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Climate Change Adaptation and Impact Mitigation: A Case Study of *Abraha Wa Atsebaha* Village in Tigray, Northern Ethiopia

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Tsegay Wolde-Georgis, Kiros Meles Hadgu, Amanuel Zenebe Abreha and Aklilu Habtu. 2010. Climate Change Adaptation and Impact Mitigation: A Case Study of Abraha *Wa Atsebaha* Village in Tigray, Northern Ethiopia. Journal of the Drylands 3(1): 150-157

In the last two decades, Ethiopia has been implementing a community based environmental rehabilitation program that focused on water and soil conservation with optimistic outcomes. This paper describes the experience of a successful local based and cost effective intervention that transformed a food-insecure, drought-prone Ethiopian village into a sustainable food secure community in Tigray region of northern Ethiopia. The result of the study indicates a partnership between the local community, the government, micro-credit institutions and extension agents which the regional food security bureau calls it a food security demonstration project. Sharing this experience with the wider world is timely as "climate change adaptation" has become a buzz phrase. The experience of this "bright spot" as opposed to "hotspot" is important because it is a testimony that climate change adaptation policies should be considered part of the development process and be implemented at the local level. It is believed that when such holistic interventions are upscaled the problems associated with food security might be resolved sustainably.

Keywords: Climate Adaptation; Environmtal Rehabilitation; Ethiopia; Food security; Tigray.

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INTRODUCTION

Climate change and variability is commonly blamed for food insecurity in many parts of the world. This is certainly true in many regions of Africa, where economic fortunes often parallel precipitation patterns. The gross national product (GNP) of Ethiopia, for example, declines significantly during droughts because of the high contribution of agriculture to the economy (World Bank, 2006). The relationship between climate change/variability and crop failures is not a new phenomenon, but in areas where infrastructure is limited and people are poor and vulnerable climate often becomes a hazard that leads to disaster (Ziervogel *et al.,* 2006). This was the case in Ethiopia during the famines of 1973-74 and 1983-84. During the El Niño of 1997-98, October, often the driest Ethiopian month, ended up being the wettest, destroying the harvests in many areas (Wolde-Georgis *et al.,* 2001).

Compounding the hydro/climatic/environmental factors that have led to food insecurity are also political, institutional, technological, social, and infrastructural variables. Small-scale traditional farmers, for example, have been expected to provide food to the nation using old technologies and seasonal rainfall despite the dramatic changes in the demographic and natural resources conditions. Demographic changes often lead to land fragmentation and environmental degradation (Glantz, 1994).

A major constraint for increasing the low per capita food production has been a constant decline in the quality and availability of natural resources, especially soil fertility (Sanchez, 2001). Lack of land productivity has led to declines in the carrying capacity of the land and the emergence of a chronically poor group of people, even during good weather (Glanz, 1999). Soil degradation (Figure 1) has led to decreases in the resilience of the farmers to climate change related hazards. Degraded land is more susceptible to climate change and variability impacts such as droughts and floods (Henry *et al.,* 2006).

Ethiopia continues to have very low levels of investment in basic infrastructures (access to irrigation, farm inputs, transportation, marketing etc) that are very important for enhancing food security (UNFAO, 2005). The problem of food insecurity is expected to increase with the anticipated increases in the fragmentation and intensification of climate-related hazards unless adequate intervention is made. The main problems faced by the communities in Abreha wa Atsebha

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include shortages of water, energy and other basic household necessities. Despite equal access to land by all members of the community, land alone will not provide food due to the acute shortage of inputs (Wolde-Gerogis, 1995).

The traditional systems of environmental conservation such as zoning, fallowing and protected community forests have also disappeared mainly due to deterioration of age long social institutions (Bellay and Edwards, 2003). Even under normal weather conditions the people are unable to provide food for their households as the physical and ecological resources have changed. There is a need for an intensive form of farming to supply food because of the increasing demand.

Figure 1. Location map of the *Abraha wa Atsebaha* village in Tigray, northern Ethiopia.

There was a change of government in Ethiopia in 1991 and Tigray became one of the nine autonomous regional states that constituted the Federal Democratic Republic of Ethiopia (FDRE) following the new federal constitution. With Tigray as one of Ethiopia's most vulnerable regions to drought and environmental change, the regional government has been trying to introduce environmental rehabilitation and water conservation measures (Alemayehu *et al.* 2009). The case study demonstrates the assertion by Mortimer that "at the community or local level, adaptation to drought in the Sahel is inseparable from a development context" (Mortimore, 2010). Even though they were constrained by resources and technical staff shortages, many agricultural development activities to reduce poverty were being implemented following the national government's priority in agricultural development. The following is an attempt to enable one cost effective project in Tigray region that can serve as an example that is making itself sufficiency in food production in the face of climate change and variability.

MATERIALS AND METHODS

Study Area Description: the Experience of the *Abraha wa Atsebaha* Village in Tigray

The northeastern part of Tigray where Abreha wa Atsebaha is located (Figure 1), is one of the most vulnerable (Figure 2) and prone to drought impacts (Ezra and Kiros, 2000). Discussion was made with about 121 farmers who had shallow wells in their farmlands.

According to the regional government, a family of five requires 17 quintals of grain per year for food and for sale to purchase other necessities (Tigray Food Security Office, 2003). The land productivity in eastern Tigray using normal seasonal rainfall is 7.7 quintals per hectare (Tigray Food Security Office, 2003). All the harvested cereal is consumed by the household, usually before the next harvest. The average subsistence farmer cannot produce surplus by using seasonal rainfall alone. A further limitation is that the food culture in the region is entirely grain-based, incorporating no fruits or vegetables. According to the regional food security office, the poverty line in the region is 18,000 Ethiopian birr (ETB; $1,595 USD) per year (Pers. Comm., 2005). Bringing the income of the farmers above the poverty line by increasing and diversifying their sources of income and by solving the constraints to traditional farming is a timely public policy.

Figure 2. Soil erosion in koraro, near *Abraha wa Atsebaha* in Tigray, northern Ethiopia, T. Wolde-Georgis.

The Concept

The solution to any problem starts with studying and diagnosing the problem and then coming up with solutions and options. As stated above, the problem of access to land was resolved by the Ethiopian land reform. After the land reform, the farmers identified lack of access to water for irrigation as the primary constraint for food production. The diminishing land size due to demographic changes (such as population increase) also meant that the low-input low-output subsistence farming system has to be transformed for high value and marketable crops. The land also has to be cultivated multiple times instead of depending on the yearly seasonal rainfall. Even in good seasons one production per annum would not supply enough food to the households. It was also obvious that extension agents and inputs such as micro-credit needs to be provided to the subsistence farmers.

Providing access to water would need physical investment but the kind of water source (wells, micro dam, ponds, river diversion, individual surface harvesting, etc.) would depend on the local

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endowment. In the village of *Abraha wa Atsebaha*, the farmers' water demand was resolved by digging wells and ponds. The experts did not come with predetermined production packages to impose on the farmers from above. The participating farmers were given choices between combinations of development packages. The program incorporated the adaptation of appropriate farm and water technologies with farmers training in horticulture and gardening. It provided bundled support packages, including beehives, water pumps, seeds, fruit trees, and vegetable production as well as marketing and extension support. Notably, some participants initially refused to take the packages for fear of loans, shortage of labor, and lack of appreciation of the potential benefits (Pers. Comm., 2008). Others wanted to use the water to produce their traditional grains such as barley and maize, while the progressive ones wanted high value crops and vegetables that can be sold in the market. Initial information showed that farmers were reluctant to borrow and invest even in the digging of wells. Funding for these activities was provided from the Safety Net Program and the farmers contributed up to 40 days of annual free labor for water development, soil conservation and maintenance works (Nega *et al.,* 2008). As Figure 3 and Table 1 show 19.66 %, 24.76 % and 11.67% of the total area of land in the village is used for agriculture, sparse mixed land uses and dense mixed land uses, respectively.

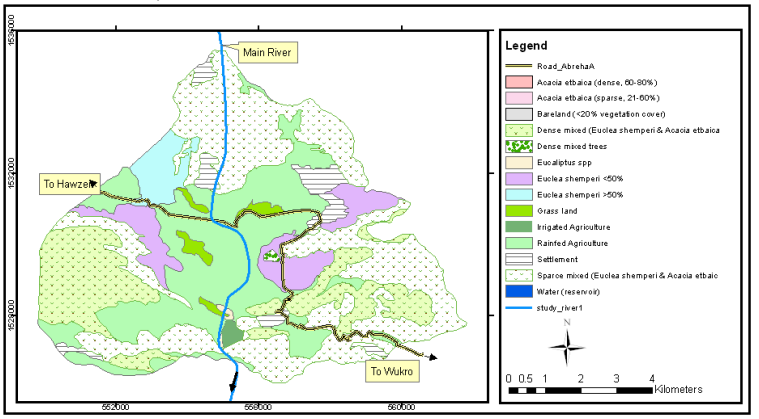

Figure 3. Land use/land cover map of *Abreha wa Atsebaha* in Tigray, northern Ethiopia.

The ultimate objective of the experiment has been to help farmers to produce surpluses and to stay above the poverty level. The extra income generated by selling surplus production would allow households to fill the gap between what is grown and what must be purchased from the market. Its final objective has been to transform subsistence farmers into small-farm entrepreneurs. With the introduction of the bundled support packages, some farmers took full advantage of these opportunities and succeeded in creating wealth (Robinson *et al.*, 2001).

Table 1. Area cover of each land use land cover types in *Abraha wa Atsebaha* village in Tigray, northern Ethiopia

S.no	Land cover/use types	Area in Km^2
1	Dense mixed (Euclea schimperi & Acacia etbaica)	11.67
2	Dense mixed trees	0.11
3	*Eucaliptus* spp	0.13
4	*Euclea schimperi* <50%	5.04
5	*Euclea schimperi* >50%	2.36
6	Grass land	0.98
7	Irrigated Agriculture	0.33
8	Rainfed Agriculture	19.33
9	Settlement	2.95
10	Sparse mixed (Euclea schimperi & Acacia etbaica)	24.76
11	Other land uses	32.34

RESULTS

Key Interventions for Success

The key components of the intervention are access to water, micro-finance (credit), technological packages and environmental rehabilitation. Almost all the farmers used the project's opportunity and dug their shallow wells manually (Figure 4). About 90% of these were dug since 2005. Initially, 37 model farmers participated in the project, and results indicate that many have tripled their incomes. Those who implemented the packages successfully created wealth. Even the lowest of these earners are excelling, when compared with the farmers outside the project. According to the respondent farmers and extension agent, there are now more than 641 wells in the village.

Figure 4. Shallow well in *Abraha wa Atsebaha* village in Tigray, northern Ethiopia, T. Wolde-Georgis.

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The majority of farmers use treadle pumps for their irrigation. There are 281 treadle pumps (84%) in the village, making it the technology of choice (BoANR, 2008). REST (Relief Society of Tigray), a local NGO, provided credit to farmers wishing to purchase manual or motorized water pumps. Some farmers used these to access water from ponds, springs, the river, and wells. Some farmers even experimented with gravity-fed drip irrigation by filling water barrels placed on higher ground.

The major constraint for even greater production remains water. Farmers hope that they will bring more land under irrigation once the plan of REST to divert water from the nearby river is realized. The current average irrigated land per household is 0.125 ha (0.3 acres). A village committee resolves water-use disputes, and the farmers with whom we spoke had not experienced any shortage of water.

In tandem with water resources development are efforts to conserve water and soil. These measures include catchment area terracing, planting hedges along rivers, and protecting valley slopes from soil erosion. The ultimate aim is to retain water and infuse it back into the land to help recharge aquifers and ecological restoration (Environment Education Media Project, 2009). The dominant sources of water in the village are underground wells.

3.2. Key Impacts of the Intervention

Initially, farmers used their new access to water to irrigate their traditional crops. As Table 2 shows, however, the situation began to change as farmers shifted their water use in favor of valuable crops. The size of irrigated land to produce traditional cereals and pulses began to shrink in favor of cash-earning spices and vegetables.

Table 2. Growth of fruit trees in *Abraha wa Atsebha* village in Tigray, northern Ethiopia

	Before 2004	Post 2007	
Fruit Types	#trees	#trees	HH
Apple	0	10	2
Avocado	87	1476	49
Banana	5	55	39
Citron	30	85	31
Coffee	180	2330	561
Guava	652	38350	595
Hops	2337	2132	421
Lemon	70	355	205
Mango	36	1212	175
Orange	34	910	121
Papaya	412	6790	295

The access to water for irrigation and the introduced packages led the subsistence farmers to grow diverse spices and vegetables during the dry season. These include cabbage, mustard, potatoes, garlic, onion and tomatoes. The irrigated land for vegetables doubled from 32 hectares (79 acres) to 68 hectares (168 acres) between 2004 and 2007. Farmers' income from this activity tripled from 520,000 ETB ($46,085 USD) in 2004 to 1.5 million ETB ($132,939 USD) (Table 3). The farmers were able to sell vegetables and spices valued at 14 million ETB ($1,240,762 USD) in 2008. This is income in addition to their traditional rain-fed farming during the rainy season.

Table 3. Vegetables output and price in *Abraha wa Atsebaha* village in Tigray, northern Ethiopia

	Year				
Unit	2004	2005	2006	2007	Post-2008
Ha	32	50	61	69	74
Qnt[1]	3488	5593.5	7417	8566	9627
Birr[2]	523260	866993	1186768	1378563	1594085

Note: Qnt: quintal (100 kg); Birr: Ethiopian Currency

Many farmers in the village also cultivate exotic fruit trees such as apple, avocado, citron, guava, papaya, lemon, mango, orange as well as coffee. Like the vegetables, the tree crops have also slowly increased family revenues. As the trees mature and yields increase, the households derive even greater diversification and more sustainable incomes. The district irrigation agent reports that there are some farmers with as many as 1000 fruit trees. Guava has become the dominant fruit tree, followed by papaya. The rate of growth of guava between 2004 and 2008 ranged from 17 to 71% (Table 2). The income from the sale of vegetables continuously increased between 2004 and 2008.

Another successful intervention in the project was the restocking of the household assets such as goats, sheep, cows and honey bees that had been depleted by recurrent droughts. The revitalizations of the forests helped the expansion of the bee industry as happened in other parts of Ethiopia (Wood, 2010). Four hundred beehives are now owned by subsistence farmers in the village enabling some farmers to earn about 3,385 ETB ($300 USD) annually from the sale of honey alone (Pers. Comm., 2008).

Farmers say that they now harvest three times a year. The high value spices and vegetables bring them cash and the tree fruits give them sustainable income and good nutrition and food independence/ self sufficiency. This success is the result of the participation of the people at the local level, technical interventions, the provision of inputs, and the support and commitment from all levels of administration in the region.

Farmers say that in the past they defined wealth in terms of land size and the number of animals a person owned; it is now determined by the number of wells and water pumps one owns.

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For example, those who have two or three water wells in different plots now command more income than those with only one well. Many farmers have opened bank accounts for the first time in their lives, and they certainly are no longer dependent on humanitarian aid. Due to the success of the experiment, most of the farmers have already repaid their loans on time. One indicator of the success of the project is the number of homes being newly built by the participating farmers. Some have also built rental houses and are earning additional revenue. The greatest achievement of this project, however, has been the independence and confidence of the farmers.

DISCUSSION

Some of the reasons for the success of the pilot project include the vision that solutions for solving the interrelated problems of food security and climate variability should be viewed at the local level. In northern Ethiopia where the project is located creeping environmental conditions due to continuous land use for hundreds of years, degradation of the environment and small land size make it difficult to produce enough food for the households even during a favorable rainfall season. Thus, the provision of water to help farmers grow a second harvest as well as perennial sources of food becomes very important. The best water infrastructure for the *Abraha wa Atsebaha* village was the digging of individual household wells and continuous basin conservation and management that will help water recharge to keep the water table high. The second paradigm of the project was the provision of inputs to the farmers but they have to pay for it. The inputs were bought through a micro-finance program and all the farmers have paid their loans.

The role of local administration that provides capacity building and arranges for the delivery inputs is very important. Between 2005 and 2010, the number of permanent extension agents in the village who interacted daily with the farmers was raised from one to four. The extension agents advise the farmers on water harvesting and irrigation techniques, natural resources management, and animal husbandry. They teach farmers how to grow vegetables, spices, and fruit trees. They also multiply fruit tree seedlings, distribute them, and train the farmers in the timing of planting the tree crops. Extension agents that we interviewed for the research remain invaluable to the effective implementation of the program in the village.

Most administrative and judicial matters at the village level are resolved through the village administrative and judicial system. Unlike previous periods, the role of the local government at the county/wereda level is primarily developmental. The branch ministry of agriculture and water resources at the wereda level is in constant contact with farmers and extension agents. The county/wereda has experts in various development-focused fields such as irrigation, agro-forestry and beehive and traditional crops.

As with all complex issues, when one constraint is solved a new one often emerges. Developing well-functioning markets has become one such new challenge in this food security pilot project. According to one key informant from the irrigation promotion department of the Kilte-Awlalo wereda/county, the major problem is the tendency of the farmers to produce the same vegetables at the same time but without a suitable means of distribution and marketing. For example, the price of tomatoes in September 2007 was 0.25 ETB (.03 USD) per kilogram. One year later in 2008 it was 6.50 ETB (0.68 USD). Some farmers complained that they didn't benefit from the surge in prices nearly as much as the middle men who pay almost nothing for their produce but are the only means available to transport it to the big cities where it sells at a huge profit. There is also a tendency for farmers to grow food crops such as corn on the irrigated plots, contrary to the advice of the extension agents who urge them to cultivate high-value vegetables and spices/herbs. The lesson of this experience is that the farmers need help in marketing by making cooperatives so that they can transport their goods to the remote markets and negotiate better prices. They also need storage and processing technologies.

A second constraint faced by the farmers is the lack of access to energy and they depend on the direct use of biomass for fuel. This shows that to make a project succeed one has to look at the issues of food, water and energy as inseparable parts of the problem. We hope that the next stage of the project will be access to renewable energies and a marketing cooperative that will increase the price of farmers' commodities.

The Lessons Identified from the study

1. The risk of disaster due to climate hazards is often greatest when a society is also confronted with other seemingly unrelated dangers. The communities studied are simultaneously confronted by numerous slow-onset (creeping) environmental problems such as soil erosion, deforestation, and the disappearance of indigenous trees as witnessed in other societies. Therefore, the nature of interventions should be development-oriented and contribute to reducing the long- term chronic poverty that makes communities vulnerable to even slight climate fluctuations.
2. Many subsistence farmers face socioeconomic constraints that are related to the depletion of their household and community assets. The

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depletion of these assets makes them vulnerable to the slightest perturbations in hydro/climatic changes.

3. Subsistence farmers use traditional knowledge to design their living spaces and manage their natural resources in a sustainable manner. Diminishing land productivity and lack of inputs have made these management responses increasingly irrelevant, continually amplifying the importance of understanding these transitional management systems so that the kinds of interventions to be employed are based on local knowledge. It also means that capacity building and infrastructure development are very important aspects of climate change adaptation.
4. The kinds of interventions needed to achieve food security among subsistence peasants have to first identify the major constraints that arise due to changes in climate and the environment. As is shown in the case study, water was identified as the foremost constraint within the hierarchy of problems facing the people.
5. Interventions to mitigate climatic changes must be based on the availability of local resources and the interests of local populations. As in this case study, farmers were active participants in solving their community's problems.
6. Continuous delivery of inputs including technology, micro-credit, and extension services are important for the sustainability of food security interventions. Food security projects that are introduced without building local capacity inevitably fail. Permanent extension agents in the villages can monitor the interventions continuously and support farmers to ensure a project's success. Extension agents also provide farmers with seedlings, financing, and other advice for continued success.

   Technology is an important tool for achieving food security in the face of climate change. Whatever new technologies are introduced must be manageable in terms of cost and utilization. In these projects, accessing water from the surface and from wells was important. Increased infrastructure to deliver water by means of gravity was important to water harvesting, which proved vital to the success of the project in the communities.
7. An important lesson learned is that even though the problems of food security due to climate variability may be solved, other socioeconomic problems tend to arise. The farmers were able to produce food and cash crops; however, they were unable to profit from the fluctuations in the prices of their products due to the lack of direct access to the large markets. In order to maximize profits, farmers would have to market their produce in cooperatives and negotiate with distributors in the largest market instead of selling to middlemen. They would also need greater capacity for food storage and processing to minimize post-production losses.
8. Even though farmers have not yet faced the need to maintain and manage long-term utilization of new technologies, this issue will surely arise. Those who depend on surface reservoirs might face decreased water due to silting. Underground water table levels might also decrease in the future unless users continue to recharge them with seasonal floods or through extensive watershed management.
9. As subsistence farmers began to harvest multiple times in a year, they filled the food gap by selling excess produce to the market. In the process, the farmers transitioned from subsistence producers to entrepreneurial producers. The isolation of the peasants from the outside world was broken. In the process of attaining food security, the farmers also became business people.
10. The regional government has been encouraging the construction of water harvesting ponds by individual farmers in the region. Even though the ponds are an important initiative, the water retentiveness of the ponds needs to be improved. There must also be ways to make the water more useful for micro-irrigation in support of food security. Appropriate technologies such as clay pot irrigation can be relevant to make such ponds useful.
11. The scaling-up process will take the form of peer and group discussions between poor and successful farmers. Successful farmers are now taking positions as village leaders. The widespread construction of small-scale, village-level reservoirs, ponds, and canals for irrigation during the dry season are urgently needed in Tigray and other marginal areas that are vulnerable to climate change impacts.

CONCLUSION

Rain-fed farming in Ethiopia faces an uphill struggle to supply subsistence farmers with enough food to feed their families. The productivity of their land is low; there is increased seasonal rainfall variability; the environment is degraded; and demographic changes, e.g., population increases, are increasing the demand for food. Even with good seasonal rainfall, subsistence farmers are still unable to provide enough food for their families. They constantly teeter on the edge of disaster due to diverse hazards including climate anomalies.

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Unsustainable government safety-net programs that support the chronically poor are, however, insufficient substitutes for attaining personal independence.

This case study is one of the Ethiopian government's diverse programs of community-based environmental rehabilitation to enhance the productivity of land and reduce poverty. Despite problems in marketing and access to energy, the village of *Abraha wa Atsebaha* is a "bright spot" (as opposed to hotspot) that has demonstrated that the major constraints on food security can be overcome. It demonstrates that vulnerability to climate change related hazards can be resolved through holistic local level interventions. The study also demonstrates that achieving adaptation to climate variability and change is a development process that requires that all the weak points of the multifaceted subsistence production chain be addressed. It means that the project has to be cost effective that enhances the self esteem and independence of the people. This pilot project teaches that any project should be measured by the lasting outcome left after it is officially "completed."

Fundamentally important to this success, therefore, is that through flexible collaboration with subsistence farmers whose local knowledge was respected as needs were defined and recommendations were changed. The farmers did not get free inputs. They paid back their loans following surplus production. They avoided becoming indebted to lenders.

However, remaining need is money to "scale-up" for the creation of producers' cooperatives to address market disparity and insufficient returns on local investments. The pilot project's success will also be sustainable, if energy insecurity is especially addressed. Renewable energy sources such as biogas and wood gas can, if introduced, contribute fuel as well as free organic fertilizer. With an increase in disposable income in the long run, farmers can introduce wind and solar energy. Renewable energy will protect the environment such as forests. Finally, there is a need for a training center with a curriculum so that the achievements can be sustainable through generational knowledge transfer and to avoid a lapse to the low-input and low-output farming.

Often the hundreds of recommendations and pilot projects organized by global experts on climate change adaptation and poverty reduction fail because they are dependent on the infusion of fertilizers. They fail once the projects are terminated. Often, no one has ever accounted for the outcomes of those recommendations and the projects developed from them. No development recommendation should be accepted without note about ramifications in case the recommendations are not pursued.

In Africa, where the reports and anticipation of environmental conservation and food security is bleak the bright spots of successful interventions in climate change adaptation are not reported. There is a need for the identification of these dispersed bright spots and the lessons are identified and adopted. The best practices should also be upscaled across Sub-Saharan Africa so that sustainable and entrepreneurial villages can have access to basic needs and are resilient adapters to potential climate change in the future.

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