Food and Agriculture Organization of the United Nations

THE IMPACT OF DISASTERS ON AGRICULTURE AND FOOD SECURITY

AVOIDING AND REDUCING LOSSES THROUGH INVESTMENT IN RESILIENCE

IN BRIEF

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This booklet contains the key messages and content from the publication *The Impact of Disasters on Agriculture and Food Security 2023.* The numbering of tables and figures corresponds to that publication.

COVER PHOTOGRAPH ©Toon de Vos/Pexels.com
THE KINGDOM OF THE NETHERLANDS. An average of 12 000 hectares of crops like cotton, corn and walnut were affected by rain and river overflows.

CONTENTS

KEY MESSAGES

➔ Defined as serious disruptions to the functioning of a community or society, disasters are producing unprecedented levels of damage and loss in agriculture around the world. Their increasing severity and frequency, from 100 per year in the 1970s to around 400 events per year in the past 20 years, affect agrifood systems across multiple dimensions, compromising food security and undermining the sustainability of the agriculture sector.

➔ Data for describing the impact of disasters on agriculture and agrifood systems is partial and inconsistent, especially in the fisheries and aquaculture and forestry subsectors. There is an urgent need for improving data collection tools and systems to support evidence-based policies, practices and solutions for risk reduction and resilience building in agriculture. Despite these limitations, this new flagship report presents the first ever global-level estimation of the impact of disasters on agriculture.

➔ Over the last 30 years, an estimated USD 3.8 trillion worth of crops and livestock production has been lost due to disaster events, corresponding to an average loss of USD 123 billion per year, or 5 percent of annual global agricultural GDP. In relative terms, the total amount of losses over 30 years is approximately equivalent to Brazil's GDP in 2022.

➔ Over the last 30 years, disasters inflicted the highest relative losses on lower- and lower-middle-income countries, ranging between 10 and 15 percent of their total agricultural GDP, respectively. Disasters also had a significant impact on Small Island Developing States (SIDS), causing them to lose nearly 7 percent of their agricultural GDP.

➔ Understanding interconnected and systemic risks and underlying disaster risk drivers is essential to build resilient agrifood systems. Climate change, pandemics, epidemics and armed conflict are all affecting agricultural production, value chains and food security. Therefore, gaining a better understanding of their interactions is essential for developing a comprehensive view of today's risk landscape.

➔ Research aimed at deciphering the impact of climate change on agriculture indicates that climate change is likely to lead to more frequent yield anomalies and a decrease in agricultural production. Global crises such as the COVID-19 pandemic and ongoing armed conflicts have impacted agricultural production as well as input and output markets, resulting in negative effects in the wider agrifood system and for overall food security.

➔ Proactive and timely interventions can build resilience by preventing and reducing risks in agriculture. The available information indicates that there are quantifiable benefits to investing in farm-level disaster risk reduction (DRR) good practices. Anticipatory actions undertaken in several countries through early warning systems, such as combined preventative control against the desert locust outbreak in the Horn of Africa during 2020–2021, demonstrated favourable benefit to cost ratios for investing in disaster prevention and resilience.

➔ Urgent action is needed to prioritize the integration of multisectoral and multihazard disaster risk reduction strategies into agricultural policies and programmes. This can be achieved by enhancing the available evidence, fostering the adoption of available innovations, facilitating the creation and uptake of more scalable farm-level risk management solutions, and strengthening early warning systems that lead to anticipatory action.

FOREWORD

Disasters are causing unprecedented levels of destruction across the globe, demanding new approaches to reducing risk, strengthening response and building resilience capacities.

The year 2023 has broken all existing records for the highest temperatures recorded on our warming planet and episodes of extreme floods, storms, droughts, wildfires, and pest and disease outbreaks are becoming daily features in global headlines. As the effect of the climate crisis unfolds, the frequency and intensity of climate-related disasters are also increasing, inflicting a heavy toll on communities and livelihoods across the world. Agriculture is one of the most highly exposed and vulnerable sectors in the context of disaster risk, given its profound dependence on natural resources and climate conditions. Recurrent disasters have the potential to erode gains in food security and undermine the sustainability of agrifood systems.

With this report, the Food and Agriculture Organization of the United Nations (FAO) presents groundbreaking evidence on the global impact of disasters on agriculture and food security over the last three decades. It was my decision to elevate this report to the level of a flagship publication, to reflect our commitment to investing in evidence-based disaster risk reduction solutions and promoting more efficient, inclusive, resilient and sustainable agrifood systems for a better future all around the world.

The findings of the report are stark. We have lost an estimated USD 3.8 trillion worth of crops and livestock production due to disaster events over the past three decades. This corresponds to more than 5 percent of annual global agricultural GDP, a figure that would be significantly higher if systematic data on losses in the fisheries and aquaculture and forestry subsectors was available. We urgently need better information on the impact of disasters in all subsectors of agriculture to create data systems that can serve as the foundation upon which effective action can be built and informed, and to meet the monitoring requirements of the Sendai Framework on Disaster Risk Reduction 2015-2030 and the 2030 Agenda for Sustainable Development.

In some ways, disaster events represent the tip of the iceberg. There are deeper underlying challenges and vulnerabilities created by social and environmental conditions that generate disastrous outcomes and produce cascading effects across agrifood systems.

Poverty, unequal access to resources and governance structures all play a pivotal role in determining the impacts of disasters and crises. Among these, the climate crisis is having a significant effect in amplifying existing risks, but recent pandemics and armed conflicts have also contributed to losses experienced in the agrifood sector. Reducing the impact of disasters will require not only understanding their direct effects, but also necessitates unpacking the overarching conditions that drive risks and the way in which their impacts cascade over sectors, systems and geographical regions.

In a world with limited resources, we need to increase investment in resilience by adopting creative, innovative and scalable solutions that can avoid and reduce losses generated by disasters. Leveraging FAO's technical expertise, this publication showcases opportunities to proactively address risks in agriculture while demonstrating ways to mainstream disaster risk reduction into agricultural practices and policies. It calls for a deep understanding of the context in which these solutions are implemented, as well as strengthened partnerships and collaboration with all relevant partners.

As part of FAO's work to support risk-informed agrifood systems, this report is a valuable addition to the knowledge base required for adopting and scaling up innovative approaches to resilient and sustainable agriculture, thus enabling better production, better nutrition, a better environment and a better life – while leaving no one behind.

Qu Dongyu
FAO Director-General

PART 1
INTRODUCTION

The occurrence and intensity of disaster events is increasing and is expected to worsen as a warming planet faces up to the challenges of an uncertain risk landscape in the context of finite biological and ecological resources. According to the Emergency Management Disasters Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED), the frequency of disaster events has increased from 100 per year in the 1970s to around 400 events per year worldwide in the past 20 years.

The Food and Agriculture Organization of the United Nations (FAO) is launching this new flagship report on *The Impact of Disasters on Agriculture and Food Security*, as part of its ongoing commitment to promote a more inclusive, resilient and sustainable future for agriculture. Building on three prior publications by FAO on this topic, this report aims at organizing and disseminating available knowledge on the impact of disasters on agriculture with a view to promote evidence-based investment in disaster risk reduction.

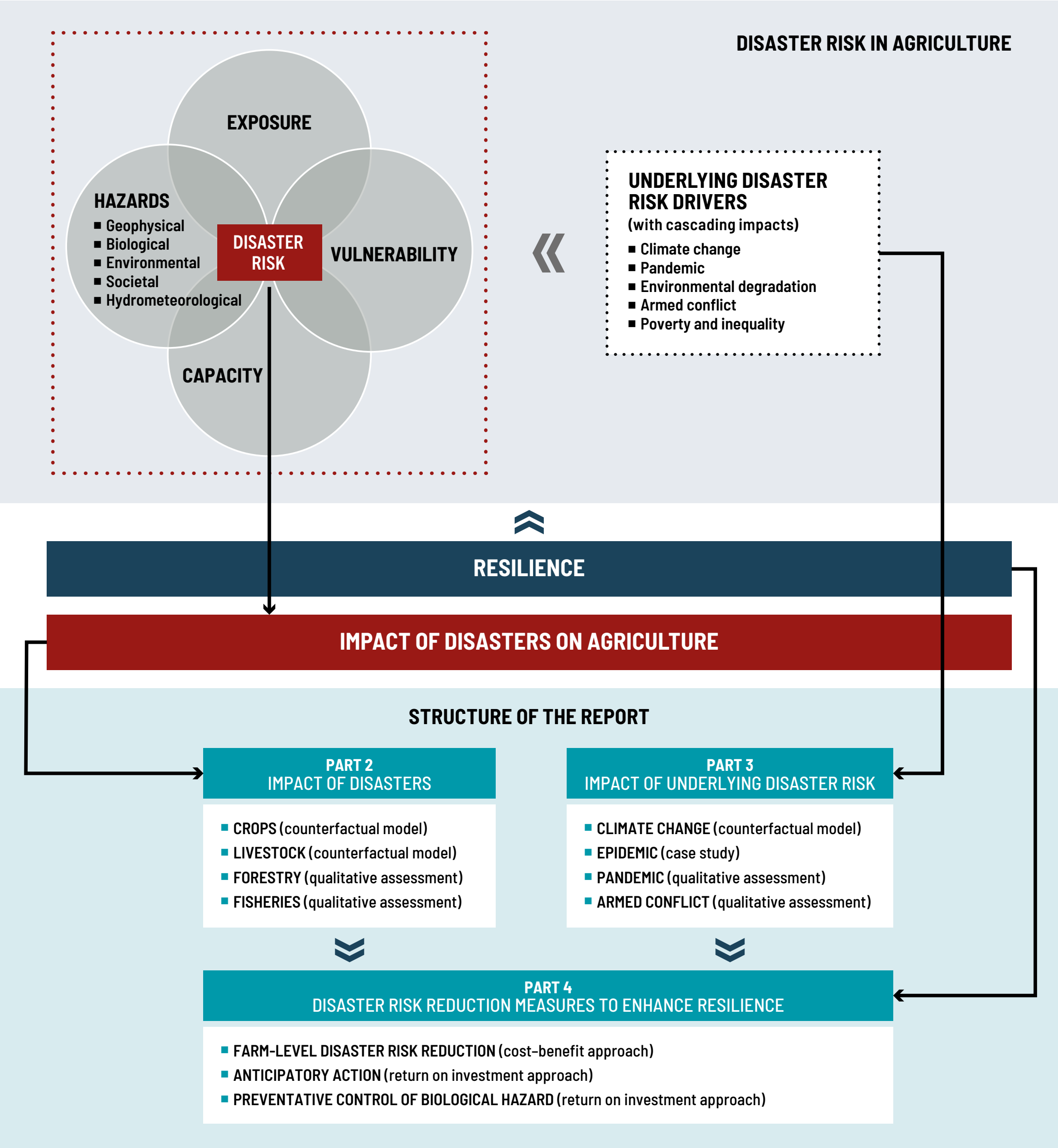
1.1 A CONCEPTUAL FRAMEWORK

Disaster risk is composed of a complex interplay between the physical environment (both natural and built), and society (such as behaviour, function, organization and development). Disaster risk is determined probabilistically as a function of hazard, exposure, vulnerability and capacity, while a disaster refers to a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts (FIGURE 2).

Agriculture is predominantly affected by meteorological and hydrological hazards, geohazards, environmental hazards and biological hazards, although societal hazards such as armed conflict, and technological and chemical hazards also pose potential threats. The amount of loss and damage produced by a disaster

FIGURE 2

CONCEPTUAL FRAMEWORK FOR THE REPORT



Source: Authors' own elaboration.

depends on the speed and spatial scale at which a hazard interacts with vulnerability and pre-existing risks, along with the amount of exposed assets or livelihoods.

The dynamic interaction between hazards and other components of disaster risk is also influenced, as shown in FIGURE 2, by underlying risks drivers and shocks that have cascading impacts, affecting multiple systems and sectors within and across boundaries. The underlying drivers of disaster risk encompass climate change, poverty, inequality, population growth, as well as factors like pandemics, unsustainable land use and management practices, armed conflicts and environmental degradation. ■

PART 2

IMPACT OF EXTREME EVENTS ON AGRICULTURE

2.1 MULTIFACETED IMPACTS OF DISASTERS IN AGRICULTURE

Agriculture around the world is increasingly at risk of being disrupted due to multiple hazards and threats such as flooding, water scarcity, drought, declining agricultural yields and fisheries resources, loss of biological diversities and environmental degradation.

The current warming trends around the globe are already impacting agriculture. In extreme cases, disasters result in the displacement and outward migration of rural populations. Pakistan's southern province of Sindh is an illustrative example of how the combination of slow and sudden onset hazards triggered displacement, negatively impacting food systems and increasing food insecurity.

Women are often the most adversely affected by disaster. Resource and structural constraints are the main drivers of gender disparities in disaster impacts. They have difficulty accessing the information and resources needed to adequately prepare for, respond to and recover from a disaster – including access to early warning systems and safe shelters, as well as access to social and financial protection schemes and alternative employment.

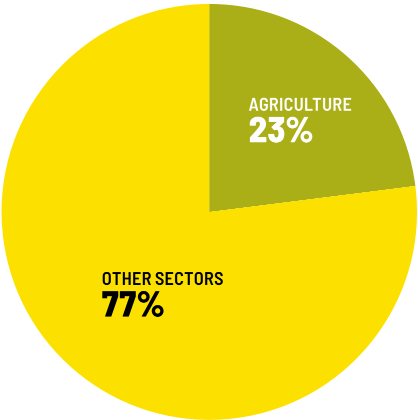
2.2 TOWARDS AN ASSESSMENT OF GLOBAL AGRICULTURAL LOSSES

Understanding the extent and degree to which these weather anomalies and extreme events affect agriculture is the first step to developing disaster risk reduction and climate adaptation strategies. Although several databases record losses and damage associated with disaster events, losses occurring in agriculture and its subsectors are currently not comprehensively assessed or reported as part of total economic losses in existing global, multihazard disaster databases. Missing data and a lack of consistency across existing databases are known limitations of international repositories such as the EM-DAT, DesInventar, the World Bank, the International Federation of Red Cross and Red Crescent Societies (IFRC), databases maintained by global reinsurance groups, as well as national level databases.

Currently, there are two sets of methodologies that are used to collect information on disaster losses in agriculture. The first forms part of post disaster needs assessment surveys (PDNAs), while the second was developed by FAO in coordination with the UN Office for Disaster Risk Reduction (UNDRR) to measure indicator C2 of the Sendai Framework Monitor for Disaster Risk Reduction 2015-2030.

Data from PDNAs show that agricultural losses made up an average of 23 percent (FIGURE 4) of the total impact of disasters across all sectors; and that over 65 percent of losses caused by droughts were experienced in the agriculture sector. Floods, storms, cyclones and volcanic activities account for around 20 percent each.

FIGURE 4
SHARE OF SECTORAL LOSSES



Source: Authors' own elaboration based on data derived from PDNAs.

Data from the Sendai Framework subindicator C2 – which corresponds to direct agricultural losses attributed to disasters – was reported by 82 countries out of the 195, with 38 reporting subsectoral data. Total agricultural losses from disasters reported in the Sendai Framework Monitor amount to an average of USD 13 billion per year, mostly from floods (16 percent), fire and wildfire (13 percent) and drought (12 percent). These figures are likely to be a significant underestimation, given the limitations and delays of data reporting.

2.3 MEASUREMENT AND EVIDENCE ON CROPS AND LIVESTOCK

Data from the EM-DAT and FAOSTAT are used to quantify the impact of disasters on agricultural production at a global scale, focusing on crops and livestock. National average productivity reductions by item are compared to a counterfactual scenario in which disaster events did not occur. Losses are aggregated across different products using prices deflated with 2017 purchasing power parity (PPP) USD. The estimation is repeated 1 000 times to include random disaster events to create a null distribution that determines significance levels and filters for significant yield losses.

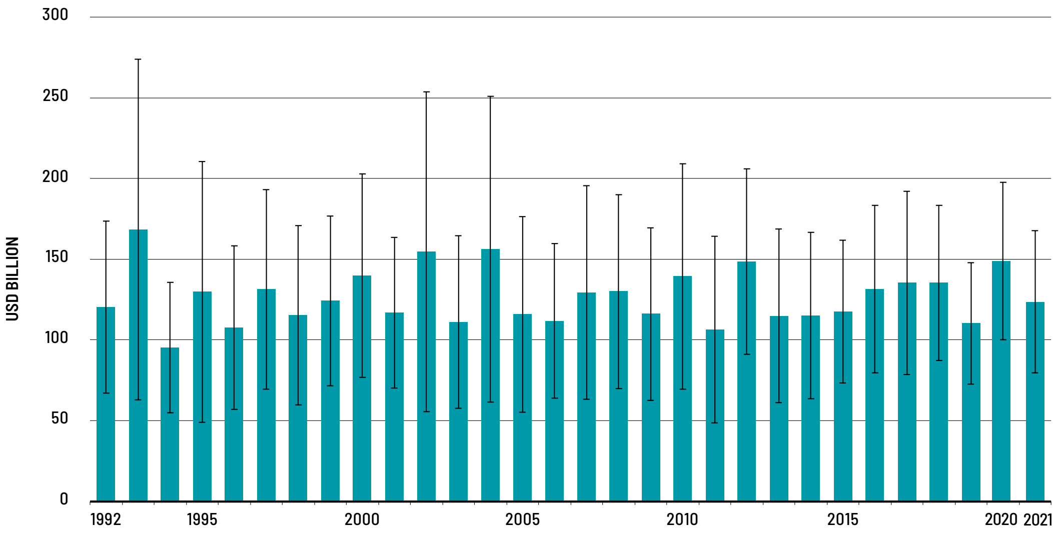
Global aggregated losses for the 1992–2021 period amount to USD 3.8 trillion, corresponding to about USD 123 billion per year. This value is equivalent to 5 percent of global agricultural GDP, and nearly 300 million tonnes of accumulated losses per year, or the real GDP of Brazil in 2022 (FIGURE 9).

For the major product groups, losses display increasing trends. Losses in cereals added up to an average of 69 million tonnes per year in the last three decades, corresponding to the entire production of cereal of France in 2021; followed by fruits and vegetables and sugar crops, which both approached an average of 40 million tonnes per year. For fruits and vegetables, losses correspond to the entire production of fruits and vegetables in Japan and Viet Nam in 2021. Meats, dairy products and eggs show an average estimated loss of 16 million tonnes per year – corresponding to the whole production of meats, dairy products and eggs in Mexico and India in 2021, along with roots and tubers. Both fruits and vegetables present a markedly increasing trend of the estimated losses.

Global losses mask significant variability across regions, subregions and country groups. Asia experiences by far the largest share of the total economic losses.

FIGURE 9

TOTAL ESTIMATED AGRICULTURAL PRODUCTION LOSSES



Source: Authors' own elaboration based on FAO and EM-DAT data.

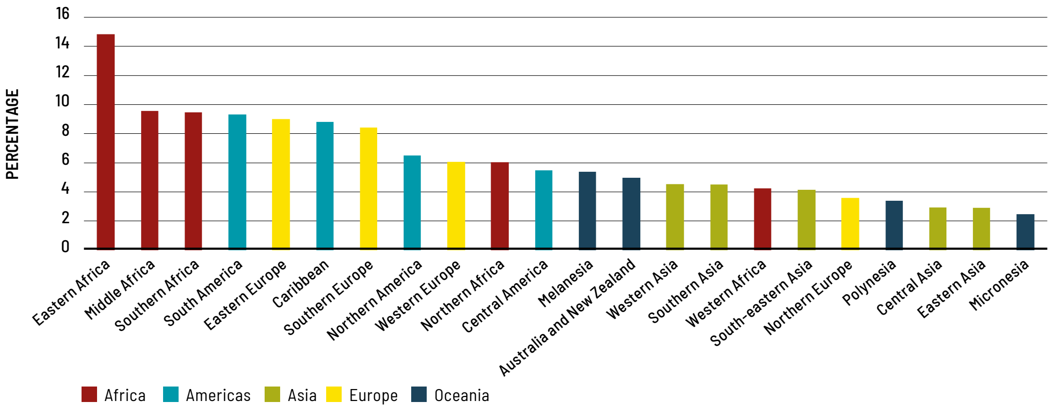
Africa, Europe and the Americas also display a similar order of magnitude. However, losses in Asia only account for 4 percent of the agricultural added value, while in Africa they correspond to nearly 8 percent of the agricultural value added. The variability is even higher across subregions (FIGURE 13).

In absolute terms, losses are higher in high-income countries, lower-middle-income countries and upper-middle-income countries, but low-income countries, and especially SIDS, present the highest incidence of losses in agricultural value added. Compared to the estimated counterfactual production, losses appear to be particularly important in several parts of Africa, primarily eastern and northern Africa, and in the SIDS of the Caribbean, as well in subregions such as western Asia and southern America (FIGURE 14).

A precise attribution of losses to specific hazard types cannot be determined with the estimated crop and livestock data, mainly due to the difficulty of disaggregating impacts for multiple disasters occurring in the same year. Results from a mixed effects regression model show that at the global level,

FIGURE 13

TOTAL AGRICULTURAL LOSSES AS A SHARE OF AGRICULTURAL GROSS DOMESTIC PRODUCT BY SUBREGION (1991-2021)



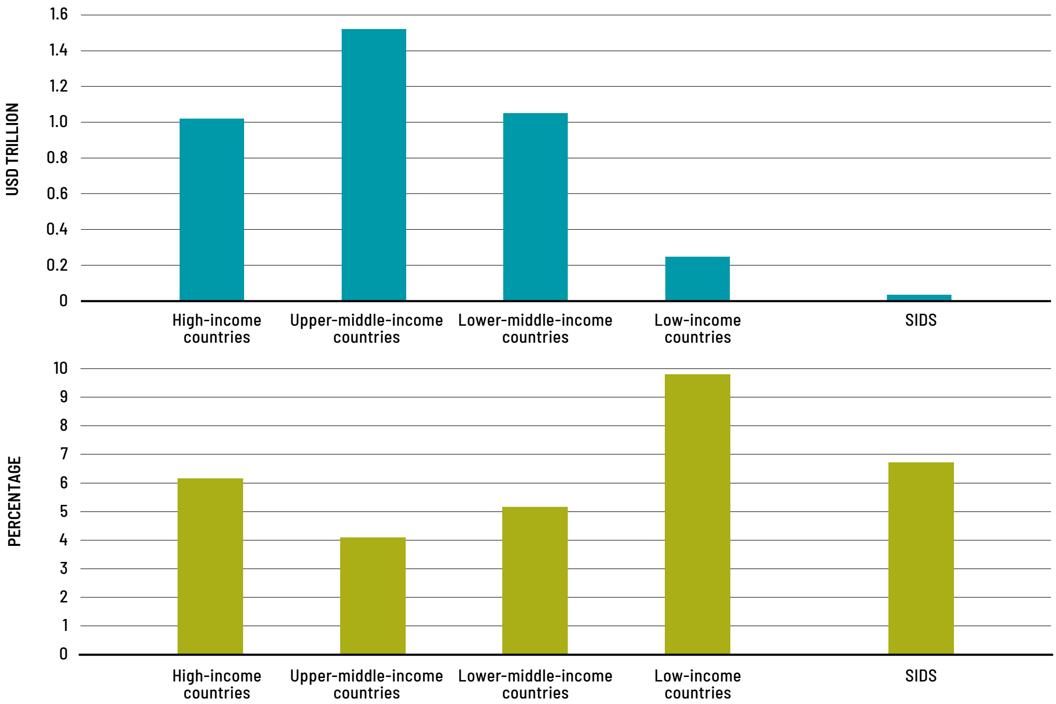
Note: Loss as a share of agricultural GDP is a ratio of subregional aggregate losses by subregional aggregate agricultural GDP over 30 years.
Source: Authors' own elaboration based on FAO and EM-DAT data.

extreme temperatures and droughts are the hazards that bear the largest impact per event, followed by floods, storms and wildfires.

Global losses in crops and livestock are considered also in terms of their corresponding energy and micronutrient values lost for human consumption due to disaster-induced shortfalls in agrifood supplies from 1991 to 2021. It is important to emphasize that the focus here is on the availability of nutrients and energy, and not on changes in consumption patterns due to disasters. Estimated losses are around 147 kcal per person per day over the past 31 years. This corresponds to the daily energy requirements of roughly 400 million men or 500 million women. Compared to

FIGURE 14

TOTAL AGRICULTURAL LOSSES (TOP) AND TOTAL AGRICULTURAL LOSSES AS A SHARE OF AGRICULTURAL GROSS DOMESTIC PRODUCT (BOTTOM) BY COUNTRY GROUPS (1991-2021)



Source: Authors' own elaboration based on FAO and EM-DAT data.

requirements, nutrient losses appear to be particularly prominent for iron, phosphorus, magnesium and thiamine. At a regional level, the estimated nutritional losses linked to production lost due to disasters are around 31 percent in Asia and the Americas, 24 percent in Europe, 11 percent in Africa and 3 percent in Oceania.

2.4 MEASURING IMPACTS IN FORESTRY AND FISHERIES AND AQUACULTURE

For the subsectors of forestry and fisheries and aquaculture, data do not allow for the assessments conducted for crops and livestock. Insights on the importance and relevance of losses from disasters in these two subsectors are therefore gathered from the literature and published anecdotal evidence obtained from the analysis of specific cases.

Forests are extremely vulnerable to the impacts of disasters and climate change but also play a key role in risk reduction and mitigation. Wildfires and insect infestations are the two most significant hazards that affect forestry. Most hazards affecting the forestry sector are driven by meteorological factors, long-term climate variability and human influence, including land-use change, land management practices and introduction of invasive species.

In the *Global Forest Resources Assessment 2020*, only 58 countries, representing 38 percent of the global forest area, reported monitoring the area of degraded forests. Challenges in collecting data on forest impacts include inconsistent approaches to loss and damage assessments, inadequate application of methodologies and a lack of coverage of the full suite of impacts.

Wildfires, driven by a rising population density in the wildland–urban interface, are increasingly damaging the environment, wildlife, human health and infrastructure. Every year, about 340 million–370 million hectares (ha) of the Earth's surface are burnt by wildfire. In 2021 alone, 25 million ha of forest land were burnt. Tackling the underlying causes of fires using risk reduction actions can help avoid considerable damage and loss. The purpose of integrated fire management (IFM) is to make landscapes and livelihoods resilient and sustainable. IFM does so by considering the ecological, socioeconomic and technical aspects of fire management.

Forest damage by invasive species can be economically catastrophic, but determining the thresholds beyond which a tolerable presence of pests transitions into an infestation poses a significant challenge. Current reporting of pest and disease damage is based on land area of damage, volume of tree mortality or economic impacts – there is no harmonized system for reporting impacts. Overall, data on insect pest and disease outbreaks is limited, especially in developing countries. In high-income countries, reported losses are significant.

Turner *et al.* concluded that the net value of economic impacts associated with pests in New Zealand was NZD 3.8 billion to NZD 20.3 billion when projected to 2070. Damage by invasive species costs the United Kingdom of Great Britain and Northern Ireland's economy roughly over USD 2.2 billion per year.

An important aspect of assessing timber losses after large-scale disasters in the forestry sector is that a significant portion of damaged timber can usually be salvaged. The number of trees destroyed after a disaster does not automatically result in a drop in timber production. Rather, an increase in timber sales is observed in the immediate aftermath of the event as more timber is put on the market than usual.

FAO has been promoting a specific methodology for data collection and for calculating losses and damages to improve and standardize the estimation of forestry losses from disasters. It offers an assessment of forest resources that differentiates between the value of mature merchantable timber stands (stumpage) and timber stands that have not yet reached their rotation ages at the time of damage.

Wild capture and aquaculture fisheries are vulnerable to multiple sudden and slow onset disasters, including storms, tsunamis, floods, droughts, heatwaves, ocean warming, acidification, deoxygenation, disruption to precipitation and freshwater availability, and salt intrusion in coastal areas. A key ecosystem risk driver for capture fisheries is the increasing intensity and frequency of marine heatwaves, which threaten marine biodiversity and ecosystems, make extreme weather more likely, and negatively impact fisheries and aquaculture. In aquaculture, short-term impacts can include losses of production and infrastructure, increased risks of diseases, parasites and harmful algal blooms (HABs).

Extreme events and climate change directly affect the distribution, abundance and health of wild fish, and the viability of aquaculture processes and stocks. Climate change, variability and extreme weather events are compounding threats to the sustainability of capture fisheries and aquaculture development in marine and freshwater environments. At the same time, the rapid restoration of capture fisheries activities after a disaster can provide nutritious food and employment and can fast track a community's return to normal economic activity.

HABs occur when algae – simple photosynthetic organisms that live in the sea and freshwater – grow out of control while producing toxic or harmful effects on people, fish, shellfish, marine mammals and birds. In March 2021, for instance, South Africa's west coast experienced a 500 tonne "walk out" of west coast rock lobster. This event was of particular concern given that local small-scale fishers identified most of the lobster that died to be small in size.

As another example, since 1990, the Philippines has been affected by 565 disaster events. Coastal communities, especially small-scale enterprising poor people, such as fishers and shellfish gatherers, have been found to be most vulnerable to coastal flooding, coastal erosion and saltwater intrusion. One telling example is that of the Hunga Tonga–Hunga Ha'apai (HT–HH) undersea volcano in Tonga, which erupted on 15 January 2022. The initial disaster assessment report produced in February 2022 by the Ministry of Fisheries in Tonga focused on damage to fisheries assets covering small-scale, tuna and snapper vessels, and their engines and gear. The total estimated damage to the fisheries and aquaculture subsectors was USD 4.6 million. ■

PART 3
DISASTER RISK DRIVERS AND CASCADING IMPACTS

Risk is omnipresent, and it is growing at a rate that is outstripping our efforts to reduce it. Global risks like climate change, environmental degradation and biodiversity loss are existential in nature. Beyond the direct impact of disasters, indirect, cascading impacts are also significant, even at the global level.

Addressing risk requires not only an assessment of the direct impacts of disasters, but also an understanding of how the impact of disasters cascades within and across sectors and over geographic areas, the way in which elements of affected systems interact with each other during a hazard event and the systemic factors driving risks.

Case studies on climate change, pandemics and epidemics, and armed conflict provide evidence on the systemic nature of risk, and the increasing vulnerability and exposure to disasters that agriculture is currently facing.

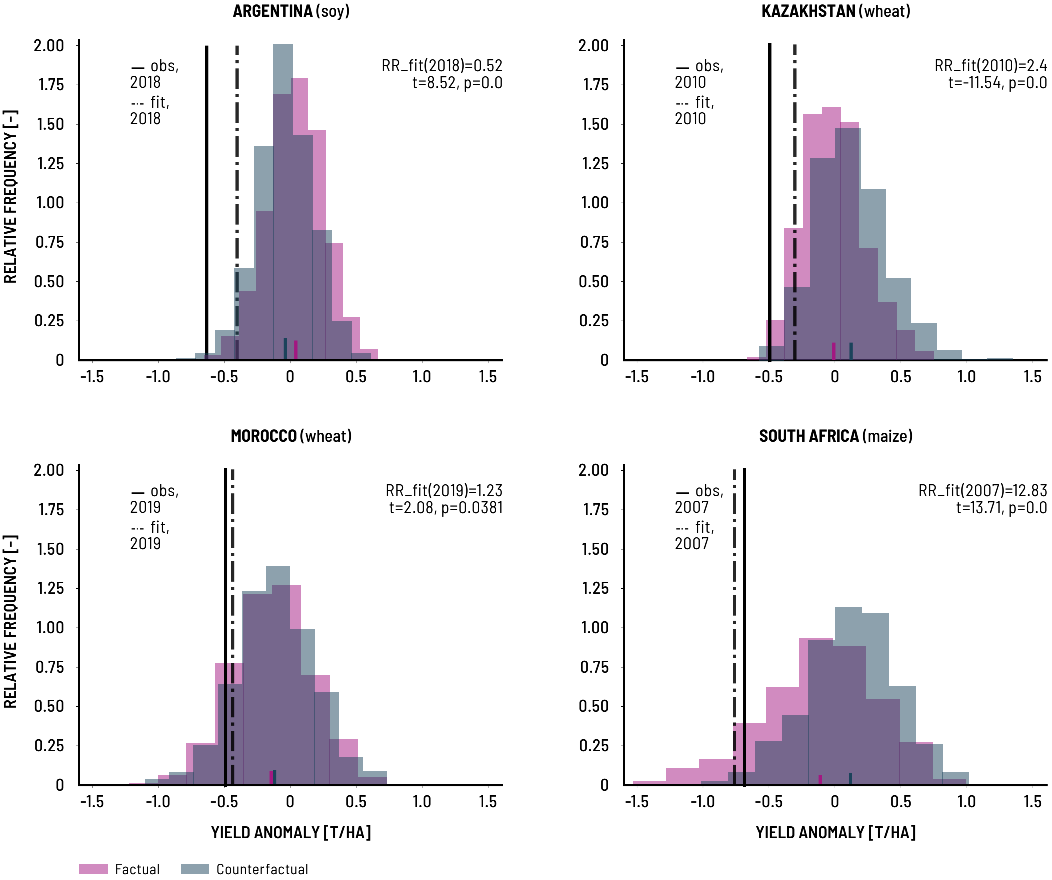
3.1 LINKING CLIMATE CHANGE TO AGRICULTURAL PRODUCTION LOSS

Climate change is contributing to a rise in hazard incidence, leading to increased vulnerability and exposure and diminishing the coping capacity of individuals and systems. Attribution science, defined as evaluating and communicating linkages associated with climate change, offers an entry point for estimating the effect of climate change on crop yields and the degree to which agricultural production is being influenced by extreme and slow onset events exacerbated by climate change. The analysis evaluates how climate change affects yield levels by comparing observed records with estimated counterfactual and factual yield distributions for soy yields in Argentina, wheat yields in Kazakhstan and Morocco, and maize yields in South Africa (FIGURE 34).

In Argentina, the model shows that observed variations in high and low temperatures, rainfall intensity and drought explain the higher share of the recorded soy yield variations in the highest-producing provinces. Results suggest that climate change increased average yields during the period of 2000–2019 by less than 0.1 t/ha, amounting to about 3 percent of the average observed yield during that period. Results also indicate that yield anomalies in Argentina that are as low or lower than those in 2018 may have become about half

FIGURE 34

ESTIMATED INFLUENCE OF CLIMATE CHANGE ON CROP YIELDS TO DATE: FOUR CASE STUDIES



Notes: Red = factual yield distribution for 2000–2019 based on the statistical yield model run applied to 50 factual historical climate simulations from the MIROC6 climate model from CMIP6-DAMIP. Blue = counterfactual yield distribution based on corresponding counterfactual climate simulations in which greenhouse gases and other anthropogenic forcing factors are set to their pre-industrial value. The factual and counterfactual distributions are statistically significantly different in each case as indicated by the t-test results stated. Solid black line = yield anomaly observed in a year of specific interest as indicated in the text in the plot. Dashed black line = yield anomaly predicted by the statistical model based on observationally derived climate data for the same year of specific interest. The RR fit value stated indicates how the predicted value for that specific year is estimated to have changed due to climate change.

Source: Authors' own elaboration showing analysis results based on crop yield data from FAOSTAT. 2023. Argentina, Morocco, South Africa. In: *FAO*. Rome. [Cited June 2023]. https://www.fao.org/faostat/en/#data/QCL and Bureau of National Statistics Kazakhstan. 2022. *Statistics of agriculture, forestry, hunting and fisheries*.; climate reanalysis data from Frieler, K., Volkholz, J., Lange, S., Schewe, J., Mengel, M., del Rocío Rivas López, M., Otto, C. *et al*. 2023. Scenario set-up and forcing data for impact model evaluation and impact attribution within the third round of the Inter-Sectoral Model Intercomparison Project (ISIMIP3a). Preprint. In: *EGUsphere*. [Cited July 2023]. doi:10.5194/egusphere-2023-281; Lange, S., Mengel, M., Triu, S. and Büchner, M. 2022. ISIMIP3a atmospheric climate input data (v1.0). In: *ISIMIP*. [Cited July 2023]. doi:10.48364/ISIMIP.982724 and references therein; output data from the MIROC6 climate model from Tatebe, H., Ogura, T., Nitta, T., Komuro, Y., Ogochi, K., Takemura, T., Sudo, K. *et al*. 2019. Description and basic evaluation of simulated mean state, internal variability, and climate sensitivity in MIROC6. *Geoscientific Model Development*, 12(7): 2727–2765. doi.org/10.5194/gmd-12-2727-2019 that are part of CMIP6/DAMIP (Eyring, V., Bony, S., Meehl, G.A., Senior, C.A., Stevens, B., Stouffer, R.J. and Taylor, K.E. 2016. Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization. *Geoscientific Model Development*, 9(5): 1937–1958. doi.org/10.5194/gmd-9-1937-2016; Gillett, N.P., Shiogama, H., Funke, B., Hegerl, G., Knutti, R., Matthes, K., Santer, B.D. *et al*. 2016. The Detection and Attribution Model Intercomparison Project (DAMIP v1.0) contribution to CMIP6. *Geoscientific Model Development*, 9, 3685–3697. doi:10.5194/gmd-9-3685-2016); bias-correction code from Lange S. 2019. Trend-preserving bias adjustment and statistical downscaling with ISIMIP3BASD (v1.0). *Geoscientific. Model Development*, 12, 3055–3070. doi:10.5194/gmd-12-3055-2019 developed for ISIMIP3, and methods adapted and combined from the climate attribution and impact modelling literature.

as likely due to climate change, subject to uncertainty (FIGURE 34).

In Kazakhstan, results show that a substantial share of recorded wheat yield variations in the highest-producing oblast (an administrative division, corresponding to a region or province) can be explained by variations in growing degree days, temperature variability, cold, precipitation variability and drought. In this case, climate change decreased average yields during the period of 2000–2019 by about 0.1 t/ha, which is more than 10 percent of the average observed yield during that period (FIGURE 34).

A significant portion of the observed wheat yield variability in Morocco can be attributed to fluctuations in temperature variability, high temperatures, drought and high precipitation. It suggests that climate change decreased average yields during the period of 2000–2019 by less than 0.1 t/ha and amounted to about 2 percent of the average observed yield during that period (FIGURE 34).

For South Africa, the model shows that a large share of the recorded maize yield variations in the highest-producing provinces can be explained by variations in growing degree days, temperature variability, cold, drought and high precipitation. Climate change to date has been statistically significantly detrimental to maize yields in South Africa. The model suggests that climate change decreased average yields during the period of 2000–2019 by more than 0.2 t/ha, amounting to more than 5 percent of the average observed yield during that period, and that the negative impact of climate change was even stronger in the lowest-yielding years. Altogether, results indicate that climate change may be already exacerbating agricultural losses and they highlight the importance of investing in measures to reduce losses and damages.

3.2 PANDEMIC AND EPIDEMIC: THE COVID-19 PANDEMIC AND AFRICAN SWINE FEVER

This subsection presents and analyses the impacts on agriculture and food security of two recent biological disasters, the COVID-19 pandemic and ASF.

An initial assessment from the Data In Emergency (DIEM) surveys shows that the COVID-19 pandemic disrupted food systems through labour shortages, impeding seasonal labour movements, particularly for labour-intensive production systems. A cross-country analysis conducted for the agriculture sector in food crisis countries found that the COVID-19 pandemic had caused a shock to food security and livelihoods comparable to that of conflicts or natural hazard-induced disasters. Livestock and cash crop producers were among the most severely affected and reported difficulties in accessing inputs, selling their products, accessing pastures due to movement restrictions and accessing international markets.

Agricultural production was affected by reduced input access and labour shortages. Disruptions in transport and logistics for agricultural products led to a decrease in farm-gate prices. Meanwhile, retail prices increased, affecting farmers' incomes as the cost of living rose. Planted areas were more likely to be reduced for cereal and vegetable crops than for fruit or cash crops, where the latter are produced for their commercial value rather than for use by the grower. When COVID-19 pandemic-related restrictions were implemented during the main planting season, there was an unambiguous reduction in the area planted. The log-odds coefficient for restrictions on people gathering is -0.157, with a 95 percent confidence interval, which translates into an average predicted probability of farmers reporting less or much less area planted that increases from around 22 percent without gathering restrictions to roughly 50 percent if the gathering restrictions were very stringent. Likewise, gathering restrictions are associated with odds of only 56 percent reporting an increase in harvest compared to places that were not under these restrictions at harvest. The likelihood of farmers reporting difficulty in accessing agricultural inputs increased significantly.

Among transboundary animal diseases, ASF has had catastrophic impacts. Since January 2020, ASF has been reported in 35 countries across five continents, with consequences most evident in Asia.

Between the first ASF outbreak in China on 3 August 2018, and 1 July 2022, a total of 218 outbreaks have been reported to the World Animal Health Information System of the World Organization of Animal Health (WOAH). The culling of 1.2 million pigs as of 2019 has led to heavy economic losses. By the end of 2019, the inability to meet the national demand for pork became evident, as shown by the fact that average pig and pork prices skyrocketed to 161 and 141 percent higher than pre-ASF levels, respectively. The impacts of both ASF and the COVID-19 pandemic compounded, and pork production in China in 2020 decreased by 25.8 percent compared to 2017. In terms of volume, pork production in China experienced a 22 percent contraction when comparing 2017 to 2019. China tried to partially cover the gap by importing pork, so that imports went from 20 percent of the global pork trade in 2017 to 45 percent in 2020.

Using findings from the OutCosT tool in 2020, it can be estimated that the cost of the ASF outbreaks in Lao Cai province of Viet Nam in 2019 was USD 8.6 million. In the Philippines, 10 provinces were affected by ASF in 2019, but by the end of 2020 it had affected 32 provinces. The approximate cost of the ASF outbreaks in 2020 in the Philippines was between USD 194 million and USD 507 million.

3.3 THE IMPACT OF ARMED CONFLICT ON AGRICULTURE

Active armed conflicts are at their highest level since the Second World War. While the risk of armed conflict is outside the scope of the Sendai Framework for Disaster Risk Reduction 2015–2030, the interplay between conflict and disaster risk requires further examination, including as it relates to damage and loss. The number of national, regional, and sectoral disaster risk reduction strategies and plans that consider societal hazards is increasing. Examples include the Central African Republic's draft National Strategy, Iraq's National DRR Strategy and Afghanistan's National Strategy on Disaster Risk Reduction.

Conflicts can increase the vulnerability of a society to disasters as infrastructure is destroyed, poverty increases, and long-term investments in disaster risk reduction are no longer considered important or cannot be funded. Unsustainable agricultural practices that lead to increased disaster risk may be driven by disruption and/or loss of livelihoods due to armed conflict. Given that armed conflicts also limit access to land, cause populations movements, and disrupt access to health care and social protection systems, we need to be cognizant of armed conflicts' wider damage and loss implications.

Assessments of the impact of armed conflicts on agriculture include calculations of damage and destruction of equipment and infrastructure, and loss of productive assets such as livestock. However, other impacts on agriculture have longer-term consequences, including forced displacement and the availability of agricultural labour. Tools and guidance have been developed for adapting PDNAs to complex operating environments, including where armed conflict manifests. An example of this is a guide developed as part of a joint initiative by the European Union, the World Bank and the United Nations, and led by the United Nations Development Programme (UNDP), to conduct PDNAs in conflict situations. The guide provides information on how to ensure that post-disaster activities and response operations do not exacerbate conflict dynamics.

Recurrent drought, food insecurity and subsequent famine risk have become a devastating and increasingly unsustainable cycle in **Somalia** in recent decades. Between the 2011 famine and the huge 2016–2017 drought, it was estimated that approximately USD 4.5 billion was spent on emergency responses to save lives. In 2017, a multisectoral damage and loss assessment conducted under the overall coordination of UNDP indicated that damage and loss in agriculture amounted to a total of just under USD 2 billion.

Soon after the initial uprisings in 2011, **the Syrian Arab Republic** was plunged into a complex set of conflicts. Five years into the crisis, FAO conducted a comprehensive damage and loss assessment. The results indicated that during the first five years of the crisis, total damage in the agricultural sector amounted to USD 16 billion. This was the equivalent to one-third of the Syrian Arab Republic's GDP in 2016. The largest dollar impact was in terms of losses (USD 9.21 billion), although in this case the level of damages was USD 6.83 billion.

The impact of the armed conflict in **Ukraine** was assessed between September and October 2022 in 22 oblasts. It showed the damage and loss of the war as experienced by rural households, livestock keepers, and fishers and aquaculture producers to be nearly USD 2.3 billion. On average, 25 percent of the rural population stopped or reduced agricultural production, although along the contact line more than 38 percent of respondents reported stopping agricultural production. The overall effects on the aquaculture and fisheries sector in Ukraine for the first eight months of the war in 2022 accounted for damages of USD 4.97 million, and losses (changes in financial flows) of USD 16.6 million, which is 63 percent of the total annual output of the Ukrainian aquaculture sector (USD 34 million). ■

PART 4
DISASTER RISK REDUCTION SOLUTIONS IN AGRICULTURE

This part of the report focuses on the viability of investments in enhanced proactive disaster risk reduction good practices in agrifood systems; and in anticipatory action to increase the resilience of livelihoods to disasters. The actions to reduce the potential impacts of disasters and underlying risks are thus analysed in terms of their benefit vis-à-vis the cost of their implementation. Several examples are offered of analysis of the benefits associated with disaster risk reduction good practices and anticipatory action that can serve as blueprints for the comparative assessment of scalable investments.

4.1 BENEFITS FROM FARM-LEVEL DISASTER RISK REDUCTION GOOD PRACTICES

Farmers, particularly smallholders farming under rain-fed conditions, are the most vulnerable stakeholders in the agrifood systems and thus tend to bear the brunt of disaster impacts. There are multiple pathways for farmers, policy makers, development and humanitarian actors to pursue to reduce the vulnerability of smallholders. Among those are preventative farm-level disaster risk reduction good practices and technologies. These technical solutions are scalable and tested under both hazard and non-hazard scenarios, and thus proven to help avoid or reduce agricultural production losses caused by natural or biological hazards.

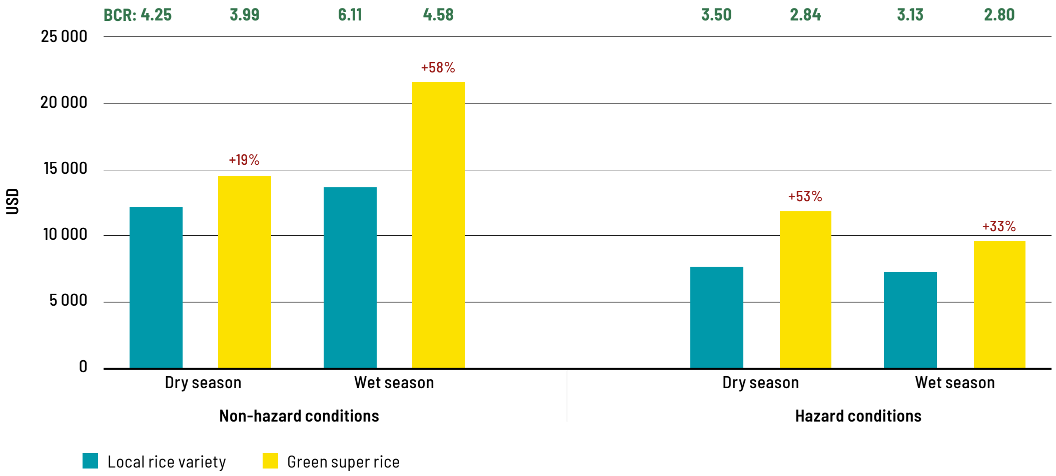
For instance, in Uganda, to reduce the impact of increasing dry spells, the cultivation of high-yield and drought-tolerant banana varieties was combined with soil and water conservation practices, such as mulching, trenches and the use of organic compost. The study calculated that in farms affected by dry spells, the good practice package brought cumulative net benefits per acre over 11 years, which were about ten times higher than those of the existing local practices. The benefit–cost ratio (BCR) of good practices was 2.15, as compared to 1.16 for the existing local practices.

In the highlands of the Plurinational State of Bolivia, to reduce mortality of the llama camelids from frost, snow, heavy rains and hailstorms, good practices were experimented with, entailing the building of semi-roofed livestock shelters (*corralónes*) and the deployment of veterinary pharmacies. The BCR of these practices resulted in 17 percent higher cumulative net benefits than that of the previous local practices over 11 years. The simulation analysis also showed that if the good practices were systematically scaled up, camelid mortality could become 12 times lower than under the previous practices.

In Pakistan, DRR good practices were tested on wheat, cotton, rice, sugar cane, and vegetable and oilseed crops, including okra and sunflower during the two main cropping seasons, namely the dry (*kharif*) season and the wet (*rabi*) season in districts of the Punjab and Sindh provinces, which are highly vulnerable to climate change and among the most vulnerable districts within the Indus Basin. Cost–benefit analyses were conducted over six seasons. Results indicate that every USD 1 invested in this good practice package will generate USD 8.18 and USD 6.78 in benefits under non-hazard and hazard conditions, respectively.

FIGURE 41

BENEFIT-COST RATIOS AND NET PRESENT VALUES OF THE GREEN SUPER RICE AND LOCAL RICE VARIETY UNDER NON-HAZARD AND HAZARD CONDITIONS IN THE BICOL REGION OF THE PHILIPPINES



Notes: Appraisal period: 11 years; Discount rate: 10 percent; Sensitivity analysis uses 15 percent and 5 percent discount rate.
Source: Authors' own elaboration based on FAO data.

In the Philippines, green super rice (GSR) cultivation in the Bicol region was tested over three successive seasons (the 2015 dry and wet seasons, and the 2016 dry season). Results showed clear economic benefits, along with an increased agricultural productivity when adopting the multistress tolerant crop variety compared to the local varieties under both hazard and non-hazard conditions. The BCR of adopting GSR varieties was higher than that of cultivating local varieties in both the wet and dry seasons (FIGURE 41).

To realize the full potential of the proactive risk reduction measures such as those analysed here, they must be broadly scaled up and replicated. As a result, addressing challenges and barriers encountered by farmers in adopting these measures requires supportive policies. The integration of these disaster risk reduction measures in social protection programmes can also offer important opportunities for scaling up.

4.2 RETURN ON INVESTMENT OF ANTICIPATORY ACTION INTERVENTIONS

Anticipatory action is defined as acting ahead of predicted hazards to prevent or reduce acute humanitarian impacts before they fully unfold. The window of opportunity for anticipatory action is between an early warning trigger and when the actual impact of the hazard is felt on lives and in livelihoods. A trigger system is developed and dedicated funds are pre-allocated to be quickly released when pre-agreed thresholds are reached. The trigger system is developed based on relevant forecasts (for instance, rainfall, temperature, soil moisture, vegetation condition and others in the case of climate-related hazards), along with seasonal observations and vulnerability information.

Anticipatory action is a proven cost-effective measure for mitigating the impact of disasters with significant resilience dividends. By delivering support before a crisis has occurred, efficient and timely anticipatory action can curb food insecurity, reduce humanitarian needs and ease pressure on strained humanitarian resources. Triggered by context-specific early warning systems, anticipatory actions are short-term interventions that aim at protecting DRR and resilience gains from the immediate impact of forecast shocks. Results of the BCR for anticipatory action for the ten interventions analysed is this section are mostly positive, reaching up to 7.1.

Anticipatory actions to protect livestock ahead of forecast hazards have proven particularly effective in reducing animal mortality, maintaining animal body condition and productivity, as well as the reproductive capacity of herds. Positive results were also recorded for anticipatory action interventions centred on crops. Depending on the context, these may include stress-tolerant seeds, early harvesting, plant protection from hazard-induced pests and diseases, short-cycle crop seeds, and small irrigation equipment, among other interventions.

Anecdotal evidence suggests that anticipatory action interventions can also reduce existing risk, protecting livelihoods well past the effects of the initial hazard. Effective early warning systems can lead to timely interventions, and further incorporating anticipatory action within disaster risk reduction policies, plans and financial frameworks, as well as within humanitarian and development frameworks, will allow countries to strengthen resilience and reduce disaster risks.

4.3 COMBINING PREVENTATIVE CONTROL AND ANTICIPATORY ACTION – THE CASE OF DESERT LOCUSTS IN THE HORN OF AFRICA

The desert locust upsurge that occurred in the greater Horn of Africa in 2020 and 2021 was one of the most severe crises of its kind ever recorded in the region. It was an unprecedented threat to food security and livelihoods, with the potential to cause widespread suffering, displacement and conflict. Based on previous experience of implementing the desert locust control operation in 2020–2021, a new living methodology was developed to calculate the return on investment of FAO's risk-informed intervention. Reports from the field provided details about the nature of the control operation (air and ground) as well as the ratio of hoppers to swarms. The timely and accurate early warning and forecasting information provided by FAO's Desert Locust Information Service (DLIS) throughout the upsurge allowed the risk-informed strategies to be deployed. As a result, 2.3 million ha of affected area were treated in the Horn of Africa and Yemen. The commercial value of the overall averted cereal and milk losses was estimated at USD 1.77 billion. At scale and risk-informed desert locust control interventions provide a return on investment of 1:15. This means that every USD 1 invested in the intervention averted an estimated USD 15 of losses in the greater Horn of Africa. These collective efforts by FAO and partners averted 4.5 million tonnes of crop losses, saved 900 million litres of milk production, and secured food for nearly 42 million people.

The overall lesson learned is that risk-informed action in the case of the locust upsurge has limited considerably the potential negative impact of the shock on agrifood systems and the associated livelihoods. It resulted in reduced damage to crops and rangelands, reduced pesticide sprays that have negative impacts on human health and the environment and lowered financial costs. ■

PART 5
CONCLUSIONS

The need for improved data and information on the impacts of disasters in agriculture is the first key theme running across all sections of the report. Investment in enhanced data monitoring, reporting and collection methodologies and tools is an essential first step in building national capacities to understand and reduce disaster risks in agriculture and wider agrifood systems. This report has advanced the knowledge base by providing the first ever global estimate of the impact of disasters on crops and livestock production.

Sector-specific approaches for assessing vulnerability, evaluating impacts and reducing risks are essential. Even in subsectors with better information access, there is a need to develop standardized tools for measuring the impact of disasters to assess direct damage and loss, build capacity at various levels, support coordination mechanisms for prevention and response, and scale up these loss estimations to a national or global scale. The vast and often remote space occupied by the forestry and fisheries subsectors, and the diversity of their ecological stocks, requires different approaches to valuing assets and calculating impacts than those employed for crops or livestock.

These two subsectors suffer from a lack of comprehensive information on their production, assets, activities and livelihoods, and are frequently overlooked in post-disaster impact evaluations and needs assessments.

Emerging technologies and advances in remote sensing applications offer new avenues towards improving information on disaster impacts in agriculture. At a policy level, promoting and strengthening data reporting for the Sendai Framework C2 indicator on direct economic losses in agriculture attributed to disasters, corresponding to indicator 1.5.2 of the United Nations Sustainable Development Goals (SDGs), will also provide a systematic and comprehensive database for disaster losses in agriculture.

A second key conclusion of this report is **the need to develop and mainstream multisectoral and multihazard disaster risk reduction approaches into policy and decision making**. Disaster impacts are worsened by multiple drivers and overlapping crises that produce cascading and compounding effects and worsen the exposure and vulnerability of people, ecosystems and economies. As described in this report, factors such as climate change, the COVID-19 pandemic, the African swine fever epidemic and armed conflicts, all result in the amplification of disaster risk and impacts on agrifood systems. In the case of climate change, the use of attribution science methodologies provide new information on the degree to which climate change is exacerbating losses in agriculture.

Effective strategies for reducing disaster and climate risk must adopt a holistic, systemwide view of the different drivers and impact pathways that produce losses in agrifood systems. This is particularly relevant in countries that have a large number of vulnerable people or communities, have less developed capacities or resources to prepare for or respond to disasters, or where fluctuations in agricultural production can easily threaten food security.

The third main conclusion from the report is **the need for investments in resilience that provide benefits in reducing disaster risk in agrifood systems** and improve agricultural production and livelihoods. Context and location-specific farm-level disaster risk reduction good practices are cost effective solutions to enhance the resilience of livelihoods and agrifood systems against natural and biological hazards. The case studies presented in this report demonstrate that not only do good practices reduce disaster risks, but they also display significant additional benefits. This calls for urgent action to foster the adoption of available innovations, promoting the generation of more scalable risk management solutions, and enhancing early warning and anticipatory actions.

Though not yet comprehensive, the available evidence suggests a set of actions that can be undertaken to improve disaster impact assessments and to step up disaster risk reduction policies and actions. National, sectoral and local disaster risk reduction strategies are a cornerstone for achieving inclusive and resilient agrifood systems, and the United Nations system can be an important collaborator in mainstreaming disaster risk reduction in national and sectoral policies, programmes and funding mechanisms. However, there is a need to expand the knowledge base of studies that can guide evidence-based policies and decision making to further promote resilience in agriculture and agrifood systems at large. This is a fundamental first step for the successful integration of multihazard disaster risk reduction into agricultural policies and extension services, as well as national and local disaster risk reduction strategies. ■

2023
THE IMPACT OF DISASTERS ON AGRICULTURE AND FOOD SECURITY
AVOIDING AND REDUCING LOSSES THROUGH INVESTMENT IN RESILIENCE

Disasters are resulting in unprecedented levels of destruction across the world. These shocks and disruptions affect the functioning and sustainability of agricultural production and threaten the livelihoods of millions of people reliant on agrifood systems. Reducing the impact of disasters in agriculture requires a better understanding of the extent to which these events produce negative impacts in agriculture and necessitates an investigation into the underlying risks that make agriculture vulnerable to the effects of disasters.

This report provides an assessment of losses caused by disasters in agricultural production over the past three decades and delves into the diverse threats and impacts affecting the crops, livestock, forestry, and fisheries and aquaculture subsectors. These impacts are amplified by underlying factors and vulnerabilities created by social and environmental conditions such as climate change, global pandemics and epidemics, and conflict situations, which can generate disastrous outcomes and produce cascading effects across agrifood systems. Facing up to these challenges demands new approaches to risk reduction and response mechanisms. This publication provides examples of actions and strategies for investing in resilience and proactively addressing risks in agriculture. It demonstrates ways to mainstream disaster risk into agricultural practices and policies and calls for a deeper understanding of the context in which these solutions are implemented.

The Impact of Disasters on Agriculture and Food Security (full text)