Briefing note

11

Ecosystem-based Adaptation in Agriculture: A Path to Climate-resilient Food Systems

Conventional agriculture has been the major driving force of increased yields over the past decades and still makes up most agricultural production practices. However, this food production system and a significant amount of associated waste (approximately 30 per cent of global production) has come at a cost, depleting or polluting bodies of water, replacing natural ecosystems, and eroding the rich ecosystem underlayer supporting microorganism biodiversity, the basis of soil fertility. To compensate, more ecosystems are continually converted to agricultural or grazing land.

In the course of a global analysis conducted in 2020, researchers found more than 90 per cent of the conventionally farmed soils they studied were thinning, while 16 per cent had lifespans of less than a century, and nearly 33 per cent had a lifespan under 200 years (Evans *et al.* 2020). Additionally, conventional agriculture's steady march into ecosystems and the reliance on a handful of crops such as corn, rice and wheat – which constitute over 40 per cent of the world's calorie intake (Food and Agriculture Organization of the United Nations [FAO] 2018) – have greatly diminished genetic diversity, rendering our food systems highly vulnerable to a variety of shocks (Campbell *et al*. 2017).

Climate change only adds to all these problems. For example, by 2050, it is predicted that agricultural yields could drop by up to 25 per cent by 2100 (Wing *et al.* 2021) due to climate impacts. This picture is worse for regions like sub-Saharan Africa, where social fragility and poverty (a lack of assets to rely on during shocks) compound the effects of climate change. Furthermore, major ongoing global crises – such as the Covid-19 pandemic and the war in Ukraine – are serving to deepen the pressures on the world's food systems by constraining exports and skyrocketing the price of food.

GLOBAL ADAPTATION NETWORK

UN environment programme

Ecosystem-based Adaptation Practices in Food Systems

Ecosystem-based Adaptation (EbA) is the utilization of biodiversity and ecosystem services as part of a strategy to aid people in adapting to the adverse effects of climate change. Experts claim the practice can be used to restore ecosystems, improve food production, and ensure sustainable livelihoods for hundreds of millions of people in the face of growing climate threats. To cope with climate impacts in the short term, farmers can change seed varieties, adjust irrigation and drainage practices, and modify dates for planting, harvesting, and applying soil and crop amendments.

In the long term, farmers will need to increase soil biodiversity and to improve soil fertility through soil regeneration techniques (such as cover cropping, contour cultivation, terracing or increasing organic matter, etc.) and by protecting or replanting forests and natural vegetation in key locations near their land. Pre-industrial traditional farming methods indigenous to a given location can also be learned and incorporated as appropriate, as in some cases they may already support local ecosystem services (Harvey *et al*. 2017).

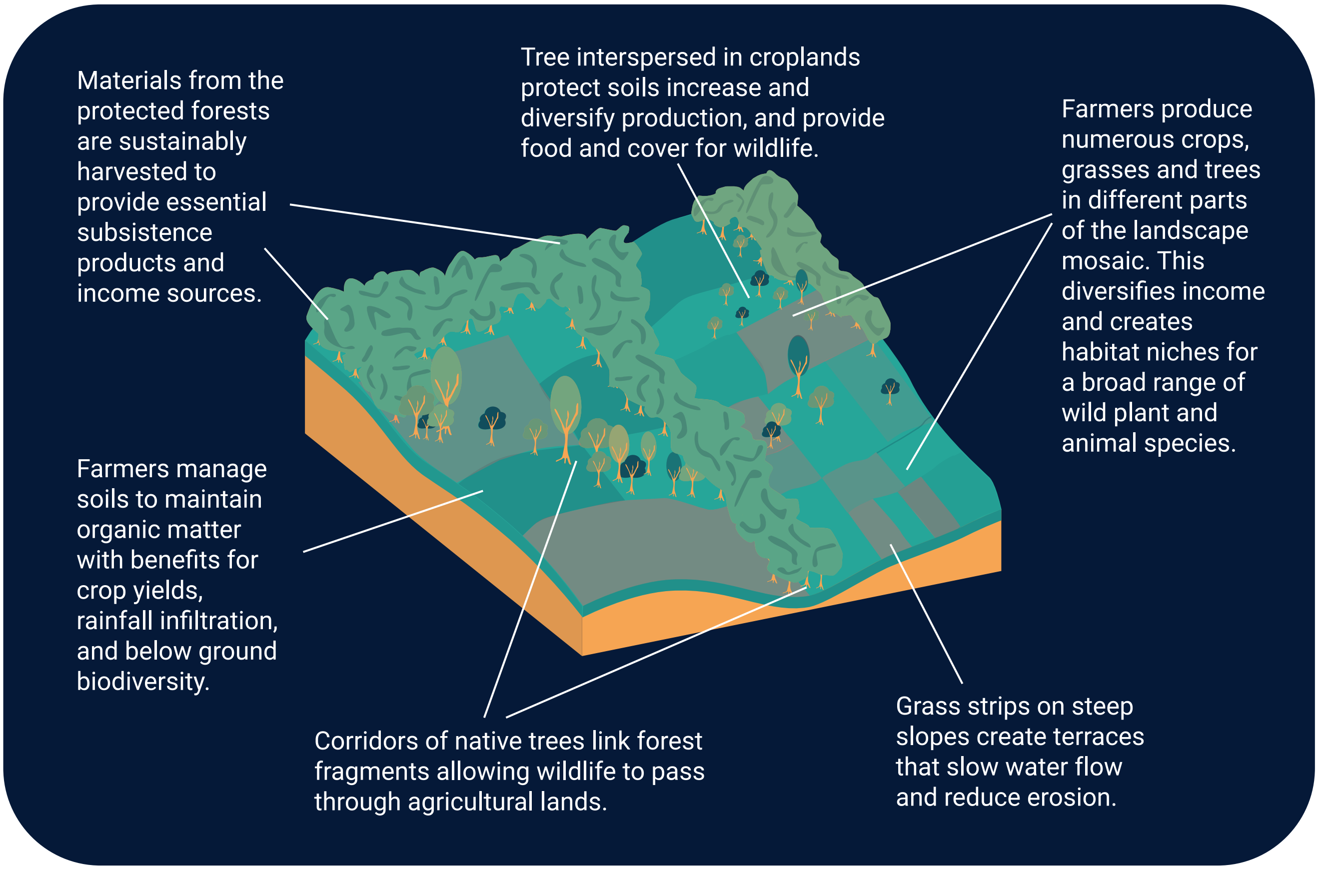
Table 1 contains EbA practices applicable to a wide range of farmers. However, it should be noted that these practices – addressing the social, economic and environmental impacts of climate change – are most effective when used in combination rather than as isolated approaches, as the multiple threats facing our food systems are complex and interrelated. Thus, these issues must be tackled in a comprehensive and holistic manner, recognizing that agriculture is embedded in nature and ecosystem services. For that reason, this document and the *Ecosystem-based Adaptation & Forestry Briefing Note* should be read in conjunction with one another.

A man works on his home garden around a community-protected area where UNEP and partners are supporting people to build climate-resilient livelihoods in Cambodia. ©*UNEP/Hannah McNeish*

Table 1: Agricultural EbA practices for environmental, economic and social impacts from climate change

Environmental Impacts (direct hazards)
Water stress, drought, higher temperatures, increased evapotranspiration
Use early warning systems to help farmers adapt planting schedules and strategies.
Improve water infiltration, storage capacity of soils (for example, more organic matter from composting) and harvesting/conservation systems using storage ponds, wetlands, infiltration ditches, rooftop capture, drip irrigation, water tanks (see Case Study I on page 8), etc.
Encourage agroforestry and agrosilvopastoral practices for drought resilience (see Case Study I on page 8): • Integrating trees and bushes for nitrogen fixation, green fertilizer cuttings, and shade can sometimes more than double yields and reduce vulnerability to pests, crop price fluctuations, and drought by capturing rainfall and maintaining soil moisture. • 'Assisted natural regeneration' consists of allowing bushes and trees to regrow on land from stumps, roots and seeds in soil. It is easy to implement, cost-effective, and provides a multitude of co-benefits. • Introducing livestock into production (agrosilvopastoral systems) can help control pests, take advantage of plant waste, provide fertilizer, and diversify diets. • See *Ecosystem-based Adaptation in Forestry Briefing Note* for more information on agrosilvopastoral practices and benefits.
Ensure water storage, flow regulation, and provisioning via the protection of watersheds, headwaters, and springs.
Maintain forested hilltops for humidity collection and water infiltration.
Use windbreaks to reduce desiccation (see Case Study II on page 9).
Implement drip irrigation systems.
Shift in viable crops and livestock species with temperature changes
Use protected areas to conserve vulnerable species and habitats, especially pollinators, and to create corridors (Figure 1) for migration (see Case Study I on page 8).
Assist crop adaptation to new conditions with artificial selection and seed banks, use drought-tolerant crop varieties (see Case Study I on page 8), or diversify to other crops entirely.
Greater intensity and frequency of storms and flooding
Improve early warning systems.
Ensure species diversity to promote resilience (intercropping, agroforestry, etc.; see Case Study I on page 8).
Protect forests and vegetation in riparian zones and headwater and spring sources (see Case Study I on page 8).

Figure 1: Ecological corridors and farms

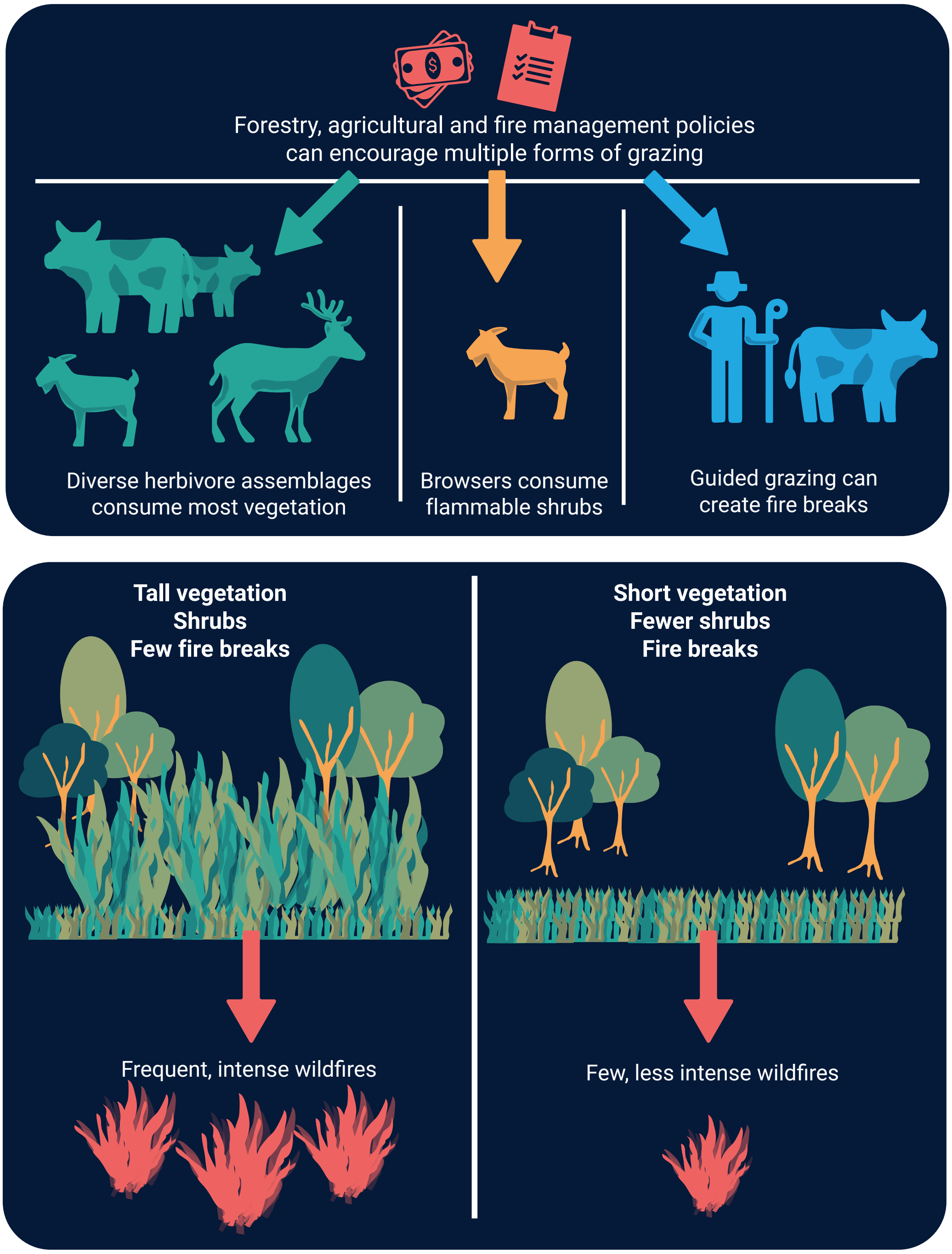


Adapted from Scherr and Buck (2011)

Maintain organic matter, use cover crops in harvested areas and avoid use of heavy machinery to prevent soil compaction, thereby ensuring infiltration and water-storage capacity.
Avoid planting in flood-prone areas or use water-loving plants if necessary.
Improve drainage and erosion control.
Erosion and landslides
Maintain vegetation on slopes, ensuring deep and shallow root systems to hold soil in place.
Practice contour planting with planted strips.
Avoid disturbing soil in unstable areas with equipment or livestock.
Practice no-till farming and use cover crops to prevent erosion or hardpans and restore soil biodiversity.
Use rotational grazing and farming for root development and more resilient foliage and soils.

Wildfire effects on crops, livestock, soils, equipment and infrastructure
Improve early warning systems and complete a farm or ranch wildfire plan.
Create firebreaks with fire-resistant species.
Plant fire-tolerant species, and thin vegetation in vulnerable areas (Figure 2).
Maintain and restore wetlands and design water-storage structures (ponds) to block the fire path.

Figure 2: Using livestock for fire prevention



Adapted from Rouet-Leduc *et al*. (2021)

Pest and disease outbreaks

Use integrated pest management.

Invest in a transition to polycultures (see Case Study I on page 8) with combinations of crops, trees and livestock (agrosilvopastoral systems) to reduce the likelihood of outbreaks and ensure swift recovery.

Saltwater intrusion in coastal aquifers and soils

See the *Coastal Ecosystem-based Adaptation Briefing Note.*

Economic Impacts

Climate impacts may decrease revenue from farming or make rural livelihoods unreliable

Identify funding (Athelia, Eco-business Fund) and markets for sustainable products.

Improve supply chain (cold or dry storage and processing) with off-grid renewables for added-value products and premiums from certifications.

Embrace circular economy principles, using “waste” (e.g., plant matter, manure, effluent) as inputs for energy, fertilizer, irrigation.

Promote revolving microloans to implement EbA and cope with shocks

Procure ‘bundled index insurance’ to ensure recovery from shocks while promoting a shift to more resilient practices.

Explore rural tourism opportunities to supplement or diversify economic base (see Case Study I on page 8).

Design restoration initiatives (in agroforestry, for example) with a focus on job creation.

See *Ecosystem-based Adaptation in Forestry Briefing Note* for information on payments for ecosystem services.

Social Impacts

Climate change may exacerbate existing marginalization, migration trends, poverty, governance issues, community fragility and tensions over land and water

Build partnerships and networks with farmer associations to share information on EbA policies and climate coping strateges (see Case Study II on page 9).

Integrate communities and vulnerable groups into landscape planning and management to meet water, health, energy (fuelwood), and food needs (see Case Study I and II, on pages 8 and 9) and empower rural populations.

Strengthen resource tenure (especially of women, indigenous peoples, poor people, etc.) while protecting against land grabbing.

Learn from Africa’s Sustainability, Stability & Security Initiative and other peacebuilding efforts with a focus on cooperative water management and conflict resolution training (see Case Study II on page 9).

Improve famine early warning systems (EWS) access, preventative measures, and crisis responses.

Case Studies

Case Study I: Enhancing The Climate Change Resilience of Rural Communities In Cambodia

United Nations Environment Programme (UNEP) and Cambodia's Ministry of Environment are implementing an Adaptation Fund-supported project to help communities adapt to climate change impacts such as erratic rainfall and droughts, which are causing erosion on farms, crop failures and damage to infrastructure (United Nations Environment Programme [UNEP] 2019). The project was carried out in five community protected areas (CPAs) across four provinces.

EbA was a central approach for the project's interventions and consisted of forest restoration with multi-use native tree species that provide food, erosion control, timber, medicine and fruit and by planting trees alongside 2,200 hectares of rice paddies to reduce erosion and enhance soil productivity. Distributing drought-tolerant rice varieties especially adapted to the local ecosystems led to an increase in yields. Households in five communities used improved rice-storage techniques to avoid food waste. Rice harvests have greatly improved at project sites by using climate forecasting to inform planting schedules, reducing drought and heat stress. Households and schools received training on maintaining vegetable gardens to diversify families' agricultural produce and increase their food security. Previously, when rice harvests failed due to drought, people had to sell their animals or possessions to buy food. The project boosted the dependability of water availability by supplying a rain harvesting tank and pumps. Over 500 households have adopted sustainable alternative livelihood strategies, including chicken-raising, cricket-raising, and ecotourism. Moreover, over 450,000 fruit trees were distributed to 1,900 families in the five communities.

Key challenges with this project included: 1) CPA boundary enforcement and the risk of land encroachment; 2) constraints in farming and growing produce in home gardens (due to poor soil conditions, lack of irrigation water, and invasive species); 3) difficulties with training approaches due to low levels of literacy in the communities; and 4) remote locations, poor road conditions and limited telephone access of some project intervention sites. These challenges were mitigated by investing more time in the field to provide "hands-on" training, build community capacity and coach villagers on new farming techniques and agricultural practices. However, the overall challenges of the project highlight the need for a broader institutional structure to provide support for long-term sustainability of project activities.

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Case Study II: Protecting Vulnerable Communities in Sudan With Ecosystem-based Adaptation

A highly impactful project was funded by the Global Environment Facility and managed by UNEP in Sudan to strengthen resilience to climate change among smallholder rain-fed farmers and pastoralists in the White Nile State, one of the most climate-vulnerable regions in the country. Approximately 70 per cent of the population in this area depends on rain-fed agriculture and pastoral practices, which are threatened by erratic rainfall and rising temperatures resulting in declining crop productivity, land degradation, reduced grazing potential, and loss of livestock. The project's main approach is to teach these communities how to adopt alternative climate-resilient livelihoods, using a "learning-by-doing" approach to showcase innovative EbA techniques and trigger further adoption of climate-resilient practices for improving agricultural productivity and access to water, as well as providing the technology and funding to do so.

As a result of project activities, communities have local structures and platforms to participate in defining cost-effective strategies and embracing autonomous adaptation through piloted EbA technologies and practices on their farms. Local communities who are not beneficiaries of the project are also now procuring improved seeds, as well as in situ rainwater harvesting techniques on farms using appropriate agricultural tools to work the sandy and clay soils. These tools help conserve the soil's structure and enhance in situ rainwater infiltration while contributing to improved agricultural productivity and water retention, strengthening the resilience of rain-fed farmers and pastoralists to climate hazards.

In total, 8,389 households in the 43 targeted villages have adopted EbA measures. These measures include the restoration of critical ecosystem services, investment in climate-resilient agricultural land management practices, and diversification of livelihoods. Climate-resilient land management practices using drought-tolerant fruits and vegetables and integrated pest management have reached a total of 2,000 four-hectare farms. Some of the alternative livelihoods include home gardening, chicken raising, and small ruminant breeding, helping to diversify food and income sources, a key component of building resilience. Supplemental feed sources are also available to help pastoralists better manage their grazing herds in already deteriorated rangelands. To protect the land and crops from inclement weather, the project has also created shelterbelts on 10 per cent of all cultivated areas in the project sites (approximately 59 km).

Key challenges with this project included: 1) extreme weather events and seasonal variability of rainfall which pose a risk in the scheduling and implementation of project activities, 2) health and safety risks such as the danger posed by cookstoves or water reservoirs to children and animals, and 3) conflicts between farmers and pastoralists. The continuous review of climate change vulnerabilities and risks (existing and predicted) in each target community has addressed the first challenge. Additionally, all reservoirs constructed will be fenced, and beneficiaries have received training on operating the cookstoves to avoid injuries. Finally, to prevent conflicts, communities participate in land-use planning through Village Development Committees, subcommittees, and local leaders.

Students tend to a vegetable garden set up at a school where UNEP and partners are helping people that relied on rain-fed agriculture to adapt to climate change and diversify their farming methods in rural Cambodia. ©*UNEP/Hannah McNeish*

Conclusion

EbA in food systems can greatly reduce the impacts of both climate change and unsustainable agricultural practices on soils, water supplies and biodiversity while enhancing food production and providing a multitude of co-benefits, including more varied diets, a more diverse and resilient economic base for hundreds of millions of people, and long-term savings in comparison to conventional production methods that rely on expensive inputs and are prone to waste. Governments should embrace EbA in food systems as an opportunity for smart growth and economic development, in addition to being a means of adapting food production to climate change.

In line with UNEP's guidelines, gender equality concerns were taken into account in both case studies of this briefing note, and acknowledging the linkages between gender inequality and adaptive capacity is crucial.

Further Resources

- Ecosystem-based Adaptation Briefing Note Series
- Climate adaptation resources and multimedia
- Lessons Learned: Ecosystem-based Adaptation and an Integrated Resilient Rice Model in Madagascar
- UN Decade on Ecosystem Restoration
- Ecosystem-based Adaptation for Food Security in Africa Assembly

For more information about UNEP's work in ecosystem-based adaptation, contact Jessica.Troni@un.org

Enhancing the climate resilience of rural communities living in protected areas of Cambodia. ©*UNEP/Hannah McNeish*

References

Campbell, B.M., Beare, D.J., Bennett, E.M., Hall-Spencer, J.M., Ingram, J.S.I, Jaramillo, F. *et al*. (2017). Agriculture production as a major driver of the Earth system exceeding planetary boundaries. *Ecology and Society*, 22(4). https://doi.org/10.5751/ES-09595-220408.

Evans, D., Quinton, John N., Davies, J.A.C., Zhao, J and Govers, G. (2020). Soil lifespans and how they can be extended by land use and management change. *Environmental Research Letters* 15(9). https://doi.org/10.5751/ES-09595-220408.

Food and Agriculture Organization of the United Nations (no date). Food Loss and Waste Database. https://www.fao.org/platform-food-loss-waste/flw-data/en/. Accessed 24 March 2022.

Food and Agriculture Organization of the United Nations (2018). Nearly half our calories come from just 3 crops. This needs to change, 4 October. https://www.weforum.org/agenda/2018/10/once-neglected-these-traditional-crops-are-our-new-rising-stars. Accessed 24 March 2022.

Harvey, C.A., Martínez-Rodríguez, M.R., Cárdenas, J.M., Avelino, J., Rapidel, B., Vignola, R. et al. (2017). The use of Ecosystem-based Adaptation practices by smallholder farmers in Central America. *Agriculture, Ecosystems & Environment*, 246, 279-290. https://doi.org/10.1016/j.agee.2017.04.018.

Nielsen, U.N., Wall, D. H. and Six, J. (2015). Soil biodiversity and the environment. *Annual Review of Environment and Resources* 40, 63-90. https://doi.org/10.1146/annurev-environ-102014-021257.

Rouet-Leduc, J., Pe'er, G., Moreira, F., Bonn, A., Helmer, W., Shahsavan Zadeh, S.A.A. *et al*. (2021). Effects of large herbivores on fire regimes and wildfire mitigation. *Journal of Applied Ecology* 58, 2690-2702. https://doi.org/10.1111/1365-2664.13972.

Scherr, S.J. and Buck, L.E. (2011). Moving ecoagriculture into the mainstream. In: *State of the World 2011: Innovations that Nourish the Planet. Worldwatch Institute* (ed.). London: W.W. Norton & Company. Chapter 2. 1-13. https://www.researchgate.net/publication/305315832_Moving_Ecoagriculture_into_the_Mainstream.

Wing, I., de Cian, E. and Mistry, M.N. (2021). Global vulnerability of crop yields to climate change. *Journal of Environmental Economics and Management* 109. https://doi.org/10.1016/j.jeem.2021.102462.

United Nations Environment Programme (2019). *Ecosystem-Based Adaptation in Cambodia 2013-2019 Factsheet. Enhancing Climate Change Resilience of Rural Communities Living in Protected Areas of Cambodia*. https://wedocs.unep.org/bitstream/handle/20.500.11822/28423/EBA_Cambodia.pdf?sequence=1&isAllowed=y.

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