates existing inequalities, and can create new vulnerabilities that are difficult and expensive to address.

Observed and projected impacts

There is hardly any good news for observed and projected impacts of climate change on crops, livestock, fisheries, and aquaculture. These impacts include yield declines; a rise in weeds, pests and diseases; supply chain disruptions; economic damage; increasing food and nutritional insecurity; and conflicts and migration. For example, as stated in the report: “the rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt (high confidence).” Extreme events are increasing, causing substantial direct economic damage, and reducing economic growth, up to 15 years after the event. The authors suggest that around 10 percent of current areas of production will be climatically unsuitable by mid-century under high emission scenarios.

There is hardly any good news for observed and projected impacts of climate change for crop, livestock, fisheries, and aquaculture. These include yield declines; a rise in pests and diseases; supply chain disruptions; economic damage; increasing food and nutritional insecurity; and conflicts and migration.

For crops, there are some positive effects in high latitudes, but mostly negative effects in sub-Saharan Africa, south America and the Caribbean, southern Asia, and western and southern Europe. For example, in western Africa, warming has increased heat and rainfall extremes, and reduced yields by 10–20 percent for millet, and 5–15 percent for sorghum. Increased, potentially concurrent, climate extremes will periodically increase simultaneous losses in major food-producing regions.

Climate change impacts livestock systems in many ways, including negative effects on animal heat stress, changes in rangeland quality and water access, and increased incidence of vector borne diseases and parasites. For example, there has been an observed range expansion of economically important tick disease vectors in north America and Africa posing new public health threats to humans and livestock. Woody encroachment is projected to occur on 51 percent of global rangeland area.

Rural households in low and middle-income countries earn almost 70 percent of their income through mixed production systems and mixed production systems can help in adapting to climatic risks and reducing greenhouse gas emissions. However, mixed systems may come with trade-offs, such as the high levels of management skill and extra labour required and increasing burdens on women.


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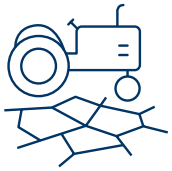
Pests, weeds, and diseases, including zoonoses, are expected to change in occurrence and distribution, while control will become costlier. Significant poleward expansions of many important groups of crop pests and pathogens; climate change and rising carbon dioxide levels favouring the growth and development of weeds over crops and reducing herbicide efficacy; and a warmer climate increasing the need for pesticides were amongst the many findings cited in the Assessment.

Ocean and inland systems and their fisheries, both wild capture and aquaculture, are already facing significant impacts of climate change. In the northeast Pacific, for example, over five years of warmer than average water temperatures have affected the migration, distribution, and abundance of several fisheries resources. Increasing ocean acidity, declining dissolved oxygen, the redistribution of salt content, and the increasing vertical stratification, all have negative consequences for marine organisms and the associated fisheries and mariculture.

Supply chains will be hit by food safety concerns, impacts on storage, and disruptions to transport and trade networks. Food safety is impacted by climate change through multiple pathways: toxigenic fungi; plant and marine based bacterial pathogens; harmful algal blooms; and increased use of chemicals for plant protection and veterinary drugs. Extreme weather events can impact storage, for example, through electricity failures and loss of cold storage. This is a particular problem for nutrition-dense foods, which tend to be more perishable than other foods. Warming can also impact the cost of storage, given an increased need for cooling facilities, and reducing producer incomes and raising consumer prices. Post-harvest losses are expected to increase, given the number of mice, rats, insects, and microorganisms such as toxigenic fungi are expected to increase in warmer and more humid conditions.

Climate change also increases the risk of hunger, malnutrition, and diet-related mortality. Increased carbon dioxide concentrations are



Around 10 percent of current areas of production will be climatically unsuitable by mid-century under high emission scenarios.

Many options may be effective in a 1.5 ℃ or 2 ℃ world, but the negative impacts will grow with greater warming levels.

expected to decrease the nutritional density in some crops. In sub-Saharan Africa, climate change is an emerging risk factor for undernutrition, especially in countries relying on subsistence agriculture. Women and children are particularly at risk. Due to rising temperatures in 51 countries affected by El Niño southern Oscillation intensity in 2015–2016, it is estimated that 5.9 million children became underweight. Geographically, nearly 80 percent of the population at risk of hunger are projected to occur in Africa and Asia. Agricultural labour will be increasingly exposed to heat stress.

Weather events can act as indirect drivers of migration and displacement. Rising food prices can affect conflict, political instability, and migration, but often interact with other non-climatic drivers.

Climate change disproportionately affects vulnerable groups (women, children, low-income households, Indigenous or other minority groups, and small-scale producers). It can lead to malnutrition, livelihood loss, rising costs, competition oaver resources, and most importantly, further amplify vulnerabilities and inequalities and undermine sustainable development. Globally, smallholders are more vulnerable than large-scale producers to climate change due to, amongst other things: limited policy, infrastructure, and institutional support; low credit access; lack of viable markets; limited political voice in policy debates; and heavy reliance on one crop for income.

Adaptation actions

The overall situation is that, while many adaptation options have been implemented, on-farm adaptations are insufficient to meet Sustainable Development Goal 2 (SDG2) on zero hunger, with climate impacts interacting with non-climatic drivers of food and nutritional insecurity. The most frequently reported adaptation-related responses are autonomous adaptation: behavioural changes made by individuals and households in response to drought, flooding, and rainfall variability in Africa and Asia.

Autonomous adaptation includes livestock and farm management; switching varieties or species (for example to less water-intensive crops); diversifying farming systems and livelihoods; altered timing of key farm activities such as planting, stocking, and harvesting; and making fish harvesting gear modifications to access new target species. However, individuals and households often have insufficient adaptive capacities, and non-climatic factors further drive food insecurity, especially in Africa, Small Island Developing States and south Asia.

There are, however, increasing numbers of government-led planned adaptation initiatives, including coordination mechanisms; disaster and emergency planning, and social safety net interventions (that relate to agricultural livelihoods); extension services to support farmer uptake of, for example, drought tolerant crops; and managing weather risks through insurance products.

The authors state that currently available management options have the potential to compensate global crop production losses due to climate change up to ~2 °C warming, but the negative impacts even with adaptation will grow substantially from the mid-century under high temperature change scenarios. Under this high temperature scenario, the costs of adaptation will be substantial.

Some countries will have the resources to support people at risk with planned adaptation actions, as illustrated by the compensation payments for drought exposed farmers in Australia. However, the literature shows that the poorest groups in society, especially those in poorer countries, often lose out due to climate change and require greater planned adaptation support. Unfortunately, this support is often lacking due to disenabling policies and the difficulty of mobilising the needed finance.

Maladaptation emerged as a major topic in AR6 across all sectors. Many examples of maladaptation are drawn from activities common to agricultural development (and not primarily climate change response). This indicates that strategies and action for agricultural development and climate adaptation should be carefully selected and implemented. Three categories of maladaptation can be recognized: (1) Short-term adaptations that decrease adaptive capacity and hinder future choices; (2) Shifting vulnerability from one group to another, or one area to another; and (3) Eroding sustainable development through adaptation strategies which increase emissions or deteriorate environmental conditions and/or social and economic values.

The following are some of the many examples of maladaptation given in the report. Efficient irrigation technologies like drip and sprinkler irrigation can reduce water application rates per unit output, but their broad application can increase overall water extraction by increasing the total land under irrigation. Shifting from agroforestry coffee and cocoa systems to high-input monoculture systems can raise incomes in the short term, but in the longer term there is reduced resilience and carbon storage. Water-related and other technologies can have negative outcomes on certain groups when only rich and male farmers can adopt high-cost technologies like solar irrigation pumps. Large-scale irrigation schemes can reduce the long-term potential of hydropower and groundwater availability, and increase salinization and the cost of water.

Adaptation technologies and practices

There are many technical adaptation options but these need to go hand in hand with creating an enabling environment. Unfortunately, for many options there is a lack of information on their economic or institutional feasibility, as well as on the limits to adaptation like, for example, the degree to which they are effective under different warming scenarios. Effective adaptation options for specific localities, farming systems and farmer socioeconomic situations (related to gender and income levels) are obviously highly context specific. Many of the options involve ecosystem-based adaptation, such as diversification, agroecology, and agroforestry. These have the potential to strengthen resilience to climate change, but co-benefits and trade-offs vary with socioecological context.

Creating an enabling environment

The WGII AR6 states that worldwide climate resilient development is more urgent than previously assessed in AR5. We need to shift away from the current situation of small, fragmented, sector-specific actions that will lead to the adaptation gap growing. The Assessment distinguishes between soft limits to adaptation and hard limits and suggests that soft limits have been reached for many smallholder farming households. These soft limits can be overcome by realizing an enabling environment for adaptation action.

Dealing with structural vulnerabilities

Impacts of climate change in combination with non-climatic drivers can create poverty-environment traps that increase the probability of chronic poverty. Many adaptations aim to reduce exposure to climate-related hazards or help households cope with climate change, rather than addressing the root causes of structural vulnerability. Addressing structural vulnerability means that responses to climate change should consider institutional root causes, be intersectoral, and require higher levels of coordination from community levels to national levels, and higher coordination and integration across sectors.

For many adaptation options there is a lack of information on their economic or institutional feasibility, as well as on the limits to adaptation.

Climate services can improve agricultural practices but must be carefully employed as not to worsen existing inequalities.

Table 1. Summary of possible adaptation options

Cultivars and breed improvements (crops, livestock, aquaculture)	Genetic improvements are an effective option for adapting to climate change, drawing on modern biotechnology and conventional breeding. Genome sequencing significantly assists in identifying genes relevant to adaptation. However, a variety of socioeconomic and political variables limit uptake of climate-resilient crops and breeds, especially by the most vulnerable farmers.
Changing management practices for crops, livestock, and aquaculture	Many management adaptation options are available, including changing the timing of key farm operations and implementing different tillage practices. For livestock, options include matching of stocking rates with pasture/feed production and adjusting herd and watering point management. Land-based aquaculture systems may reduce exposure to climatic extremes, due to a better control of the environment, and buffer climate effects using optimal diets.
Switching crops, breeds, and farming systems	Farming system transitions are already occurring in a variety of settings. Given that there are many different crop species, there is great potential for crop switching to match changing climates, but cultural and economic barriers will make implementation difficult. Similar considerations apply to livestock and fish. In general, many of these switching options come with trade-offs.
Managing water	Irrigation is one of the most common adaptation responses in agriculture. Hence, expansion of irrigation in the coming decades is expected, leading to shifts from rain-fed to irrigated systems. Many techniques can be used to make irrigation more efficient. However, irrigation is also associated with adverse environmental and socioeconomic outcomes, including the concentration of benefits in richer households.
Diversifying agricultural systems	Various types of diversification can strengthen resilience to climate change, with socioeconomic and environmental co-benefits. However, tradeoffs and benefits vary by socioecological context. Multiple diversification options are feasible, including mixed planting, intercrops, crop rotation, diversified management of field margins, agroforestry, and integrated mixed systems.
Managing fisheries	For coastal and inland fisheries, there are relatively few well-documented examples of eaffective adaptation responses to climate change. Over-fishing is a critical non-climatic driver in the fisheries sector, and reducing over-fishing is an important adaptation measure.
Supply chain options	There are also a range of supply chain adaptation options, like selecting crops with longer shelf life; better-planned harvesting schedules to maximize shelf life; different processing techniques for longer preservation; enhanced hygiene through improved packaging; and improved cold storage mechanisms.

Source: Bruce Campbell

Addressing gender and other social inequalities (like racial, ethnicity, age, income, and geographic location) in markets, governance and control over resources is a key enabling condition for climate resilient transitions. If not addressed, adaptation strategies and technical approaches can worsen socioeconomic inequalities. Key to an enabling environment for tackling inequalities involve inclusive decision-making; capacity-building; shifts in social rules, norms, and behaviours; access to resources for marginalized groups for climate change adaptation; empowerment; and structural approaches to tackling gender inequalities. Furthermore, it is important to understand the role youth play in all aspects of the agrifood system. Harnessing youth innovation and vision will support effective climate change adaptation, foster systemic change, as well as address youth marginalisation. Indigenous and local knowledge facilitate adaptation strategies, especially when combined with scientific knowledge using participatory and community-based approaches.

Political commitment and follow through

The WGII AR6 concludes that political commitment and follow through across all levels of government accelerate the implementation of adaptation actions. Political commitment and follow through is needed because implementing actions can require large upfront investments of human, financial and technological resources, whilst benefits may only come much later (in the next decade or beyond). Accelerating commitment and follow-through is promoted by rising public awareness; building business cases for adaptation; accountability and transparency mechanisms; mainstreaming adaptation into institutional budget and policy planning cycles; monitoring and evaluation of adaptation progress; social movements; and fostering enhanced knowledge on impacts and solutions.

Institutional frameworks

Successful adaptation action will require effective coordination within government, for example in dealing with growing demands for food, water, and energy under a changing climate. Single-sector policies can create strong trade-offs with other policy targets and Sustainable Development Goals. Maladaptation can also be avoided by flexible, multisectoral, inclusive, and long-term planning and implementation of adaptation actions with benefits to many sectors and systems.

Policies, market, and other instruments with clear goals and priorities

Policies and market instruments that support adaptation actions and system transitions include shifting subsidies; removing perverse incentives, regulation and certification; investment in sustainable value chains; support for capacity-building; empowering farmers; improved access to insurance premiums and credit; payments for ecosystem services social protection; and more secure land, property and grazing rights, among others. Policy support is also needed to incentivize local and national markets, shorter food chains, and food sovereignty, for example through public procurement policies, and innovative institutional mechanisms. Multi-level policies and programs focusing on urban and peri-urban networks, including farmers' markets, public procurement, and incentives for short food value chains are possible areas to support transitions. However, international trade may also play an important role in adaptation, for example when national food systems fail due to extreme events or other related climate shocks. Climate change impacts can be significantly reduced by reducing tariffs and dealing with institutional and infrastructural barriers to trade.

Mobilization of and access to adequate financial resources

Lack of financial resources is a severe constraint to adaptation action and will increase the adaptation gap. Currently, there are still many barriers to increase private sector investment in agrifood systems. Despite increased presence of financial actors, flow of adaptation finance is impeded by weak measurement and benchmarking of financial and resilience outcomes; challenges in assessing repayment capacity of investee producers and companies; and immature information systems (weak analytics and fragmented standards). This inhibits effective due diligence and impact assessment, contributing to low investor confidence.

Insurance

Insurance is one type of financial adaptation strategy that is increasingly used in agriculture and aquaculture. Index-based agricultural insurance is particularly common and helps farmers deal with weather-related production risks. It can provide coverage at a fraction of the costs of loss-based polices, and thus makes it more affordable to insure small plots of land. As with many other adaptation options, insurance may often benefit wealthier farmers, and maladaptive cases have been identified (for example cases where insurance promotes over-fishing).

Expanded climate and extension services, and early warning systems

Limited availability of information and data pose constraints to adaptation, especially for

poorer and more marginalized farmers. Thus, improving extension services is a priority, including extension for diversification practices, agroecological approaches, and nutrient-rich crops, among others. Climate services that are inclusive can improve agricultural practices and inform better water use and efficiency. Bundling them with non-climatic services, like market information, may be effective at improving farmer decision making.

Social protection

Integrated multisectoral strategies that incorporate social protection are effective adaptation responses. These include: cash transfers; weather index insurance; farmer-managed regional storehouses; and asset-building activities such as well construction. These strategies can support short-term response to acute food security but can also build assets for increased resilience.

Index-based insurance is a promising adaptation enabling condition but must be carefully implemented to prevent growing inequalities and maladaptation.

Reference

International Panel on Climate Change (IPCC). 2022. *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Edited by: Portner, H.O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegria, A., Craig, M., Langsdorf, S., Loschke, S., Moller, V., Okem, A. & Rama, B. Cambridge, UK, Cambridge University Press. In Press.

Conclusions

The WGII AR6 makes for sober reading. Climate change impacts are severe and will intensify in the decades ahead. These impacts will have direct and indirect consequences for agrifood systems around the world. At the same time, many on-farm adaptation options will be insufficient to achieve SDG2 and will be ineffective in a more than 2-degree warmer world. Ecosystem-based adaptation does provide some optimism but will require much attention to the enabling conditions for adaptation action and to the social-ecological context.

While it is crucial to implement and scale up diverse on-farm options, it is at least as important to foster an enabling environment. Only coordinated and ambitious action on many fronts will bring the needed transformation that has to happen in agrifood systems.

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