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BIODIVERSITY, TROPICAL FORESTS, CLIMATE CHANGE: ENVIRONMENTAL THREATS AND OPPORTUNITIES ASSESSMENT

ENVIRONMENTAL ANNEX TO
ANNUAL OPERATIONAL PLANS



May 2011

This report was produced for review by the United States Agency for International Development (USAID). It was prepared by U.S. Forest Service, International Programs.

COVER PHOTO: Students at Kakum National Park Visitor Center (Photo: USFS, IP)

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ACRONYMS

CBD	Conservation of Biodiversity
CICOL	Civil Society Coalition on Land
CRC	Cooperative Research Centre
CREMA	Community Resource Management Area
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ETOA	Environmental Threats and Opportunities Assessment
FAA	U.S. Foreign Assistance Act
FtF	Feed the Future
GCMs	Global Circulation Models
GHG	Greenhouse Gas
GoG	Government of Ghana
GSBAs	Globally Significant Biodiversity Areas
IEE	Initial Environmental Examination
IUCN	International Union for Conservation of Nature
IUCN	International Union for the Conservation of Nature
LOGODEP	Local Governance and Decentralization Program
MCC	Millennium Challenge Corporation
NADMO	National Disaster Management Organization
NREG	Natural Resources and Environmental Governance (NREG) program
STEWARD	Sustaining Thriving Environments for West African Development
USAID/Ghana	US Agency for International Development Mission to Ghana
USFS	US Forest Service
USG	US Government
WD	Wildlife Division (of the Forestry Commission of Ghana)
WPAs	Wildlife Protected Areas

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INTRODUCTION

This Environmental Annex is an analysis that examines environmental threats and opportunities inherent to the Mission’s strategy and assesses the extent to which this strategy incorporates or addresses tropical forests and biodiversity concerns. This assessment does not substitute for the Initial Environmental Examination (IEE). The Mission is responsible for ensuring that an IEE or a Request for Categorical Exclusion is conducted for all activities funded by USAID.

This Annex contains a summary of the findings of the parent reports: “Ghana, Biodiversity, Tropical Forests, Environmental Threats and Opportunities Assessment (ETOA),” May 2011, and the “Ghana Climate Change Assessment,” June 2011. Both of these reports report and this Annex were prepared for USAID/Ghana by the US Forest Service, International Programs. The conclusions and recommendations contained in the reports and this Annex are the opinions of the authors and do not necessarily represent the position of USAID/Ghana.

PURPOSE OF THE ASSESSMENT

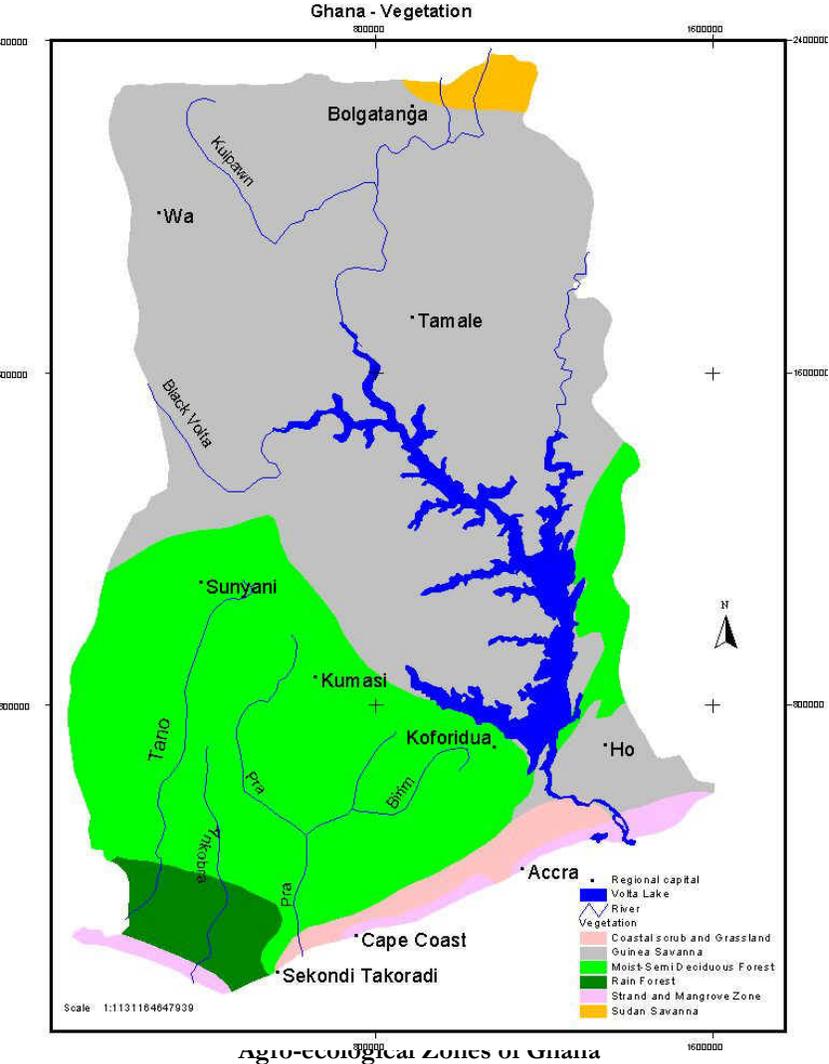
This assessment was compiled for the US Agency for International Development Mission to Ghana (USAID/Ghana) to:

- Serve as a planning tool to update data and assumptions on the status of the environment in Ghana and to better integrate environmental concerns into its overall programming.
- Meet core environmental requirements of the U.S. Foreign Assistance Act (FAA) in regard to:
 - Section 117: “Environment and Natural Resources,” which dictates that operation units will implement programs with an aim toward maintaining and restoring natural resources and to consider the impact of their activities on the environment
 - Section 118: “Tropical Forests,” which requires an analysis of actions necessary to achieve conservation and sustainable management of tropical forests
 - Section 119: “Endangered Species,” which requires an analysis of actions necessary to conserve biological diversity, and the extent to which the actions proposed for support by the Agency meet the needs thus identified
- Inform USAID planning efforts of new developments in Ghana’s environmental context which need to be taken into consideration.
- The climate change report is to provide USAID/Ghana with an overview of climate change projections for Ghana, an interpretation of the significance of climate variability and change in terms of effects on natural resources and human populations, and to suggest potential adaptation measures with a view towards future USAID/Ghana programming.

COUNTRY OVERVIEW

The following overview is drawn from the full reports. References mentioned below can be found in the appendices of those reports. A more detailed overview of sectors of interest is also found in the summaries contained in each report.

Ghana is very biologically diverse, supporting two major biomes – tropical high forest and savanna – which are further divided into agro-ecological zones (See map). The diverse ecosystems of Ghana contain a wide variety of flora and fauna. The Upper Guinean Rainforest area, which includes many forested areas in Ghana, is one of the world’s 25 biologically richest and most endangered terrestrial eco-regions in the world (Status of Biodiversity and Impact Assessment in Ghana, EPA, 2007). The flora of Ghana includes a significant amount of tropical forest which has been rapidly declining in recent decades under the combined pressures of agricultural expansion, timber harvest, human occupancy, mining, fuel wood production, and fire. Under requirements of the United Nations Conservation of Biodiversity (CBD) treaty, Ghana submitted its Fourth Country Report on Biodiversity on March 25, 2009. The website to access the complete report is shown in Appendix 8 of the ETOA report.



Source: Dickenson and Benneh 1988

Data listed in Appendix 5 of the ETOA report shows 291 forest reserves (and two pending reserves). There are 16 Wildlife Protected Areas (WPAs), including seven National Parks, six Resource Reserves, two Wildlife Sanctuaries, and one Strict Nature Reserve, in addition to five coastal wetlands (RAMSAR sites) in Ghana. One RAMSAR wetland site (Owabi) includes a 1,300 ha wildlife sanctuary. Collectively, these WPAs total about 14,890 sq km (6.2% of the country) and are managed by the Wildlife Division of the Forestry Commission (Forestry Commission, Wildlife Division website April 5, 2011). Forest reserves, when coupled with the parks, wildlife reserves, and wetlands managed by the Division of Wildlife, represent more than 38,000 sq km in some form of protected status. These areas constitute about 16% of the total land area of Ghana (Ghana, CBD Fourth report, p. 26). Appendix 5 of this report gives a listing of the protected areas of Ghana.

Ghana has set aside all or portions of 30 Forest Reserves as Globally Significant Biodiversity Areas (GSBAs), to be managed in partnership with communities to conserve, and where appropriate, sustainably use, these areas. Interviews conducted for this report indicate that GSBAs were not necessarily significant in terms of “high” biodiversity nor have these areas seen increased management support, protection or budget due to their designation. Some wildlife species “hotspots” in Ghana are thought to be outside protected areas.

In the Environmental Protection Agency’s (EPA) Status of Biodiversity and Impact Assessment in Ghana (Ghana EPA, 2007) the report characterizes a “lack of information on the full coverage of biological resources of the country,” but goes on to state that there are about 2,974 indigenous plant species, 504 fishes, 728 birds, 225 mammals, and 221 species of amphibians and reptiles that have been recorded.

Other sources show somewhat different numbers. The Earth Trends database (website shown in Appendix 8) for Ghana has 3,725 species of vascular plants (43 endemic), 729 birds, 249 mammals, and 207 amphibians and reptiles. This data was largely compiled in 2004. According to the FishBase database, there are 230 species of freshwater fish and about 483 species of salt water fish in Ghanaian waters. Of these fish, four are thought to be endemic.

The International Union for the Conservation of Nature (IUCN) maintains a status list of species worldwide. This well respected organization lists 23 species of plants and 34 species of animals as endangered or critically endangered in Ghana. The complete list of these species is found in Appendix 6. By signing the Convention on International Trade in Endangered Species, Ghana has agreed to provide protection for the species listed for Ghana under this convention.

Ghana’s rich biodiversity resources face many threats, as described in the ETOA. There is agreement from almost all sources that Ghana’s forest cover is declining rapidly. The current amount of forest and the rate of decline are both subject to widely varying estimates, all of which show a declining trend. More detail on this subject is found in Section 4 “Forest Resources.”

NORTHERN GHANA SUMMARY

Ghana's three northern administrative regions – Upper East, Upper West, and Northern – lie in the Sudan and Guinea Savanna ecological zones. Roughly 23 percent of Ghana's population resides in these three regions (GSS 2005), and the vast majority resides in rural areas (84.3% in Upper East, 82.5% in Upper West, 83.9% in Northern) (Ghana Districts 2006). A high percentage of each region's population depends on agriculture for their main source of employment (67.2 percent in Upper East, 73.4% percent in Upper West, 70.9% in Northern) (GSS 2005a, 2005b, 2005c). These percentages rise if their most urban districts (Bolgatanga Municipal, Wa Municipal, and Tamale Metropolitan) are not factored in. The most important crops are millet, sorghum, maize, yams, rice, soy beans, cotton, groundnuts, beans, onions, and tomatoes. Most agricultural production is rainfed, although some rice is under irrigation. Many households also raise livestock. Agricultural production takes place largely by smallholders.

These are Ghana's most vulnerable regions to climate change from both a natural resource and a social standpoint. The Sudan Savanna (roughly corresponding to the Upper East Region) suffers long-standing and very severe soil degradation; soil degradation in the Upper West and Northern Regions (the Guinea Savanna) is moderate (See Climate Report, "Desertification"). However, all three regions exhibit either high or very high vulnerability to desertification (with the exception of the southern portion of the Northern Region, below 10 degrees N latitude).

Northern Ghana is also the most important part of the country for livestock production, giving it an advantage over the south in this regard. Cattle, goats, sheep, chicken, guinea fowl, and pigs are the main animals raised (Dietz et al. 2004, Hesselburg and Yarro 2006). For some agriculturally-dependent communities in Upper East and Upper West, household food security relies more on livestock than on farming (Hesselburg and Yarro 2004). Weather and the high cost of farm inputs can make farming unreliable unless households have access to irrigated fields.

In northern Ghana, non-farm activities help people cope with temporary adversity in the agricultural sector, and also represent a longer-term adaptation strategy when other options fail (Scoones 2008). These activities include hunting, fishing, non-timber forest product harvesting, local manufacturing, charcoal production, petty trade, and wage labor (Hesselburg and Yarro 2006). Non-farm income-earning activities are especially important during the dry season. Note the extensive maps, tables and discussion in the climate report, which provide more detail on the social and climate conditions and issues in northern Ghana. Note also the appendix of the climate report that provides temperature and precipitation change scenario data for different locations in Ghana.

With the conditions described above, northern Ghana is among the poorest regions in Ghana, with the least infrastructure, making it an important area in which to focus energy on: agricultural stabilization, improvement of livelihoods and off-setting the significant deforestation/desertification pressures of fuelwood consumption, and over-use of fire for grazing, hunting, and agricultural purposes. It is also important to increase the adaptability of the region to the likely affects of climate change which have increasingly affected rainfall patterns in this dry region of the country.

WESTERN REGION SUMMARY

The Western Region of Ghana holds much of the existing high forest of the country, many of the county's forest reserves, and several wildlife protected areas. (See Map 1, ETOA report).

The Western Region also includes areas with significant gold reserves, the subject of extensive legal and illegal mining. It is also (with the Ashanti Region) the primary focus of the expansion of cocoa production in the country. The Western Region is the most important region of Ghana for timber production and is the focus of much legal and illegal timber harvest.

The coastal portions of the Western Region (as well as the coastal portions of the Regions farther to the east) are also important for their coastal wetland habitats (particularly mangroves). The coastal portion of the Western Region is also the focus of much of the shore impacts from off-shore oil development. This impact is seen in both shore-based infrastructure development for oil (and potentially gas) handling and processing facilities, as well as increased land occupancy (and land speculation) related to direct and indirect employment related to the oil industry or support of it. Oil development also has effects on the important fishing industry, which is found in the Western Region (as well as in coastal portions of the Central, Greater Accra, and Volta Regions).

As discussed in the "Case Study: Climate Change Adaptation Strategies in Ghana's Coastal Zone" of the Climate Change Assessment, several factors are combining to significantly affect the coastal zone of the country. Ongoing overfishing issues in this area are further compounded by water level increases and shoreline erosion, which will be exacerbated by projected climate changes discussed in Chapter 3 of the main report. These issues, in turn, increasingly reduce limited coastal wetland habitats as they are pressed between coastal erosion and rising sea levels and increasing development nearby on-shore. The most rapidly growing urban areas are in coastal areas and are growing at a rate nearly twice the national average and will double in size over 16 years.

These factors combine to make the Western Region, from coastal areas to forested areas, one of the most critical areas of the country experiencing negative effects on its biodiversity, tropical forests, and the lives of residents in this area. These issues are compounded by the effects of climate change (such as seas level rise and coastal erosion). Taken together, this convergence of issues makes the Western Region a logical focus of USAID programs that will help the Government of Ghana (GoG) improve the management of fisheries, coastal wetlands, and tropical forests and better plan and mitigate effects from climate change as well as the ongoing oil development in the Region.

ISSUES AND OPPORTUNITIES OF NOTE

- Rate of decline of the off-shore fishery is serious, significant, and attributable to deficient legal frameworks, lack of conservation knowledge in the sector, low enforcement capacity, and limited policy engagement with the fishing community, while fishing pressure is increasing.
- There is the opportunity to increase fisheries management capacity within the Fisheries Commission, particularly with the goal of increasing the ability of fisheries stocks to be monitored by a management agency (and/or non-industry based partners) rather than solely through self reporting of fishers as currently occurs.
- Climate change will affect the regions of Ghana differently. Although Global Circulation Models (GCMs) generally agree that mean temperatures will rise, there is little agreement in future precipitation amounts or seasonality; some GCMs project increased precipitation in the northern three regions (and countrywide) and others project decreases. People interviewed during our field visit to the north reported delays in the onset of the rainy season, heavier rains late in the rainy season, and increased flooding, causing crop damage.
- The incidence of poverty is highest in northern Ghana, where temperatures are hottest, rainfall is low, and there is only one rainy season; thus, people residing in northern Ghana may be the most vulnerable to the effects of climate change, a contention supported by our own vulnerability analysis. Climate variability contributes to current food insecurity and will be exacerbated by a changing climate.
- Wood accounted for 78% of domestic energy in Ghana (FAO, Woodfuels use in Ghana: social, economic and energy dimensions, 2000), and deforestation around urban areas for firewood and charcoal exert a heavy toll on forests and woodlands. This is a significant ongoing agent of deforestation and is an important issue particularly in the Northern Region. The fact that wood fuel is by far the most common means of cooking food in Ghana, links food production with a significant deforestation agent, particularly in northern Ghana. Further, deforestation for agricultural expansion and fuelwood gathering in desertification-vulnerable areas (like northern Ghana) strengthens the link between wood fuel, food production, and soil degradation. Ultimately, the success of the Feed the Future (FtF) program may depend in part on appropriately addressing the issue of cascading links among fuelwood/deforestation/desertification/food security.
- Wildfires and biomass burning are a significant component of Ghana's Greenhouse Gas (GHG) Emissions. The draft National Wildfire Policy (as of 2006) seeks to overcome past policy limitations (unclear authorities, lack of deterrents, disregard of traditional practices, and no involvement of traditional authorities in policy formulation or implementation). Nevertheless, the draft policy is overly focused on fire prevention and suppression, ignoring the role of fire as an ecological agent and a traditional management tool. The policy assigns key roles to the Ghana National Fire Service (Ministry of the Interior), including fire suppression and training programs throughout the country and developing a system to detect and monitor fire occurrence. Neither of these roles has been addressed and the Fire Service is focused almost entirely on fire fighting of structures.
- The rate of deforestation is significant and affects both biodiversity and tropical forest conservation. The following are contributory factors to this decline:

- Clearing for agricultural expansion is likely the largest single deforestation factor in the country at present
 - High dependence nation-wide on charcoal production and wood use for fuel
 - Burning for hunting, grazing
 - Logging practices, including often unauthorized “chainsaw lumbering”
 - Clearing for human occupancy
 - Clearing increasing for cocoa production
 - Increasing illegal occupancy in some protected areas
- Land and resource tenure systems are complex, multi-layered, not transparent, and often a disincentive for long-term care of (and investment in) forest and agricultural lands. There is opportunity to reform it, particularly as it relates to tree tenure, with the associated benefit of making family forests, community forest, and Community Resource Management Area (CREMA) type activities more viable and enduring.
 - Natural resource management capacity for law enforcement and environmental monitoring is limited in most resource management agencies, which negatively impacts environmental sectors. This represents a distinct opportunity for improvement.
 - Much environmental monitoring falls on the US Environmental Protection Agency (EPA), an agency with limited field capacity to carry it out, representing an opportunity for legal reform, budget reform, agencies coordination, and technical capacity building both within the EPA, but also potentially within the natural resource management agencies themselves.
 - If REDD becomes viable, Ghana has gone a long way to prepare itself to take advantage of it .
 - Equitable distribution of REDD credits and governmental mechanisms to ensure benefits reach the people living in and near the forests claiming the credits have not generally been developed. The multiple land/resource tenure systems of the country make this very complex and subject to misappropriation unless solid, transparent, equitable benefit-sharing systems, with local buy-in, are developed. There is opportunity for pilot development in this regard.
 - There is some skepticism that REDD payments will be significant and sustainable in the long run.
 - There is an extensive protected area system in the country, which is highly variable in its effectiveness, but which is extremely important in the maintenance of biodiversity and tropical forests in the country. Opportunities for protected area specific and generalized capacity building in the management of protected areas are plentiful.
 - There is some potential for increased habitat maintenance and connectivity through site-specific, community-based programs. The CREMA concept has worked in some areas and failed in others. Though not a universal solution to habitat maintenance, if thoughtfully applied in appropriate situations, it can help maintain biodiversity while improving community livelihoods. Conversely, where natural revenue streams and intrinsic community support are lacking, the concept is not likely to work.
 - Cocoa expansion, particularly in the Western Region, is currently a deforestation factor. There appears some potential to turn that around and, with agro-forestry technical aid and incentives, potentially use cocoa expansion as both a reforestation vehicle and an economic engine.

- The social responsibility and environmental mitigation aspects of the current oil development in Ghana are only broadly addressed in law, leaving EPA with a difficult task. However, there is still time for the GoG, civil society, and industry to make the broadly stated mitigation objectives become tangible projects and more enforceable legal requirements.
- Biofuels development on plantations, especially jatropha and oil palm, is controversial and has led to, and may continue to lead to, land grabs in some places.
- The current state of the inland fishery resource in Ghana deserves further scientific attention as does the potential impacts climate change might have on this resource.
- There is an opportunity to assist farmers in gaining access to credit on terms that are feasible for them. Micro-financing projects also hold promise for helping individuals start small businesses.
- Charcoal production in Ghana is largely in non-sustainable operation and loss of tree cover may make charcoal production less viable in the future. Low-cost diversification strategies that are ecologically sustainable should be pursued. Particularly in the Northern Region (but applicable nationwide), to complement FtF, and to provide deforestation mitigation, programs for more efficient cooking stoves, use of alternative energy sources where feasible, and forestry initiatives to promote planting fast growing tree species for use in family and community wood lots for fuel or charcoal should be encouraged.
- Livestock loan programs modeled on traditional practices in which relatives loan animals to kin who have lost their herds or wish to start new ones until they reproduce have been successful in some parts of Africa. There is high potential to assist households in developing livestock husbandry.
- Improving water infrastructure could help improve household drinking water quality and health; reduce travel time to water, freeing up labor; increase water supplies for livestock, an important limiting factor on their production; and increase water availability to support dry season household gardens and cash crop production. There have been notable failures in this arena to learn from.
- In northern Ghana, with existing dry conditions and foreseeable climate affects, agriculture stability is highly likely to be improved by irrigation and water retention projects, which capitalize on capture and use of seasonal rainfall as well as better use of existing water sources.
- In development of irrigation and water retention infrastructure there is the potential issue of adverse impacts to riparian areas from ill designed infrastructure development and clearing for agriculture. Conversely, there is the opportunity to accommodate riparian function and structure in design of these agricultural programs and to increase local knowledge of the water quality, water quantity, soil stabilization, biodiversity, and forest retention benefits of well managed riparian areas within agricultural settings.
- There is a general lack of knowledge and emphasis both in the regulatory structure and in administration at District and Regional levels in riparian management. The issue presents the opportunity, particularly in the north and in the Western Region, for USAID programs to assist local governments, communities, and the GoG in improving technical knowledge on best management practices within riparian areas. Improvement in such practices would have direct benefits on water quality and quantity, as well as on the maintenance of habitats key to many species of plants and animals.
- There is a lack of local processing facilities for agricultural and wild-harvested products. Establishing local processing facilities – for example, for shea butter or soybean oil – would make it possible to produce value-added products that increase incomes relative to the sale of raw products.

- Investments in education enable people to develop skills and knowledge that can help them pursue off-farm livelihoods and work outside of the natural resource sectors that are less vulnerable to climate change impacts. Education can also help migrants get better jobs in urban areas, earn more, and increase remittances back home.
- An issue of note is hydropower. (For a more thorough discussion of the issue see the Climate Change Assessment, “Climate Change and Hydropower”). First, the water development focus between the two major countries in the Volta River Basin is fundamentally different. Burkina Faso has and is concentrating effort in the Basin on improved use and increased retention of water for agriculture with demands in that country (as well as northern Ghana) expected to increase rapidly. In contrast, Ghana’s primary objective is to keep Lake Volta at optimal levels for power production. Clearly, potential exists for major conflict. Second, past meteorological data and hydrological modeling indicate water levels in Lake Volta are highly sensitive to even small changes in rainfall. Rainfall projections of global climate models are mixed, adding to the uncertainty; however, trends from historical data indicate fairly dramatic decreases from long-term averages. Third, the design of Akosombo dam was premised on one of the wettest periods on record affecting optimal power production even during relatively short or modest dry periods in an inherently variable precipitation regime. Fourth, water allocation agreements are lacking among Ghana and the other riparian countries in the Lake Volta Basin. Finally, the future power production at Akosombo dam clearly will affect Ghanaian choices for alternate energy sources (i.e., fossil based or alternative) in an attempt to meet shortfalls and ever increasing demand.

CONCLUSIONS ON THE STRATEGIC EFFECT OF USAID PROGRAMS ON THE ENVIRONMENT

USAID has taken the lead in successful programs to nearly eradicate guinea worm in Ghana, distribute bed nets to fight malaria throughout the country, dramatically increase immunization coverage for children under five, and has made other substantial improvements to the health of Ghanaians. Many other donors, including the World Bank, have used USAID's health program as a model for their own activities. With its increased focus on HIV/AIDS and Malaria prevention, the Mission has the opportunity to address related environmental issues such as loss of human capacity, sanitation, and best management practices that result in conservation of natural resources.

USAID, through its Strategic Objectives Program areas of Health, Education, Democracy and Governance, Feed the Future Initiative and Millennium Challenge Corporation (MCC) programming contribute to biodiversity conservation and the protection and management of tropical forests in Ghana. While benefits to forests and biodiversity conservation are not explicitly portrayed in the results framework for these programs, these programs do play a major role in these areas as follows:

- USAID and the US Government (USG) have built up a strong comparative advantage in its health programs, which over the last decade have improved the health of the poorest Ghanaians', particularly in rural areas. Health programs, particularly as they improve water quality and sanitation, have direct and indirect benefits to the environment and biodiversity conservation as described in section 4 A. To that extent, these programs comply with the FAA, Sections 117, 118, and 119.
- Through its Democracy and Governance program, particularly Local Governance and Decentralization Program (LOGODEP), USAID has the opportunity to encourage more accountability for conservation activities and could provide a voice for development activities that consider the conservation and equitable distribution of Ghana's natural resources. In so doing, this program area can help improve/maintain the environment and natural resource management, tropical forest conservation and endangered species protection, consistent with the intent of the FAA.
- The Mission's Education program has been at the forefront in providing access to education including disadvantaged and vulnerable populations. This approach to education and training would enable it to respond to the variety of learning challenges that are being faced by Ghana's environment and natural resource management institutions, again consistent with the intent of the FAA.
- USAID's agricultural program has the opportunity to enhance the long term protection of biodiversity and tropical forests by promoting sustainable use and by providing a much needed source of alternative income. Agricultural program activities, with proper design, can also help orient people away from critical protected areas as well as other areas highlighted as important for conservation. Such activities would be highly consistent with the FAA. Important specific caveats in this regard are noted in the "Long and Medium-Term" recommendations found in the full report. There is the potential, without adequate program design features to offset them, for FtF programs to have unintended negative effects on tropical forests and biodiversity by creating incentives which would make it profitable to clear currently forested areas for agriculture. Design features which

could help mitigate such effects are listed in the recommendations section below. Related fuel wood program recommendations are also given below.

- An increased emphasis on alternative livelihood activities along with new community rights/tenure legislation (particularly related to tree tenure), increased support to the decentralization of natural resource management , including expanded support to USAID’s Our Coast, Our Future land use planning, and a better understanding of climate change adaptation issues would all combine to make a thoroughly integrated USG conservation and development program, one that is responsive to GoG needs and concerns, and one that contributes substantially to reducing threats to biodiversity and tropical forests as intended by the FAA.

RECOMMENDATIONS

The assessment team has formulated a set of recommendations for program actions for USAID to consider towards improving its contribution to natural resources management and biodiversity conservation in Ghana. Although the recommendations do not address all the actions needed to protect tropical forests and conserve biological diversity, the assessment team believes that these recommendations would lay the foundation for a more comprehensive and cohesive approach to natural resource management in Ghana and future longer-term investments.

RECOMMENDED SHORT-TERM INTERVENTIONS

The short-term recommendations are targeted primarily as specific actions based on existing USAID programs. These are incremental additions to, or changes in, USAID's current and projected program areas. This seems to be the most practical short-term approach to addressing biodiversity conservation given possible current and future funding constraints and opportunities. More detail on these recommendations and their rationale is found in the "Recommendations" section of the ETOA and the "Options for Future USAID Programs" in the climate report.

- The Feed the Future initiative, in order to insure that it does not have unintended consequences on tropical forests and biodiversity, should incorporate several design features aimed at limiting deforestation potential while still achieving the beneficial goals intended by the program. These design features are:
 - Insure forestry input into the operational design of the program by having a community forester(s) on the design and implementation staff within the program who is (are) familiar with the concepts and practices of agro-forestry.
 - Support the Ministry of Agriculture, including a community forester within the staff group working with the FtF program (with monitoring functions discussed below as well as community outreach and technical assistance to program farmers).
 - The Northern Region, the focus area for FtF, does not have a well documented inventory of agricultural and forest lands. In order to establish monitoring controls for the FtF program, better baseline mapping of savanna forests and existing agricultural lands in the north should be done. Such an activity could either be undertaken by USAID directly, and/or implemented through the GoG, Forestry Division, and possibly in association with an NGO with interest and programs in baseline monitoring of forest cover and agricultural lands.
 - In the overall design for the FtF initiative, USAID should consider establishing strategic environmental support and technical capability within the program to incorporate landscape design features that consider the connectivity of forested landscapes, where possible. Within the Districts in the Northern Region, such strategic planning would present the big picture of where better transportation networks are planned, commercial hubs for storage/resale of products are (or would be), and such features as proposed irrigation networks. With this strategic planning in hand, design areas of proposed intensification and zone those areas for intense agriculture while also looking at establishing buffer areas for fuelwood and to maintain (or establish) connectivity for wildlife between protected areas where possible.
 - Related to the above suggestion, to the extent irrigation programs are utilized in the FtF program, USAID, the GoG, and/or other partners should ensure that adequate site-specific

hydrologic baseline information is available (or is gathered) prior to commitment of a given area to intensified irrigation projects.

- With the above baseline, establish with the Ministry of Agriculture (possibly through their forestry liaison position discussed above) an ongoing monitoring program of the forested areas in proximity of FtF project areas.
 - Design, within the FtF program, verification mechanisms to ensure that targeted acres under the program are existing farmland (or most importantly, not forests or critical habitat areas whose development for farming would adversely affect forests or biodiversity habitat).
 - To the extent that the FtF program increases road access to improve the economics of crop production, it may increase the viability of firewood gathering or timber harvest, and increase the physical area where farming may be economically viable. Such consequences, both unintended and intended, obviously could directly affect forests. Such effects could be mitigated by concurrently reducing the dependence on existing forests for wood fuel, and, as discussed above, by designing the program to ensure that currently forested areas (previously not accessible or viable) are not cleared.
- Fuelwood use and charcoal production in the northern regions (as well as nationwide) is an extremely important driver of deforestation and, in the far north, a potential factor accelerating desertification. USAID development of, or assistance in, programs which increase the efficiency of wood stoves, promote the development of family and community forests to develop fast-growing wood sources, and, where feasible, to develop use of alternative fuel sources, could potentially reduce significantly the current rate of deforestation due to this pressure. Such programs could complement and help mitigate deforestation pressures (discussed above), which could develop from improved agricultural conditions spurred by the FtF program. Technical forestry assistance embedded in the Ministry of Agriculture and within USAID’s operational team for FtF could help develop forestry program assistance to the FtF program while integrating complementary programs to reduce the fuelwood pressure on existing forests.
 - USAID should promote increased technical capacity and capability within the Fisheries Commission to both monitor and manage fisheries stocks and catch. Currently, nearly all catch is self-reported and such reports are, at times, somewhat suspect. Increased capability and capacity in this regard could greatly assist the GoG in actively managing the fishery resource. As discussed in the ETOA, “The Fisheries Act granted the Fisheries Commission broad powers for developing fisheries plans and licensing vessels and canoes. The Minister of Agriculture sets the policies to be pursued by the Commission. The Act also created a monitoring, control, surveillance and enforcement unit in association with law enforcement agencies.” To this extent, supporting the development of more technical and management capacity within the agency would be highly consistent with existing law.
 - In addition to the above, personnel capacity for enforcement of fishing regulations, and the physical capacity (boats, fuel, work stations) is a program area that USAID should support and encourage. Perhaps more difficult will be to encourage the political will of the GoG to take on an issue tied to so many voters. Gaining an understanding of the issues at the community level through programs such as those offered by Cooperative Research Centre (CRC), while simultaneously encouraging the GoG to engage with the communities to enforce regulations, that, in the long run, will be to the benefit of the Ghanaian people, is a vital element of any initiatives to sustain and improve Ghana’s important fishery resources.
 - USG has opportunities to assist with drought preparedness training as well as training district technicians (in the Northern Region targeted for the FtF initiative) and local communities on sustainable use of water and watershed management objectives.

- Support, promote, and encourage the GoG, District, and local governments in the understanding and maintenance of riparian areas and increase the technical capabilities of institutions in this regard. Greater technical capability (based on research referenced in the ETOA, Section 4: “Freshwater Resources”) is needed to promote such understanding and gain acceptance for riparian area best management practices from local communities. With community input, regulations and community norms could be improved and made more meaningful. The largely policy driven (on private lands) current approach has not been highly effective. (Some sources attribute this to limited capacity at the regional and district levels where the literature indicates riparian management has devolved.) Community foresters/biologists in the Department of Agriculture stationed in key western or northern districts might be the most direct way to convey this type of knowledge.
- USAID could support or develop a pilot cocoa agro-forestry project as an independent project or as an expanded element of CRC’s programs. Expansion of cocoa plantations is a significant driver of deforestation in the Western Region. Such a project, using programs like Sustaining Thriving Environments for West African Development (STEWARD), community forests, or a CREMA- type approach in conjunction with one or more local NGOs with interest in this arena, could create a valuable learning tool.
- With USAID’s ongoing interests in the Western Region, a forest/wetland cover mapping project as described for northern Ghana would help provide a more accurate baseline to establish the rate of decline of forests and wetlands in this Region. As discussed in several areas of the main report, data on forest cover in Ghana varies widely. Very little data at all is available on wetlands/mangroves. Technical assistance to the Forestry Division, and/or through partners (CRC, Nature Conservation Research Centre or NCRC, for example) could foster collaboration to define agreed definitions of “forest cover” and help map them as described above in the recommendation for northern Ghana. Such information would be useful for planning and monitoring forest conditions in the Western Region. Such information is critical given the combined pressure of mining, legal and illegal logging, cocoa expansion, slash and burn agriculture, potential shoreline impacts due to climate change, and the infrastructure and population pressures from oil development that are all coming to play at once on the forests, mangroves, and wetland habitats of the Western Region.
- National and regional level coastal development plans should include adaptation strategies for sea-level rise (e.g., relocation of transportation, housing, and business zones) and natural mitigation measures to slow coastal erosion (e.g., mangrove zones, sand mining restrictions).
- The National Disaster Management Organization (NADMO) within the Ministry of the Interior is responsible for the management of disasters and similar emergencies. In addition, NADMO is charged with ensuring that Ghana is prepared to prevent disasters and manage them well when they occur. Currently, NADMO needs strengthening in its capacity to respond to extreme weather events (such as flooding and drought) and should disaggregate its national level planning to local development plans. Disaster planning and climate change adaptation are conceptually linked and should be explicitly coordinated within the GoG.
- USAID could support an assessment/evaluation of community-based conservation activities in Ghana. The assessment should include an assessment of lessons learned, legal framework and needs for increased community based conservation, and a toolkit that communities can access to demonstrate conservation options and the identification of realistic potential social benefits. This could also be jointly considered as part of STEWARD or as a stand-alone assessment of conservation activities in Ghana (including CREMA’s community-based natural resource management, etc.).
- A particularly difficult, site-specific, problem in protected area management in Ghana has been, and continues to be, the internal occupancy and degradation of the Kalakpa Resource Reserve. USAID

assistance may be useful to the existing players (Wildlife Division (WD) of the Forestry Commission of Ghana, Katoomba Group, SNV) to help resolve this site-specific issue and/or applied to any of several protected areas with internal occupancy and external degradation issues.

- USAID should consider expanding upon the Our Coast, Our Future Project in the Western Region to include improved forest-related benefit sharing arrangements especially with regard to payment for ecosystem services arrangements in the Amansuri wetlands area. We suggest exploring whether the scope and scale of the Our Coast, Our Future USAID funded program can be expanded to be used as a platform for increased sustainable landscape funding that includes payments for ecosystem services, and stewardship contracting on and off of forest reserves.
- Continue to support – and look to increase support – to USAID’s Our Coast, Our Future Project land-use planning (especially with respect to spatial land use zoning and strategic environmental assessments of proposed land uses). Also continue to support this project to gain a better understanding of climate change adaptation issues. The key opportunity within the marine and coastal environments include the development of Integrated Coastal Zone Management, which includes expanding upon the lessons learned from the USAID-funded program in the Western Region and developing zoning and sound land-use development planning.
- Also look to develop similar partnerships with inland fisheries organizations similar to those that are being developed with coastal fishermen via the Our Coast, Our Future Project.
- USAID should encourage GoG to develop as soon as possible a natural gas pipeline from Jubilee Oil Field to an onshore gas processing and power production plant to prevent months or even years of wasteful gas flaring in a country that currently struggles to meet electrical demand.

Other short-term possible interventions, based on what the team heard or observed on its field trips, include:

- An evaluation of Kakum National Park trust funds and potentially re-invigoration of the Kakum Trust Fund originally facilitated through USAID. (Main collaborators: WD and local community groups)
- A possible health-based intervention is to look into the feasibility of staffing the vacant clinic in the community of Abrafo near Kakum Park. According to villagers, the building was constructed about 10 years ago with USAID funding, but never staffed or supplied.
- Assistance to the Forestry Commission in the mapping and clarification of the amount of forest cover in Ghana to facilitate planning efforts. A possibility includes working with groups such as the NCRC, International Union for Conservation of Nature or IUCN, and the Forest Services Division to develop a project to define and map current forest cover in Ghana.
- Provide technical assistance/support to the maintenance aspects of the Forestry Commission’s reforestation program to improve long-term results from reforestation efforts. This may not be an area where USAID has a competitive advantage, but could play a technical role.
- Relative to ongoing oil development, which is particularly impacting the Western Region, USAID could explore governance and technical assistance to EPA to improve the nation’s legal framework, planning, and technical capability to make the existing oil spill contingency plans more concrete and operational, as well as to move broadly stated environmental and social mitigation plans in the Jubilee Environmental Impact Statement (EIS) into concrete actions. CRC could play a role in this regard in helping to ensure the voice of local affected communities is brought to the table in discussions of social mitigation programs.

- USAID could work with the Forestry Commission on a pilot program for forest timber contracts to explore utilizing “forest stewardship contracts” which, if properly used, can result in direct community and ecological benefits from the “stewardship” aspect of the sales. Such an approach would be a means by which communities could see tangible results and potentially a degree of local employment from timber sales. The US Forest Service (USFS) has the ability to assist with training on implementation of stewardship contracting.

RECOMMENDED MEDIUM-TERM AND LONGER-TERM INTERVENTIONS

The mid- to long-term recommendations focus on the future of USAID’s Governance, Health, and the Feed the Future Initiative and on the issues of community land/resource tenure and climate change adaptation. The latter two areas are broadly based and relevant for collaboration with other partners.

- USAID should assist the GOG in developing sound and equitable governance of land and forest resources legal reform of resource tenure (particularly tree tenure) as it affects forests on “off-reserve” lands.
- As a companion to the legal reform above, help the GoG create functioning community forest institutions to manage natural resources, through pilot programs aimed at legal resource tenure reform that create clear incentives (and concurrent responsibilities) for communities and individuals to engage in off-reserve forest management.
- Expansion of LOGODEP-type programs to decentralize land tenure administration in coordination with organizations like the Civil Society Coalition on Land (CICOL) to continue to work on transparency of land tenure by provision of land registration and ownership documentations services at District and Regional levels.
- Pilot Community forestry/CREMAs dedicated forests type projects adjoining protected areas where there is community interest and where background work demonstrates viable revenue streams for livelihoods. The creation of a just and workable community forestry tenure instrument – which would include within it dispute resolution mechanisms at different levels and build expertise for dispute resolution based on both customary and statutory law – will be an important advance for Ghana.
- Continued support for REDD+ at the national level is necessary while continuing to work on pilot projects in different regions throughout the country that can serve as learning experiences and examples (based on the assumption that viable long term REDD credit funding is available).
- Updating forest management plans is an action being undertaken by the Natural Resources and Environmental Governance (NREG). USAID could provide technical assistance in this arena, potentially using STEWARD models for community involvement, with a goal to improve the engagement and the resource management knowledge of local communities as such work proceeds.
- Continue to incorporate environmental education into curricula and special activities or attractions – especially targeting rural areas with education relative to use of fire, ecological, and social benefits of riparian management, and quality information and assistance on agro-forestry techniques. Kakum National Park, for example, with its steady influx of elementary aged students, is an excellent place to have such a project.
- Another option is to work with groups such as Forest Watch, the Rainforest Alliance, or others to develop short radio programs targeted for rural areas which address specific deforestation or biodiversity threats and the practices which help to combat such threats.

- The USG could provide support to Volta Basin Authority assisting with resolution to issues such as the Bagre Dam.
- The development of improved transportation networks and agricultural practices, both through USAID FtF programs and through the MCC, has the potential to reduce the dependence on forest resources and build more land tenure security (See caveats to this recommendation in Section 5 of the main report).
- USAID/Ghana and the USG can also use their positions in Ghana to help the GoG forge conservation partnerships with corporations such as Newmont, and/or other companies operating mining concessions, cocoa companies and/or oil and gas concessions. For example:
 - USAID, the Ghana Cocoa Board, and NGOs working in the cocoa sector could develop enhanced education and technical assistance programs to cocoa farmers to reduce the deforestation associated with ongoing cocoa expansion in the country. If REDD+ credits become a reality, there appears to be the possibility to couple sustainable cocoa production with REDD payments as an incentive to manage such plantations with more trees.
 - Another example would be to forge community resource area partnerships with oil companies to develop marine reserves or assist communities in the protecting community wetland areas. Social responsibility agreements with the oil industry could be required as mitigation for oil development (as for mining operations) to improve community infrastructure and livelihoods through joint industry /community/GoG projects (e.g., water treatment facilities) in communities experiencing growth due to oil development.

CLIMATE CHANGE-RELATED ISSUES AND RECOMMENDATIONS

The “Options for USAID Programming” section of the climate report contains a list of interventions related to climate change to resolve barriers to adapting to climate change and/or mitigating the effects of climate change. Possible interventions are proposed in five categories: Policy Environment, Governance and Tenure, Capacity and Infrastructure, Information and Analysis, and Awareness and Adaptation. The “Options for Interventions” Table within the climate report lists vulnerabilities in each category with a corresponding recommended intervention and the USAID program most closely related to the intervention. Recommendations this table are listed in the summary below.

POLICY ENVIRONMENT

- Within this category, many issues stem from uncoordinated response to climate change. The recommendations start with strategic support of completion and implementation of the Ghana National Climate Change strategy.
- Support development of a national energy policy that includes climate change mitigation and low emission strategies including advanced biofuels development and capturing flared gas.
- Encourage GoG to advocate development of a national policy of integrated fire management and develop regionally adapted policies that include traditional practices to manage wildland fires to protect soil quality, increase forage quantity and quality, increase rates of reforestation and afforestation, and mitigate trends toward desertification in vulnerable areas (e.g., northern Ghana).
- Support development of a water allocation agreement among all riparian countries in the Volta River Basin.
- Support implementation of national and regional level coastal development plans which include adaptation strategies for sea-level rise (e.g., relocation of transportation, housing, and business zones)

and natural mitigation measures to slow coastal erosion (e.g., mangrove zones, sand mining restrictions).

- USAID’s FtF program focuses on the northern regions where donor activity is high; western Brong-Ahafo and northern Volta regions also exhibit high social vulnerability to climate change. Consider a more targeted, district-based approach to implementing the FtF program in places where it is most needed, and explore expansion to high vulnerability areas of neighboring Brong-Ahafo and Volta regions.
- Farmers need stable and favorable crop prices to make investments in commercial crop production profitable; otherwise they can become poorer. To this end, ensure a favorable policy environment for cash crop production.

GOVERNANCE AND TENURE

- Advocate for legislation defining carbon rights that provides equity to smallholders.
- Advocate for an examination of land tenure and property rights issues at the community level.
- Capacity building with traditional land management authorities, such as chiefs and the Tendanas (“earth-priests”), to include more transparency in their dealings would help restore the customary tenancy regime, and provide for equality in land use practices.
- USAID should consider the difficulty marginalized groups face in accessing land and resources as they design and implement the FtF program, which could help improve conditions for these groups and help ensure that they are not further marginalized.
- Explore local strategies for providing affordable credit to landowners and tenant farmers.
- An equitable system of water allocation and management should be developed as an integral part of any irrigation development scheme.
- A social assessment of the impacts of implementing agricultural development projects should be undertaken to ensure that people do not lose access to land and resources, and to identify mitigation measures.

CAPACITY AND INFRASTRUCTURE

- Partner with organizations that can link FtF activity to carbon financing market or payments for ecosystem services markets.
- Improve data sharing policies among agencies, especially meteorology data (revenue recovery focus reduces ability for agencies to share and coordinate efforts).
- Meld FtF activities with reforestation and afforestation projects to meet family and community needs for fuel and construction wood, to produce non-timber forest products, to protect riparian zones, and to sequester carbon.
- Partner with local implementers to build capacity at institutions that supply climate adaptation information.
- There is a lack of technical capacity, and infrastructure in telecommunications limits ability to move large data files (such as GIS data) between agencies. To improve the interchange of information, improve data access, internet.
- Strengthen local monitoring authorities, and connect them with local, regional, and national partners. (EXP Coastal Resource Center).

- Support adoption of highly efficient charcoal and wood-burning stoves that are culturally compatible with Ghanaian cooking modalities to substantially reduce wood-based fuel use, carbon emissions, and deforestation. More efficient wood based stoves will also produce less smoke, and lessen the burden on women who are traditionally responsible for gathering firewood.
- Encourage GoG to advocate development of a national policy of integrated fire management and develop regionally adapted policies that includes traditional practices to manage wildland fires to protect soil quality, increase forage quantity and quality, increase rates of reforestation and afforestation, and mitigate trends toward desertification in vulnerable areas (e.g., northern Ghana).
- Encourage GoG to develop as soon as possible natural gas processing capabilities to avoid prolonged gas flaring (months to years) and hence increased GHG emissions at Jubilee Oil Field and to supplement an already inadequate national power grid.
- Lack of infrastructure impedes efforts to decentralize governance, especially in rural areas distant from district capitols. To facilitate decentralization, explore utilization of cell phone texting features to send online registrations, permit applications, etc.
- Explore development of farmer credit banks in rural areas to establish farmer accounts that can be used to pay remotely for permits, etc. Address land tenure constraints to obtaining credit; develop credit schemes that are feasible for smallholders.
- Investments made in tourism infrastructure could lessen the reliance of coastal residents on the marine fisheries resource by providing viable alternative livelihoods.
- Additionally, investments in education could help provide a better defined skill set and widen employment opportunities for youth and young adults.
- Encourage the government to either provide training itself, or through a third party, that offers the technical skills necessary to seek employment in the Oil and Gas Industry.
- Explore alternative energy systems (e.g., solar, biofuels) that might suit the needs of local communities.
- Due to the high percentage of households that are remote from markets and/or have no year round roads, efforts to promote agricultural development and crop marketing in Northern Ghana should evaluate how market access and transportation infrastructure can be improved, and invest in making such improvements.
- Invest in construction of local processing facilities that add value to agricultural and wild-harvested products to increase income and create non-farm jobs.
- Develop improved grain storage facilities so excess grains produced in good years can be stored to buffer against crop failures.

INFORMATION AND ANALYSIS

- Partner with regional organizations (e.g., CILSS, AGRHYMET, CORAF, INSAH, FEWSNET) to ensure availability of and access to data (weather patterns, hydrological data, ground cover change, agricultural expansion, improved land productivity, fish populations) and forecast/projections.
- Land cover/land-use inventory and forest inventory are needed to set baseline for deforestation, carbon pools under REDD, and to meet monitoring, reporting, and verification (MRV) requirements.

- Establish program of research and technology development in climate prediction, improve crop models, and link process-based crop models to high resolution regional climate models.
- Investigate uncertainties of commercial and large-scale agriculture sustainability in light of increasing (or minimally uncertain) future costs of petroleum-based fuels and agricultural chemicals and a changing climate.
- Investigate climate change at a sub-national level using appropriately scaled global climate models (GCMs) and within the context of desertification in the north, sea-level rise and coastal erosion, marine and inland fishery sustainability, water supply in the Volta Basin, and power production from Okosombo, Kpong, and Bui dam generators.
- Investigate areas where carbon sequestration can complement FtF efforts, e.g., reducing coastal erosion by increasing mangroves, rangeland management, agro-forestry, farmer managed natural regeneration, riparian forest management.
- Evaluate in all FtF irrigation projects the impacts on the quantity and quality of local ground and surface water supplies as well as downstream user impacts.
- Evaluate rates of coastal erosion nationally with an emphasis on identifying proximate and ultimate causes and near- and long-term effects on coastal infrastructure and natural resources (e.g., cities, villages, highways, ports, marine facilities, biodiversity hotspots, lagoonal and inshore fisheries).
- Conduct a quantified evaluation of the temporal pace of vegetation change and soil degradation to evaluate rates and extent of desertification in northern Ghana especially in the context of projected population increases, food security, water demands, ecological services, and climate change.
- Develop optimized shade-grown cocoa management schemes that provide high levels of return to farmers and also greater biodiversity benefits than sun grown.

AWARENESS AND IMPLEMENTATION

- Partner with local implementers to build climate change awareness of end users (e.g., farmers, fishermen, media, government) and enhance their ability to use information.
- Organize workshop on topics such as climate change, adaptation, and carbon sequestration for agriculture sector partners and FtF implementers.
- Increase cocoa productivity by intensification and access to inputs.
- Support efforts to increase awareness of GoG agencies and personnel on modern integrated fire management approaches; educate staff on traditional approaches to fire management and integrate the two.
- Increase agricultural productivity by increasing access to technology and inputs by improving distribution channels (e.g., fertilizer), farmer access to operating capital, and crop insurance schemes to mitigate effects of climate variability.
- Raise awareness of consumer quality expectations for rice, yams, and institute quality assurance schemes for improved market access.
- Lower harvesting and handling losses by developing community or cooperative drying and storage facilities.

AGRICULTURE-SPECIFIC OBSERVATIONS AND RECOMMENDATIONS

Agriculture-specific recommendations have been included in the climate report and the environmental Annex at the request of USAID due to the importance of the Feed the Future Program with its direct ties to improving agriculture in Ghana. These observations about agriculture in Ghana below are summarized from the climate report.

- Traditional cropping systems in semi-arid West Africa, including the Savanna Zone in Ghana, are dominated by cereal-based systems, usually combining two or more crops in a field. Intercropping minimizes risk of crop failure from drought or flooding and spreads the need for labor over a longer period. With the risk spread over two crops, a smallholder can take advantage of a long growing season during a year of above average precipitation. Low soil organic matter and limited availability of plant nutrients, in particular phosphorus and nitrogen, are major bottlenecks to agricultural productivity in Ghana, which is further hampered in the Savanna Zone by substantial topsoil losses through wind and water erosion.
- Recent increases in production have come from expansion of the land cropped to cocoa and higher inputs of family labor. Increasing land in cocoa production has been a driver of deforestation. Because cocoa was traditionally grown under shade, however, many valuable timber trees were retained in cocoa fields, augmented by planting of fruit and other useful trees; thus, shade-grown cocoa was an agroforestry practice with greater biodiversity value than slash and burn agriculture. Research has demonstrated the technical advantages of fertilized, low shade or full sun hybrids and current recommendations from the Cocoa Research Institute of Ghana call for fertilizing densely planted hybrid cocoa in full sun or light shade with phosphorus, potassium, and micronutrients. Little research has been directed towards increasing productivity of traditional shade grown cocoa although that is an alternative that would avoid the negative effects of full sun hybrid cocoa on biodiversity.
- Two challenges to commercialization of rice production in Ghana are to increase productivity and improve quality of domestic rice. Optimal whole-farm production systems including rice using traditional (grass fallow) methods requires over 9 ha of production land, which is about twice as much as the mean land holding for Northern Ghana. Transforming existing smallholders into commercial operations will require increasing land holdings. Replacing traditional grass fallow with short-duration leguminous cover crop fallow would be accompanied by increasing mechanization to replace the labor needed to farm the larger acreages.
- Although growth rates in agricultural production have slowed since the 1980s, they have been positive, but for most crops, growth came from increases in the area harvested, not from productivity gains; rice and millet were exceptions. For maize, there are substantial differences in regions of the country, both in terms of average growth rates and the share of growth resulting from increasing the area under cultivation (extensification) versus improving yields per ha (intensification). The strategy of extensification has caused significant environmental damage (deforestation, desertification, and soil erosion) and is clearly unsustainable. Meeting the ambitious goals set by the Government for increased agricultural productivity will be challenging; intervention is needed to set agriculture on a different development trajectory.
- Commercialization of maize and rice production requires increased land security in order to motivate farmers to invest in technology and inputs. Commercialization of maize production already has led to changes in the land tenure patterns and a tendency to preferentially allocate land to large-scale commercial farmers. Pressure on the available land resource has already intensified conflict in the northern Savanna zone, between farmers and herdsmen on the alluvial plains and among smallholders where land fallowed by one family has been reallocated to another family. Transforming rice cropping in the Northern Zone, if the model described were followed, would include

concentrating access to land in the hands of wealthy producers, while smallholders would lose their use rights.

- The complexity of crop growth requires climate data (short-term variability, frequency of extreme events) at spatial and temporal resolutions that are currently beyond the reach of climate change models. In addition to inadequate climate models, crop modeling research has favored the major global food crops and devoted less attention to crops important to Ghana such as millet and yams. Additionally, crop models generally are specified for mono-cropping and rarely consider intercropping. Improvements in both climate and crop models and the ability to model effects at scales from the farmer's field to the region and nation will be critical to formulating adaptation options for agriculture and mainstreaming climate change into development programs.

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