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Nature's Guardians: Indigenous Women Pioneering Conservation Leadership, Climate Resilience, and Livelihood Empowerment

Kamasa Dorothy

Researcher, Climate & Food security Expert, Founder, Centre for Women and Food Security, Ghana

Abstract

The notable effects of climate change on crop production are evident with negative impacts more common than positive impacts, including several periods of price spikes following climate extremes in drought-prone areas like the Upper West Region of Ghana. Climate change has negatively affected maize yields in Northern Ghana. The increased frequency of sweltering nights in northern Ghana damages crops, with severe impacts on millet, soya, and cowpea yields and quality. Several methods and many distinct crop models and model types can be used to estimate how future climate change will affect crop production. The project "Nature's Guardians: Indigenous Women Pioneering Sustainability and Empowerment" is a transformative endeavor that places Indigenous women at the forefront of environmental conservation, sustainable development, and community resilience. The project empowered Indigenous women as strategic ecological leaders. Through gender-responsive approaches, the project harnessed their profound connection to nature and cultural heritage, enabling them to lead in biodiversity conservation, climate change mitigation and adaptation, sustainable agriculture, and policy advocacy. By building their capacity, promoting traditional knowledge, and fostering meaningful partnerships, the project created a ripple effect of positive change, enriching both the ecosystem and the well-being of Indigenous communities. Through this project, indigenous women emerged as the driving force behind sustainable development, ensuring a harmonious coexistence between humanity and the environment for generations to come.

Keywords: Food Security, Indigenous Women, Biodiversity, Climate Change

Introduction

In northern Ghana, climate change is adversely impacting agricultural productivity, and indigenous communities and their surrounding ecosystems are having a tough adapting to these devastating climatic conditions. Some of these impacts can be easily predicted, while others are very complex to predict. Pests and diseases easily attack crops as a result of climatic conditions, which negatively affects the food security and nutrition of Indigenous people whose main source of human survival directly depends on agriculture for their food and livelihood: the impacts of climate change extend to distant populations due to food price volatility, and disruption in trading in agriculture and other commodities in the value chain. Climate change has direct and indirect impacts on agricultural production systems: direct impacts are directly caused by a modification of physical characteristics such as temperature levels and distribution along the year and water availability on a specific agricultural production. Indirect effects affect agricultural production through changes in other species such as pollinators, pests, disease vectors, and

invasive species. Direct effects are easily predictable since they can be simulated and easily modeled, and quite well projected for main staple crops. Indirect effects can play a major role, particularly in less controlled environments such as forestry and fisheries, and are much more difficult to model given the high number of interacting parameters and links, many of which are often not known yet. Climate impacts are worst in situations where there is natural resource depletion, especially forest biodiversity, and where there are threats to the conservation of the depleted forest.

The Ambalara Forest Reserve

Ambalara Forest Reserve embodies an enchanting blend of natural beauty and cultural heritage. This verdant expanse is a sanctuary for biodiversity, featuring diverse ecosystems including lush forests, meandering streams, and grasses. The reserve is a haven for an array of plant and animal species, some of which are endemic and rare, making it an essential hotspot for global biodiversity conservation efforts. Situated in the Upper West Region of Ghana, this area is characterized by its unique ecological features and climatic conditions. The region's semi-arid climate poses both challenges and opportunities, as the delicate balance between water availability and sustainable resource management becomes crucial for both environmental and community well-being. The interplay between the Reserve and its surrounding landscape emphasizes the interconnectedness of ecosystems, where the health of the forest influences water catchment areas, local microclimates, and the livelihoods of the communities.

Community and Culture: The landscape is home to indigenous communities that have nurtured a deep symbiotic relationship with nature for generations. These communities are repositories of traditional ecological knowledge, preserving practices that ensure the sustainable use of resources while fostering cultural identity. The project's scope encompasses the collaborative engagement with these communities, recognizing their unique insights as pivotal for both conservation and empowerment efforts. It is within this cultural fabric that the project seeks to empower Indigenous women, recognizing their invaluable role in both conservation and the broader socio-economic landscape. The Ambalara Forest Reserve, nestled within the captivating embrace of the Upper West Region of Ghana, is a realm where biological and cultural diversity interweave in a symphony of life and tradition. This pristine landscape holds within its embrace a treasure trove of natural wonders and traditional knowledge, setting the stage for our proposed project to safeguard this intricate tapestry of bio-cultural diversity.

Biological Diversity: Ambalara Forest Reserve stands as a sanctuary of biological diversity, fostering the growth and survival of an astonishing array of species. The reserve's lush forests, serene wetlands, and winding streams serve as a haven for numerous plant and animal species, many of which are endemic, rare, or endangered. The diversity extends from towering trees to tiny insects, creating a complex web of life that contributes to global biodiversity conservation. The Reserve hosts several flora and fauna species endemic to the Upper West Region, including rare orchids, vibrant bird species, and elusive mammals. In particular, the forest supports populations of West African chimpanzees and forest elephants, underscoring its vital role in preserving these threatened species. The proposed project seeks to protect these diverse habitats and species through measures such as habitat restoration, anti-poaching efforts, and biodiversity monitoring.

Forests, Climate change, and climate variability are threatening the delivery of a range of crucial goods (wood and non-wood) and environmental services from forests on which an estimated 1.6 billion people fully or partly depend. Forests' and trees' roles are varied, including, among others, delivering clean and reliable water supply, protecting against erosion and land degradation, enhancing the habitat of aquatic

and terrestrial animals, providing a range of products for household use and/or sale, and providing employment. Given that forest resources directly contribute to more than 1 billion of the 1.2 billion people living in extreme poverty (World Bank, 2002), climate change impacts on forests can be expected to hit the poorest the hardest, thus making already vulnerable people even more so. The risks that climate change and variability pose to forests and trees are well recognized. Negative impacts are apparent in many places. Although it is often difficult to separate climate change from other stresses, evidence shows that in various places climate change is contributing to decreased productivity and dieback of trees from drought and temperature stress, increased wind and water erosion, increased storm damage, increased frequency of forest fires, pest and disease outbreaks, changes in ranges of forest plants and animals.

Picture 1. Indigenous Women fetch water springing up from the catchment areas within the Ambalara Forest for domestic use during the dry season. Photo credit Kamasa.

Cultural Diversity: Ambalara Forest Reserve is not only a haven for biodiversity but also a living repository of cultural heritage. Indigenous communities residing in the Upper West Region have nurtured a profound connection with the land, enshrining traditional ecological knowledge, customs, and practices that have sustained them for generations. Their deep understanding of sustainable resource management, agricultural practices, and coexistence with nature enriches the region's cultural tapestry.

Picture 2. Kamasa with the billboard to be mounted in the Kandeh community representing the next phase of the project.

Leveraging Traditional Knowledge in Natural Resources Management for Food Security

There are many reasons why soils are overexploited and even destroyed; why farmers and other land users do not undertake adequate and appropriate measures to protect soil resources and maintain soil productivity. One of them is poverty. Land users often abandon protective measures after the expiration of development projects and the accompanying assistance and encouragement offered by them. Many forests are losing countless acres of trees that are very essential. Animals and humans lose their food

supply and homes through non-conservative methods. Conserving trees gives back to the natural environment; it aids in the protection of food sources, and medicinal properties that only the trees can provide. Trees protect the soil from harsh weather conditions and protect humans from excess carbon dioxide, enabling us to live longer and more comfortably. Trees also hold soil in place and naturally filter water that has been absorbed into the ground. Water and soil are essential for the function and structure of agricultural production systems and for overall social and environmental sustainability. Soil acts as its own supporter of life by supplying food and filtering water. Soil that is of good quality enhances the production of more nutritious crops for human and animal consumption.

Most rural and indigenous women are comparatively poor and uneducated, their impact and activities are significant as their indigenous knowledge in the management of natural resources such as land, soil, water, and forests (trees) because their traditional gender roles bring them in direct contact with these natural resources, and their survival and that of their families depend directly on exploiting and harnessing supplies from these natural resources. When the world environmental protection and conservation policies advocate for protection without any form of use, while ignoring rural women, they become the greatest victims of such a policy.

Land Management: In indigenous communities, land provides many basic needs, the most essential one being food. The main activity of rural women is producing food for their families. Women provide over 80% of labor directly in food production on most farms, firewood collection, fetching water for domestic use, cooking, and treatment of common rural ailments. Women have direct contact with land in their effort to produce food. If the soil doesn't yield enough crops as a result of exhaustion, women would have to deal with modification of farming practices like provision of local manure to replenish the soil. Their traditional activities, skills, and knowledge are crucial in understanding why lands deteriorate or remain viable, while it is becoming increasingly important to protect soils from erosion, and degradation. A lot of natural biodiversity and changes in ecologies also result when land is misused, loss of biodiversity because of intensive, indiscriminate, and careless use of land. It is of much urgent that women are taught to use farming and other compatible land-use approaches for biodiversity and ecological conservation. The common problems related to the use of land in the face of increasing human population and diminishing land resources are deforestation, and soil and water pollution.

Picture 3: Kamasa in a community engagement Meeting with some farmers, discussing farmland management.

Soil Management: Recognition of soil as the fundamental component for food security represents a significant shift in the way we view and manage agricultural production. It's important to understand that maintaining and rebuilding soil health, particularly organic matter, takes time. Inorganic nutrients are often required to ensure sufficient crop yields and food security. When inorganic and organic nutrient sources are used together, their benefits can be complementary for soil health and the environment. Healthy soil is more productive since it composes more organic matter and soil microorganisms which increase organic components and improve soil structure, aeration, water retention, drainage, and nutrient availability for plant growth. Increased organic matter enables soil to hold more water and reduces runoff. Favorable soil water retention combined with nutrient management practices prevents nutrients from leaving fields and contaminating water bodies and aquatic habitats.

Picture 4: Soil Management method demonstrated by Kamasa and some indigenous farmers.

Water Management: Issues concerning the management and conservation of water resources are of great importance in Ghana and the world at large. There is therefore an increasing concern about impacts, particularly on the current and future provision of clean water as well as the conservation of wetlands as habitats for wetland-related biodiversity. In rural Ghana Women are the main collectors and users of water.

Picture 5: Indigenous women of the Kandeh community with the CeWaFS-Ghana team at a catchment area within the Ambalara Forest

Issues concerning the management and conservation of water resources are of great importance in Ghana and the world at large. There is therefore an increasing concern about impacts, particularly on the current

and future provision of clean water as well as the conservation of wetlands as habitats for wetland-related biodiversity.

Picture 6: Kamasa with her team at a conserved riparian zone

Rural women in Ghana are the main searchers, collectors, and users of water. They have to decide where to collect water, how to draw, transport, and store it, how much water to draw, how many sources of water to exploit, and for what purposes, drinking, kitchen, and other domestic uses. In rural Ghana Women are the main collectors and users of water. Rainwater becomes a major source for drinking and other domestic use if there are larger storage media available especially in dry areas, women still depend on wells, springs, streams, and rivers for water supply. Activities that compromise water from streams, underground, and rivers directly affect the welfare of women. Stream and river sources should be conserved since they would be cool sources of water. Therefore, all agricultural practices that involve deforestation and replacement of natural vegetation must be discouraged in riparian and catchment areas. Draining of wetlands for planting rice should be discouraged if they will affect water quality, quantity, distribution, and supply. Women should be educated on the importance of conserving wetlands, riparian zones (interface between land and river or stream), and catchment areas (the area from which rainwater flows into a lake, river, or reservoir) to ensure clean and reliable water supply for their current domestic use and future supplies.

Picture 7: Indigenous women explaining to the CeWaFS-Ghana Team about the water crisis they are experiencing.

Forest and Tree Management: Forests and trees on farms contribute to food security, nutrition, and livelihoods in several ways, including as a direct source of food, fuel, employment, and cash income. They are fundamental to the survival of forest dwellers, particularly many indigenous peoples, and are important providers of ecosystem services, including maintaining or restoring soil fertility and protecting watersheds and water courses. For most of the year, herders in arid (very dry) and semi-arid lands depend on trees as a source of fodder for their livestock. As habitat to an estimated 80 percent of the world's biodiversity, forests provide genetic material important for crop and livestock improvement and are homes to many pollinator species. Forests and trees help to mitigate climate change by absorbing carbon dioxide and storing carbon. They can also help to reduce the vulnerability of people to climate change by providing food and other ecosystem services during critical periods of climate-driven food shortages.

Picture 8: Kamasa and her team survey a catchment area that serves as a drinking water source for a community.

Apart from maintaining atmospheric balance, protection and maintenance of watersheds, protection of soils, and water, and providing habitats for endemic and rare forest-related biodiversity, forests are important to women, particularly in supplying firewood. Women use forests to supplement fuel and food sources from their land, firewood nuts, wild fruits, vegetables, tubers, honey, and wild bush meat. Forests are also used for cultural purposes and in the provision of medicinal plants which cater to most rural healthcare. Women have used forest products intimately and their conservation is tightly linked with the activities of women and gender roles. Since tropical forests hold some of the world's largest and unique biological resources, they are of great concern and interest to conservation organizations and governments. Tropical forests are disappearing very fast and forest biodiversity is seriously threatened. The close association of women and forests as rural managers and users will bring women to the forefront of tropical forest conservation. To adopt new and more resilient livelihoods, farmers, herders, and foresters need to be operating in an institutional environment that supports such change. Forests play a crucial role in maintaining ecological balance, protecting watersheds, and supporting biodiversity. Specifically, for women, forests serve as a vital resource for firewood, food, and medicinal plants. The conservation of

tropical forests, which house unique biological resources, is essential for both environmental and gender-related reasons. Ensuring sustainable livelihoods requires supportive institutional environments for farmers, herders, and foresters.

Picture 9: Ghana Forestry Commission field staff take CeWaFS-Ghana on a survey of the 1 hectare of the section of the Ambalara Forest allocated for CeWaFS-Ghana for the restoration piloting project phase.

Problem Statement

Biodiversity Loss: The Ambalara Forest Reserve faces the imminent threat of biodiversity loss due to habitat degradation, illegal logging, and poaching. The delicate balance of ecosystems within the reserve is disrupted, endangering both flora and fauna species, some of which are endemic and threatened.

Gender Disparity: Indigenous women, despite their pivotal role in resource management and cultural preservation, often face barriers to active participation in decision-making processes. This gender disparity hinders the holistic conservation of the area, as their unique perspectives and traditional knowledge remain underutilized. Empowering Indigenous women as environmental leaders ensures a more inclusive approach to conservation and community development.

Climate Vulnerability: The landscape is susceptible to the impacts of climate change, including erratic rainfall patterns, prolonged droughts, and extreme weather events. These changes disrupt agricultural practices, threaten food security, and compromise the delicate balance of ecosystems.

Conservation threats:

Habitat Degradation: The unregulated expansion of agriculture, logging, and bushfires poses a substantial threat to the Ambalara Forest Reserve's biodiversity. These activities lead to habitat degradation

and fragmentation, ultimately diminishing the forest's ability to sustain diverse plant and animal species.

Limited Gender Inclusion: The absence of gender-inclusive programs hinders the active involvement of indigenous women in conservation efforts. This results in a lack of representation in decision-making processes, which in turn limits the effectiveness of resource management and conservation strategies.

Climate Change Impacts: The accelerating impacts of climate change, including altered precipitation patterns and temperature extremes, heighten the vulnerability of ecosystems and communities. This adversely affects biodiversity, agricultural productivity, and overall community well-being, necessitating adaptive strategies that can ensure sustainable development.

Picture 10: CeWaFS-Ghana Team on a survey of the 1 hectare of the section of the Ambalara Forest allocated for CeWaFS-Ghana for the restoration piloting project phase.

Project Goals and Objectives

The project envisions achieving significant milestones that lay the foundation for sustainable conservation, community empowerment, and cultural preservation within the Ambalara Forest Reserve and its surrounding communities.

Capacity Empowerment: Empowered a core group of indigenous women with leadership skills, conservation techniques, and sustainable agricultural practices. By building their capacities to position them as dynamic environmental leaders who can effectively advocate for sustainable resource management within their communities.

Pilot Nature-Based Solutions: Implemented pilot nature-based solutions within the Ambalara Forest Reserve and its surroundings. These solutions, such as reforestation and agroforestry projects, showcased the potential of harmonizing conservation and community development.

Strengthened Community Engagement: The project strengthened community engagement through workshops, dialogues, and awareness campaigns. These activities fostered a sense of ownership and stewardship over the Forest Reserve, creating a shared commitment to its preservation.

Empowered Environmental Leaders: The project envisioned a network of empowered Indigenous women who are not only leading conservation efforts but also influencing broader community decision-making processes in the longer term. Their active involvement will continue to enhance sustainable resource management.

Enhanced Biodiversity Conservation: The project contributed to the Reserve's role as a biodiversity hotspot by creating conservation corridors, reducing threats, and fostering habitat restoration. The project's impact will be measured through increased species populations and healthier ecosystems over time.

Sustainable Food Security: Through the integration of indigenous agricultural practices and climate-resilient techniques, there will be improved food security within local communities, to reduce vulnerabilities and enhance the well-being of community members.

Gender-Responsive Policies: In the longer term, the project will influence policy changes at local and regional levels that recognize and support the role of Indigenous women as environmental leaders. This recognition will create a framework for sustained impact.

Cultural Resilience: The project envisioned the continuity of traditional ecological knowledge, strengthening cultural identity, and ensuring that indigenous communities can embrace modern challenges while retaining their unique heritage.

Climate Change Adaptation: Through nature-based solutions and adaptive strategies, the project will enhance community resilience to climate change impacts. This will ensure that communities are better equipped to face future challenges.

Picture 11: CeWaFS-Ghana Team under a tree for a community engagement workshop. This shows how important trees are to humanity.

Project Implementation Criteria

Conservation Threats in The Ambalara Forest Reserve

In addressing the conservation threats, the project adopted a transformative approach by empowering Indigenous women as strategic environmental leaders, the project did not only address the gender disparity but also enhanced biodiversity conservation, strengthened climate resilience, and fostered sustainable community development. This multifaceted strategy created a ripple effect of positive change that reverberated beyond the project duration, ensuring the long-term preservation of the Ambalara Forest Reserve's ecological and cultural richness. The multifaceted approach leveraged a gender-responsive strategy and empowered indigenous women as strategic environmental leaders. The strategies were designed to tackle biodiversity conservation, community empowerment, and climate resilience through a series of targeted actions and activities.

Specific activities conducted by Indigenous women in environmental conservation:

Capacity Building: Training programs were organized to enhance the skills of Indigenous women, enabling them to take on leadership roles in environmental conservation. The focus was on building their capacity to address conservation challenges effectively. Indigenous women received training to enhance their skills and leadership abilities in conservation. This empowered them to address environmental challenges effectively.

Promotion of Traditional Knowledge: The project emphasized the importance of Indigenous knowledge systems and practices. Traditional ecological knowledge was integrated into conservation strategies, recognizing its value in sustainable resource management. Indigenous knowledge systems are integrated into conservation strategies. Traditional ecological knowledge, passed down through generations, informs sustainable resource management.

Biodiversity Conservation: Indigenous women actively participated in initiatives to protect and restore biodiversity within their territories. Specific actions included habitat restoration, species monitoring, and community-based conservation efforts. Indigenous women actively participated in initiatives to protect and restore biodiversity within their territories. This includes habitat restoration, species monitoring, and community-based conservation efforts.

Climate Action: Women were supported in implementing community-based strategies for climate change mitigation and adaptation. This involved awareness campaigns and tree planting. Women implemented community-based strategies for climate change mitigation and adaptation. This involved awareness campaigns, tree planting, or promoting sustainable energy practices.

Sustainable Agriculture: Indigenous women were encouraged to use traditional, sustainable farming techniques. The goal was to improve food security and ecosystem health while preserving cultural practices. Indigenous women adopted traditional, sustainable farming techniques. The goal was to improve food security and ecosystem health while preserving cultural practices.

Policy Advocacy: Empowered Indigenous women engaged in policy dialogues. They advocated for the recognition of their rights and the value of their environmental contributions. Empowered Indigenous women engage in policy dialogues, advocating for their rights and emphasizing the value of their environmental contributions.

Partnership Development: Collaborations were established with various stakeholders. These partnerships supported the project's goals and amplified its impact. Collaborations with stakeholders amplified the impact of conservation efforts.

Eight Hundred and Twenty-six (826) participants from Kandeh, Katua, Kpalworgu, Gbantala, Bulinga, and Holomuni communities directly benefited from the training activities. The overall focus was on empowering Indigenous women as agents of change, fostering a balance between human needs and environmental preservation. These actions empowered Indigenous women as agents of change, striking a balance between human needs and environmental preservation

The project recognized the critical role of climate change in shaping the future of the Ambalara Forest Reserve and its communities. To address climate change impacts, the project integrated mitigation and adaptation strategies at the core of our project design, ensuring a holistic and resilient approach.

Mitigation Strategies

Nature-Based Carbon Sequestration: Reforestation and agroforestry initiatives play a central role in sequestering carbon dioxide from the atmosphere. By restoring degraded areas with native tree species and implementing sustainable land management practices, we contribute to mitigating climate change.

Promotion of Sustainable Agriculture: Our project advocates for sustainable agricultural practices that emphasize agroecological principles. These practices improve soil health, water retention, and productivity but also minimize the release of greenhouse gases associated with conventional farming methods.

Adaptation Strategies

Climate-Resilient Agriculture: Through our project, we introduce and promote climate-resilient agricultural practices that enhance community food security. Diversification of crops, crop rotation, and water-efficient irrigation methods ensure that communities are better equipped to cope with changing climatic conditions.

Capacity Building for Climate Resilience: Empowering Indigenous women with climate resilience strategies ensures that communities are equipped with the knowledge and tools to adapt to the changing environment. This includes raising awareness about climate risks, implementing early warning systems, and promoting sustainable livelihood diversification.

Integrated Approach: The project's success hinged on the interconnectedness of climate change mitigation and adaptation. Simultaneously, by enhancing community resilience, empowering women, and promoting sustainable practices, we strengthen the capacity of communities to adapt to the changing climate.

Project Output

The project's reach extended to indigenous communities residing within the Upper West Region, specifically those with proximity to the forest reserve. This included local tribes and villages that have historically coexisted with the forest and depended on its resources for sustenance and cultural enrichment. Some of the primary communities involved were Kandeh, Katua, Kpalworgu, Gbantala, Bulinga, and Holomuni. The project created a framework of meaningful engagement that allowed these communities to actively participate in various project activities and benefit from the outcomes. Their involvement was multi-faceted and spanned from decision-making to skill-building:

Capacity Building and Training: Indigenous women within these communities were the focal point of empowerment. Through targeted workshops and training sessions, they acquire leadership skills, conservation techniques, sustainable agriculture practices, and climate resilience strategies. This did not

only enhance their role as environmental leaders but also strengthened their capacity to actively participate in community development.

Biodiversity Conservation: The communities played a pivotal role in biodiversity monitoring programs, which fostered a sense of ownership over the resources but also contributed vital data for conservation planning and decision-making.

Agroecology intervention: The communities actively participated in reforestation and agroforestry activities. These efforts enhanced local ecosystems but also provided tangible benefits like improved soil fertility, increased water retention, and diversified livelihood options.

Awareness Raising and Cultural Preservation: Community members engaged in awareness campaigns and workshops, further strengthening their understanding of the importance of conservation and the value of their traditional ecological knowledge.

Policy Advocacy: The communities' perspectives and needs were integrated into policy advocacy efforts. Their active involvement in shaping gender-responsive policies ensured that their voices were heard in conservation discussions.

Project Outcomes

Empowerment: Indigenous women were empowered as environmental leaders, allowing them to participate actively in decision-making and project activities.

Improved Livelihoods: Sustainable agricultural practices contributed to increased food security, enhanced livelihood options, and improved economic prospects.

Cultural Resilience: Recognition of traditional knowledge preserves cultural identity, fostering a sense of pride and continuity in the face of modern challenges.

Increased Resilience: The project equipped communities to better adapt to climate change impacts, enhancing their overall resilience and well-being.

Ownership and Stewardship: Active participation nurtured a sense of ownership and responsibility for the Forest Reserve, fostering sustainable resource management.

Gender-Responsive Approaches the Project Used to Empower Indigenous Women as Strategic Environmental Leaders.

Inclusive Participation

The project ensured that Indigenous women were actively involved in decision-making processes. This included leadership roles in community-based conservation initiatives, allowing them to voice their perspectives and influence strategies.

Leadership Roles in Community-Based Conservation Initiatives:

Empowerment and Training: Indigenous women were provided with training and resources to take on leadership roles in conservation projects. This included workshops on environmental management, leadership skills, and sustainable practices.

Decision-Making Authority: Women were given significant roles in the governance of conservation initiatives. This meant they could influence the planning, implementation, and monitoring of projects, ensuring their perspectives and knowledge were integrated into environmental strategies.

Representation in Committees and Councils: The project established or strengthened community committees and councils with a mandate to include women. This ensured that women's voices were heard in all major decisions affecting their communities and the environment.

Voicing Perspectives and Influencing Strategies:

Community Consultations: Regular community consultations were held where women could express their views and concerns. These consultations were designed to be inclusive and respectful of women's contributions, ensuring their insights were valued.

Participatory Planning: Women were involved in the participatory planning processes, which included mapping out conservation areas, identifying key environmental issues, and developing action plans. Their traditional knowledge and experiences were crucial in shaping effective and culturally appropriate conservation strategies.

Feedback Mechanisms: The project implemented feedback mechanisms that allowed women to continuously provide input and suggestions. This ensured that the strategies remained dynamic and responsive to the needs and insights of Indigenous women.

Building Networks and Alliances:

Collaboration with NGOs and Government Agencies: The project facilitated partnerships between Indigenous women and external organizations, including NGOs and government agencies. These alliances helped amplify women's voices and provided additional support and resources for their initiatives.

Peer Learning and Exchange Programs: Women leaders participated in peer learning and exchange programs, where they could share experiences and learn from other communities. This fostered a sense of solidarity and collective empowerment among Indigenous women across different regions.

Economic Empowerment:

Sustainable Livelihoods: The project promoted sustainable livelihood opportunities for women, such as eco-tourism, handicrafts, and sustainable agriculture. These initiatives not only supported conservation efforts but also provided economic benefits to the women and their communities.

Access to Markets and Resources: Women were supported in accessing markets for their products and resources for their projects. This included training in business skills, marketing, and financial management, ensuring that their economic activities were viable and sustainable.

By focusing on inclusive participation, the project not only empowered Indigenous women as environmental leaders but also ensured that conservation strategies were more effective and sustainable. The active involvement of women brought diverse perspectives and solutions, enhancing the resilience and adaptability of their communities in the face of environmental challenges.

Capacity Building

Training programs were designed to enhance the skills and knowledge of Indigenous women in areas such as sustainable agriculture, biodiversity conservation, and climate resilience. These programs were tailored to respect and integrate traditional knowledge with modern conservation techniques.

Training Programs:

Sustainable Agriculture: Indigenous women were trained in sustainable farming practices that enhance soil health, increase crop yields, and reduce environmental impact. This included techniques such as crop rotation, organic farming, and agroforestry. These practices not only improve food security but also promote biodiversity and resilience against climate change.

Biodiversity Conservation: Training sessions focused on the importance of preserving local flora and fauna. Women learned about the roles different species play in their ecosystems and how to protect

endangered species. This knowledge was combined with traditional practices, such as the use of native plants for medicinal purposes, to create a holistic approach to conservation.

Climate Resilience: Programs were designed to help communities adapt to the impacts of climate change. This included training on water conservation techniques, such as rainwater harvesting and efficient irrigation methods, as well as disaster preparedness and response strategies. Women were also educated on the effects of climate change and how to mitigate its impacts through sustainable practices.

Integration of Traditional Knowledge: The training programs were carefully crafted to respect and incorporate Indigenous knowledge systems. This meant recognizing the value of traditional ecological knowledge, which has been passed down through generations, and blending it with modern conservation techniques. For example, traditional methods of land management and resource use were integrated with scientific approaches to create more effective and culturally appropriate conservation strategies.

Empowerment and Leadership: By enhancing their skills and knowledge, the project aimed to empower Indigenous women to take on leadership roles within their communities. This included providing opportunities for women to participate in decision-making processes related to environmental management and conservation. Leadership training helped women develop the confidence and skills needed to advocate for their communities and lead conservation initiatives.

Community Involvement: The project emphasized the importance of involving the entire community in conservation efforts. Women were encouraged to share their knowledge and skills with others, fostering a sense of collective responsibility for the environment. Community workshops and events were organized to raise awareness about the importance of conservation and the role of women in these efforts.

By focusing on capacity building, the project not only enhanced the skills and knowledge of Indigenous women but also strengthened their roles as strategic environmental leaders. This approach ensured that conservation efforts were sustainable, culturally relevant, and effective in addressing the unique challenges faced by Indigenous communities.

Economic Empowerment

By creating opportunities for income generation through sustainable practices, the project helped women achieve financial independence. For example, women were trained in producing and marketing eco-friendly products, such as jams and liqueurs from indigenous fruits, which supported both conservation efforts and local economies.

Income Generation through Sustainable Practices: The project focuses on creating sustainable income opportunities for Indigenous women, which is crucial for their financial independence and overall community resilience. By integrating traditional ecological knowledge with modern sustainable practices, the project ensures that economic activities do not harm the environment but rather contribute to its preservation.

Training in Eco-Friendly Product Production: Indigenous women were trained to produce eco-friendly products, such as jams and liqueurs made from indigenous fruits. This training included not only the technical aspects of production but also the knowledge of sustainable harvesting methods to ensure that the natural resources are not depleted. For instance, women learned how to identify the right time for harvesting fruits to maintain the health of the plants and the ecosystem.

Marketing and Business Skills: Beyond production, the project provided training in marketing and business management. Women were taught how to brand their products, create appealing packaging, and

develop marketing strategies to reach broader markets. This included understanding market demands, setting competitive prices, and utilizing both local and online platforms to sell their products.

Supporting Conservation Efforts: The production and sale of eco-friendly products directly support conservation efforts. By creating a market for products derived from sustainable practices, the project incentivizes the preservation of natural habitats. For example, the cultivation of indigenous fruits for jam and liqueur production encourages the protection of these plants and their ecosystems, as they become valuable economic resources.

Strengthening Local Economies: The economic activities generated by the project have a ripple effect on local economies. As women gain financial independence, they can invest in their families and communities, leading to improved living standards and greater community resilience. The success of these eco-friendly products also creates a model for other community members to follow, further spreading the benefits of sustainable practices.

Broader Impact: The economic empowerment of Indigenous women through this project not only enhances their financial independence but also positions them as key players in environmental conservation and climate resilience. By integrating traditional knowledge with sustainable practices, the project ensures that economic development goes hand-in-hand with environmental stewardship.

This holistic approach highlights the importance of empowering Indigenous women, recognizing their unique role in both their communities and the broader environmental landscape. Their leadership in producing and marketing eco-friendly products serves as a powerful example of how gender-responsive strategies can drive positive change for both people and the planet.

Cultural Sensitivity in Practice

The project respected and incorporated indigenous cultural practices and knowledge systems. This approach not only validated the women's traditional roles but also strengthened their leadership in environmental stewardship.

Respecting Indigenous Knowledge Systems: The project acknowledged the deep-rooted knowledge Indigenous women possess about their environment. This includes understanding local flora and fauna, weather patterns, and sustainable agricultural practices. By integrating this knowledge into conservation strategies, the project ensured that the solutions were not only effective but also culturally relevant.

Incorporating Traditional Practices: Traditional practices such as rotational farming, herbal medicine, and community-based resource management were incorporated into the project's framework. This not only validated the women's roles as knowledge keepers but also highlighted the importance of these practices in modern conservation efforts.

Community Engagement and Leadership: The project facilitated community meetings and workshops where Indigenous women could share their knowledge and experiences. This participatory approach empowered them to take on leadership roles within their communities, fostering a sense of ownership and responsibility towards environmental stewardship.

Strengthening Leadership in Environmental Stewardship

Training and Capacity Building: Indigenous women were provided with training in modern conservation techniques, climate resilience strategies, and sustainable livelihood practices. This training was designed to complement their traditional knowledge, creating a holistic approach to environmental management.

Creating Platforms for Advocacy: The project established platforms where Indigenous women could advocate for their rights and the protection of their lands. This included participation in local and international forums, where they could share their success stories and challenges, thereby influencing policy and decision-making processes.

Economic Empowerment: By integrating sustainable livelihood practices such as eco-tourism, handicrafts, and sustainable agriculture, the project provided economic opportunities for Indigenous women. This economic empowerment was crucial in enhancing their roles as environmental leaders, as it reduced their dependency on unsustainable practices.

Impact and Outcomes

Enhanced Environmental Conservation: The integration of traditional knowledge with modern conservation techniques led to more effective and sustainable environmental management practices. This resulted in the preservation of biodiversity, improved land management, and increased resilience to climate change.

Empowered Communities: The project's focus on cultural sensitivity and gender responsiveness led to the empowerment of entire communities. Indigenous women, in particular, gained recognition and respect for their roles, leading to greater gender equality and social cohesion.

Sustainable Livelihoods: The economic opportunities created through the project not only improved the livelihoods of Indigenous women but also ensured that these livelihoods were sustainable and environmentally friendly. This dual benefit reinforced the women's roles as stewards of their environment. By respecting and incorporating Indigenous cultural practices and knowledge systems, the project not only validated the traditional roles of Indigenous women but also significantly strengthened their leadership in environmental stewardship. This holistic approach ensured that conservation efforts were both effective and culturally respectful, leading to sustainable and long-lasting outcomes.

Networking and Advocacy

Indigenous women were connected with broader networks of environmental organizations and advocacy groups. This helped amplify their voices on larger platforms and provided support for their initiatives.

Building Connections:

Broader Networks: Indigenous women were connected with a wide range of environmental organizations and advocacy groups. This included both local and international entities, allowing them to share their experiences and learn from others.

Collaborative Platforms: These connections provided platforms for Indigenous women to collaborate on projects, share resources, and support each other's initiatives. This collaborative approach helped in building a strong community of like-minded individuals and organizations.

Amplifying Voices:

Larger Platforms: By being part of broader networks, Indigenous women had the opportunity to present their issues and solutions on larger platforms. This included international conferences, seminars, and online forums where they could reach a global audience.

Media Engagement: Advocacy efforts also involved engaging with various media outlets to highlight the work and challenges faced by Indigenous women in environmental conservation. This helped in raising awareness and garnering support from a wider audience.

Support for Initiatives:

Resource Mobilization: Being part of larger networks enabled Indigenous women to access resources such as funding, technical expertise, and training. This support was crucial in implementing their conservation projects effectively.

Policy Influence: Advocacy efforts aimed at influencing policy decisions at local, national, and international levels. By voicing their concerns and recommendations, Indigenous women could contribute to the formulation of policies that support sustainable environmental practices and gender equality.

Capacity Building:

Training Programs: Networking and advocacy efforts included organizing training programs to enhance the skills and knowledge of Indigenous women. These programs covered various aspects of environmental conservation, leadership, and advocacy.

Mentorship: Experienced leaders and experts from environmental organizations provided mentorship to Indigenous women, guiding them in their initiatives and helping them navigate challenges.

Impact

Empowerment: The strategy of networking and advocacy significantly empowered Indigenous women by giving them a platform to voice their concerns and solutions. It also provided them with the necessary support to implement their initiatives effectively.

Visibility: By connecting with broader networks and engaging in advocacy, Indigenous women gained visibility for their work. This not only helped in raising awareness about their contributions but also inspired other women to take up leadership roles in environmental conservation.

Policy Changes: The advocacy efforts led to positive changes in policies related to environmental conservation and gender equality. This ensured that the voices of Indigenous women were considered in decision-making processes, leading to more inclusive and effective policies.

Overall, the strategy of networking and advocacy played a crucial role in empowering Indigenous women as environmental leaders, enhancing their capacity to contribute to conservation efforts, and ensuring their voices were heard on larger platforms. This approach not only benefited the women involved but also contributed to the broader goals of environmental sustainability and gender equality.

These gender-responsive approaches collectively empowered Indigenous women to become influential leaders in environmental conservation, fostering resilience and sustainable livelihoods within their communities.

Conclusion

To help achieve food security and reduce poverty, sustainable natural resource management and measures to stabilize and increase soil productivity need to be taken without delay. The use of indigenous knowledge in solving food shortage remains a powerful means of sustaining rural household food security. Trial and error natural resource management experiments contribute to developing many indigenous techniques and practices for cultivating, processing, and preserving foods at the rural community level. Indigenous methods and solutions applied by women to sustain household food supplies are culturally acceptable, economically practicable, and more appropriate for the local environment and conditions. Rural women have an important role to play in using and preserving this valuable Indigenous knowledge, they manage to achieve sustainable food security at household levels, with practical, efficient, and economic solutions.

Impacts on production directly translate into economic impacts at various scales, on the farm and in the food chain, and with social consequences. The effects of climate change are translated into social and economic consequences through a range of different pathways that can result in changes in agricultural incomes, food markets, prices and trade patterns, and investment patterns. At the farm level, they can reduce incomes. They can impact physical capital. They can force farmers to sell productive capital, for instance, cattle, to absorb income shocks. They can reduce the capacity to invest. This directly bears social impacts on farming households, limiting their capacity to face other expenditures, such as health and education. At the national level, they can trigger an increase in agricultural commodities prices (food and feed), which impacts the economic and social status of the entire population, particularly in Ghana where food takes a significant percentage of the household budget. This triggers macro-economic effects for agriculture-dependent countries for which agriculture is an important part of GDP, and/or for which agriculture constitutes an important part of employment. Climatic risks can also hinder agricultural development by discouraging investments. Climatic shocks that impact a significant volume of worldwide production or an area of importance in terms of world markets have global consequences on markets:

- quantity and price effects, with increased tension on markets
- impacts on bilateral contracts and/or import/export behavior, with disruption of trade patterns.

These consequences can be expected to unfold over time and the progression of climate change impacts, as well as varying across different locations and sectors of the population. We must consider the effects of increasing intensity and frequency of extreme events and weather anomalies at present, and the near-term as well as longer-term impacts associated with major shifts in global warming. Estimating the economic consequences of long-term global warming is difficult as it requires a reliance on the outputs from global climate modeling studies, and there is still relatively limited work in this area. Another issue is that consequences depend very much upon actions that people can take to reduce negative and enhance positive outcomes, and this is uncertain. Impact on agricultural incomes, observed and projected given the high level of dependency of poor and food-insecure people on agriculture for their incomes, including rural laborers as well as family farmers and smallholder producers. The potential impacts of climate change on agricultural incomes are of considerable concern, and the potential negative impact of climate change on agricultural GDP of poor and highly agriculture-dependent economies is of considerable concern.

Recommendations

One effective means to achieve household food security is by recognizing, supporting, and helping improve the agricultural skills of indigenous women. Several changes will strengthen women's contribution to agricultural production and sustainability. These include support for public services and investment in rural areas to improve women's living and working conditions; giving priority to technological development policies targeting rural and farm women's needs and recognizing their knowledge, skills, and experience in the production of food and the conservation of biodiversity; and assessing the negative effects and risks of farming practices and technology, including pesticides on women's health, and taking measures to reduce use and exposure.

Climate Risks Assessment, Vulnerabilities, and Adaptation: Options and area to invest.

A better understanding of local climatic risks, potential impacts on agriculture and food security, characterized vulnerabilities, and effectiveness of adaptation options, is needed to form a solid evidence

base for enabling climate change adaptation. A careful strategic assessment needs to evaluate the benefits and trade-offs in various social, economic, and environmental conditions. Assessments can determine how local climate conditions and their impact on agriculture, the natural resource base, food security, and livelihoods have been changing and are projected to change in the future. They also can identify the most vulnerable locations and contexts that require adaptation actions. Knowing which agricultural systems and livelihood activities may be more sensitive to a changing climate, for example, will help practitioners choose more resilient crops, livestock, aquaculture, and forestry species and adopt more diversified livelihoods. Informing stakeholders of the changing amounts of rainfall and the spatial distribution of precipitation will help them to better allocate resources for the management of water resources.

Also, given the multiple environmental changes driven by climate change, it may be necessary to develop environmental monitoring systems, focusing on key parameters. Assessment of impact and vulnerability needs to be completed by assessments of the effectiveness of adaptation options. It is necessary to know more about which changes in agricultural and commercial practices and the institutional and policy environment are effective and efficient measures to achieve climate change adaptation objectives. Such assessments can determine whether certain measures indeed help farmers, pastoralists, fisherfolk, and forest users adapt to climate change in a particular context. Effective adaptation options can be explored based on historical, current, and projected climatic impacts on agriculture and the vulnerability of livelihoods and food security.

Picture 9: Billboard for the next project phase.

It is also possible to simulate the adaptation activity that is more suitable for adapting to a changing climate. Any assessment should be linked to concrete development objectives and actions that result in the robust adaptation of food-insecure vulnerable populations, taking into account uncertainties in climate change scenarios. The information needs of stakeholders, as well as key risk and vulnerability questions that contribute to policy and development objectives, should be clearly defined as well as the methodologies to be employed, and the tools, data, and information necessary for the assessment to be conducted. As such, assessment frameworks should account for the different needs of end-users. Moreover, early warning systems are essential to reduce the impacts of changes, particularly of extreme events. Climate Risk and Impact Assessment and Tools A better understanding of the influence of a changing climate on agriculture is the first step to climate change adaptation. Climate impacts on agriculture specifically depend on the location.

Assessing climate risks and vulnerabilities is essential for effective climate change adaptation.

Understanding Local Climate Risks: Assessments help us understand how local climate conditions impact agriculture, natural resources, food security, and livelihoods. Identifying vulnerable locations and contexts is crucial for targeted adaptation actions.

Choosing Resilient Practices: Knowing which agricultural systems and livelihood activities are sensitive to climate change allows practitioners to select more resilient crops, livestock, aquaculture, and forestry species. Diversifying livelihoods can enhance resilience.

Resource Allocation: Informing stakeholders about changing rainfall patterns and spatial distribution helps allocate resources effectively for water management.

Environmental Monitoring: Developing environmental monitoring systems focused on key parameters is essential due to multiple environmental changes driven by climate change.

Assessing Adaptation Effectiveness: Evaluating the impact and vulnerability of adaptation options is critical. Understanding which changes in practices and policy environment are effective helps achieve climate change adaptation objectives. A comprehensive assessment of climate risks and vulnerabilities informs adaptive strategies, ensuring resilience in the face of changing conditions.

Local perception of how climate has been changing in the recent past, and how agricultural production systems are affected by changes, can be validated by an analysis of past climate variability and characteristics of extreme events from an agronomic perspective. Such an analysis forms a robust evidence base for adapting farming, fishing practices, and forestry to climate variability and climate change, and for identifying needs for further development, and even research: for example, new varieties resistant to increasing climate risks). A common climate impact assessment of agricultural productivity crop yields follows a top-down approach. Past climate conditions can be associated with past agricultural productivity to establish causal links and calibrate models. Global climate models can provide future climate projections, based on socio-economic and emission scenarios, and they can be downscaled using appropriate methods. The calibrated models can simulate future impacts of climate change on agriculture with projected climate as an input (FAO, 2012a for general methodology). Climate change can bring opportunities as well as risks. Analyses can also help identify conditions in which opportunities may (or may not) be taken advantage of, or identify cases where risks will affect systems (sectors, dependent communities, economies, natural systems, etc.) differently. UNFCCC (2010) provides a review of available agricultural models, including agroclimatic indices with geographic information systems (GIS); statistical models and yield functions and process-based crop models; and economic models, such as economic cross-sectional models, farm-level micro-economic models, household and village models, and

macro-economic models. All of these models may be useful for climate impact assessment and adaptation planning.

Picture 10: CeWaFS-Ghana Team at the tree seedling nursery offered by the Forestry Commission of Ghana in support of the project.

The Modelling System for Agricultural Impacts of Climate Change (MOSAIC)

MOSAIC is an integrated package of tools for facilitating an interdisciplinary assessment of the impacts of climate change on agriculture. Assessments should be based on the best available scientific information (methodologies, tools, models, and data), making use of model-based methodologies as well as participatory, perceptions-based methodologies. To ensure accountability, replicability, and transparency, established and robust methodologies should be selected, while allowing for uniqueness inherent to each context. Developing environmental monitoring systems As described above, climate change will profoundly affect ecosystems, directly and indirectly, through modifications of physical and biological characteristics, including water quality (temperature, salinity, acidity) and distribution of species. Environmental monitoring systems should follow a risk-based approach recognizing that increased risks require increased monitoring efforts. The involvement of local actors and the value of locally collected information is particularly important for farmers and fisherfolk to better understand the biophysical processes and become part of the solution, e.g. rapid adaptation measures and early warning, long-term behavioral and investment changes. Vulnerability assessment and tools Impacts on agricultural productivity and other aspects of the sector can lead to different repercussions in household income and food security. Vulnerability of livelihoods depends on the capacity of local communities to substitute a negatively affected production system with an alternative that could prevent losses in agricultural income,

provide subsistence production, or supply food to urban markets. Vulnerability assessments characterize and identify areas, households, or subpopulations that have particularly low livelihood resilience. This helps adaptation planners prioritize their actions and target vulnerable communities (e.g. youth, the elderly, land-less people, and women). Vulnerability assessments also provide the basis for the development of strategies to increase the resilience of systems and livelihoods to climate change. With the potential impacts of climate change identified from previous assessments, vulnerability can be assessed by evaluating the adaptive capacity of the system in a top-down approach. It is also necessary to acknowledge and improve the knowledge of social-ecological climate drivers and vulnerabilities of agriculture, forest, and fisheries systems (e.g. indirect impacts on livestock through natural vegetation; direct impacts on fish species; indirect impacts on forest-dependent communities; and direct impacts on production and post-harvest infrastructure, safety at sea, access to markets).

Vulnerability to climate change should be seen in the context of existing broader socio-economic and environmental conditions. Contextual conditions of the society and environment clarify their adaptive capacity and vulnerability to potential threats. Adaptation Options Assessment and Tools Following climate impact, risk, and vulnerability assessments, adaptation options assessments examine the extent to which different adaptation measures may achieve the objectives of increasing productivity, enhancing climate change adaptation, and improving food security, given the expected impacts of climate change. This helps practitioners identify effective adaptation options. The tools to support adaptation range from quantitative climate and crop models at various levels (global, regional, national, and subnational) and statistical analyses at the household level, to qualitative assessments of policies and institutions. Whereas global models provide an important understanding of the climate patterns and projected changes, their resolution tends to be very low to enable local action. Downscaled models of the impacts of climate change on food security dimensions are necessary to better understand localized impacts and relevant options to support adaptation. Local institutions need to develop their capacities to sustain the use of such high-resolution models and adapt them to local needs just like the MOSAIC project. A complementary set of tools includes statistical analyses that combine relevant climate data as provided by the above with large-scale household data on agricultural and other income-generating activities, adaptation strategies, and food security outcomes to understand barriers to adoption and impact on livelihoods. Given that climate change brings both extreme and slow-onset change, such analyses need to be institutionalized and regularly conducted to track change in the system (both agroecological and socio-economic). National statistical institutions can incorporate the regular collection of data relevant to climate change and adaptation into their already existing efforts (Agricultural Census or Living Standards Measurement Surveys) to ensure that site-specific relevant information is regularly collected to support evidence-based policy-making. Quantitative analyses can be complemented with qualitative analyses of local institutions and policies to support adaptation. Policy mapping and harmonization analyses are instrumental in making sure that the strategies outlined above are adapted and can be sustained by households/communities. Scenario analysis is another tool that can be used to combine qualitative analyses with quantitative modeling to assist policy planning for different futures that are possible under predicted climate change and social development paths.

Assessments of adaptation options for effectiveness are an extension of climate impact and vulnerability assessments. Having gained an understanding of the potential impacts of climate change and vulnerabilities, the best adaptation practices for local conditions can be reviewed and identified. Ideally, stakeholders are involved in undertaking and validating the findings of the assessment and help to define

and select suitable and workable adaptation options. Process-based crop growth models at the farm level could be used to suggest better management practices to improve yields. Economic models could simulate, for example, the effect of a fertilizer subsidy on productivity, market prices, and farm income. A screening analysis is a simple method in which the assessor answers yes or no questions about options. Those options with the most yeses can be given the highest priority or be further assessed using more quantitative analytical methods. In multicriteria assessments, stakeholders identify the criteria to be used in assessing adaptations. Common metrics are defined to measure the criteria. Assessors rank each adaptation option against each criterion by giving scores. In cost-effectiveness analysis, the relative costs of different adaptation options that achieve similar outcomes are compared (UNFCCC, 2010). Analytical assessments should be complemented by a bottom-up approach in which the local community is fully engaged, and where local men and women farmers and other rural dwellers discuss and agree on the best adaptation interventions that they would be willing to adopt, given the local climatic, socio-economic and environmental conditions (community-based adaptation). This provides an opportunity to link local traditional knowledge with scientific knowledge. In addition, it allows the affected populations to identify possible unintended consequences of interventions and discuss how to resolve them. When the comparative advantage of different adaptation options is not clear, an assessment of the costs and benefits of adaptation measures can be done using economic analysis or noneconomic evaluation methods. Either way, some metrics of costs and benefits need to be estimated (World Bank, 2009). An overall adaptation strategy should enhance the food security of agricultural producers and of the overall population, which often requires achieving sustainable increases in productivity. Additional assessment criteria that address a specific food security concern may need to be added to vulnerability and adaptation assessments.

Adaptation strategies should be able to address many different plausible climates and outcomes, given the large uncertainties in climate projections. For example, scenario-based assessments allow the outcomes of different adaptation options under different climate change scenarios to be explored to guide the robust adaptation of food-insecure, vulnerable populations, considering uncertainties in climate change scenarios. Tools elaborated and developed must be accompanied by training and extension to ensure their utilization and the consequent adoption and maintenance of identified suitable agricultural solutions with tools to facilitate and support their efficient and effective utilization. Early warning systems The development of early warning systems is essential to strengthen proactive decision-making at all levels to reduce the impacts of extreme weather events such as dry spells, droughts, frosts, and tropical cyclones. For example, FAO's Agricultural Stress Index System (ASIS) monitors vegetation indices and detects hotspots where crops may be affected by drought, using data on vegetation and land surface temperature. The system contributes greatly to the food security monitoring work of the Global Information and Early Warning System on Food and Agriculture (GIEWS). Analysis of meteorological data, together with information on phenology, soil, and agricultural statistics, also allows the provision of near real-time information about the crop state (crop forecasting), in quality and quantity, with the possibility of early warning so that timely interventions can be planned and undertaken. While such agrometeorological monitoring systems are becoming available, timely and effective delivery of information to the users remains a significant challenge. Beyond hydrometeorological events that progress over days and months, warning systems for very short-term events such as flash floods, landslides, and storm surges are not yet readily available in many developing countries. At national and local levels, risk and opportunity management can be enhanced by weather/climate information systems tailored to the needs of farmers, fishers, and foresters, alongside improved outreach to agricultural support services. Seasonal climate

forecasts have varying predictive skills depending on the location and lead time. Where predictability is found, farming advice can be provided according to the forecast. Irrigation schedules can be managed to increase efficiency, based on agrometeorological monitoring and short-term forecasts.

FAO's Localized Climate Information Systems

Experiences from FAO's localized climate information systems indicate the need to link information providers and users and customize information products with impact outlooks and management options for use in the agriculture sectors. The accuracy of weather/climate forecasts and early warning systems rely, among others, on the availability and accessibility of data, including hourly/daily/monthly weather data; data on extreme weather events, their anomalies, and impacts; satellite-based weather monitoring; vegetation characteristics; crop prospects, the food situation, and food prices. Support for monitoring and observation at weather stations has steadily decreased over the past decades, mainly as a result of the discontinuation of several regional and country support programs. There is an urgent need to invest in continued operational observations and data collection, and in strengthening institutional capacities. Such systems shall be developed not only for climate shocks but also for other variables of interest like pests and diseases or water quality. FAO's desert locust early warning system monitors weather, ecological conditions, and the global locust situation, and provides forecasts and warnings of potential breeding and invasions to affected countries. Information and communication technologies provide considerable opportunities to establish two-way communication systems in which farmers and forest dwellers are an integral part of surveillance both communicating and receiving information. For agrometeorological information to be used for appropriate responses, sufficient support for developing capacities of relevant institutions and personnel needs to be provided. This is true on both sides of information flow: development of the capacity of national meteorological services and agricultural line agencies on the information provider side, and the farmers and extension service personnel on the information user side. Climate-smart farmer field schools can integrate topics such as weather and climate information products and sources, and how to interpret and incorporate forecasts into farmers' decision-making process. Farmers can hedge against extreme weather risks with financial insurance (crop insurance, livestock insurance). Insurances based on weather indices have been increasingly explored in the last ten years as an option in developing countries. Payout is not triggered by damage to the crop but by the level of a weather index that is correlated to crop yield. The main advantage is that insurers do not need to assess damages, which can be costly and long, delaying payments when they are the most needed. Indices can be based on rainfall, water stress, drought, or other meteorological variables. Weather index-based insurance has the potential as an adaptation tool and further research on the quantification of benefits, and improved indices using satellite data is a necessity (Leblois and Quirion, 2011).

Achieving Adaptation Using Institutions and Policies

Presently, this kind of enabling policy and institutional environment is often lacking for smallholder producers. Institutional arrangements that support increased and stabilized returns from agricultural production are essential. For food producers to get the material and immaterial inputs needed to adapt, and for them to be able to sell the products resulting from their diversification activities, it will be even more important, under climate change, to better link smallholder farmers to local, national, and regional markets. Developing these market linkages also requires investment in small- and medium-size food processors, and small-scale traders at the retail and wholesale levels. Price volatility is a major disincentive for

smallholder investment. Government intervention is important to reduce transaction costs in accessing markets and to establish regulatory instruments to bridge gaps in economic and political power that can exist between smallholders and their organizations on the one side, and the other contracting organizations on the other side. Policies will be needed to reduce financial risks, lower transaction costs, facilitate monetary transactions, enable access to financial services, and facilitate long-term investments, such as safe savings deposits (with incentives to save), low-priced credit (such as through joint-liability group lending), and insurance (such as index-based weather insurance). Smallholders' and family farmers' financial needs for both working capital expenditures (fertilizers, seeds), and medium- and long-term investments, have to be addressed and supported. Civil society and the private sector can play important roles in the effort to build enabling institutions to reduce risks. Support and facilitate collective action Climate change gives rise to new and increased demands for collective action. This requires appropriate policies and institutions that facilitate and support the collective elaboration and implementation of adaptation actions either in a space (for instance a watershed, a forest) or sector, for instance along the food chain, including to increase and adapt storage facilities. This can be done by improving the inclusiveness and transparency of decision-making and providing means to incentivize actions that provide public and collective adaptation benefits in the long term. This is particularly important for the management of natural resources (Place and Meybeck, 2013).

National governments could provide mechanisms for proactive and integrated risk management, such as a national board that coordinates risk management strategies, with institutions for risk monitoring, prevention, control, and response at the local and global levels, and incentives for private sector participation in risk coping. Social protection programs that guarantee minimum incomes or access to food also have potential through their effects on production choices and prices. Adequation policies and institutions are crucial to ensure the diversification of livelihood strategies. Livelihood diversification is, indeed, among the most effective risk management strategies for smallholders and family farmers. Depending on the specific context being considered, these might refer to land-use diversification and income or labor diversification. Agricultural development policies need to integrate diversification as a main component, and local institutions need to facilitate it by providing incentives through improved access to credit and insurance and information/training. Integrate climate change concerns in all agricultural and food security strategies and policies Numerous instruments and policies need to be mobilized for adaptation, to build resilience of agriculture and food systems to climate change. This requires elaborating an integrated strategy covering agriculture and food security policies and measures, and those related to water management, land and natural resource management, rural development, and social protection, among others. There is a need to adopt a holistic approach considering agricultural development for food security and nutrition in the context of climate change, combining practices, enabling policies and institutions as well as financial resources.

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