

MSUS Culminating Experience Final Report

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Strategic Pest Management Booklets for Farmers in Kaffrine, Senegal

The Global Locust Initiative & the Senegalese community

Abstract

When Kaffrine, Senegal faces the threat of a locust plague, farmers tend to struggle to determine what actions should take place and when to prevent a plague. Farmers' inability to identify the early threats of a locust plague is a primary issue that has affected communities in Kaffrine for millennia.

The project focuses on the creation of 500 pest identification booklets that provide five villages in Kaffrine the proper education to prevent locust plagues from forming. I was asked to join the project by the Global Locust Initiative (GLI) in order to help the project lead, Alana Burnham, help construct booklets that improve early detection awareness that is at the root of locust plagues. Outcomes of this project include improved well-being of the farming community, increased millet yields, and enhanced global food system sustainability. As locusts are a migratory pest, providing stakeholders a guide to reference helps them identify the early signs of a locust plague. It also has a larger impact by helping reduce negative externalities, such as impacts on the functionality of Senegal's ecosystems, the welfare of social systems, and the peoples' economic opportunities.

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Introduction and Background

Locust plagues have been an issue since biblical times. Vulnerable communities lack the proper knowledge to prevent the development of a plague or sustainably mitigate the effects thereof. This issue has persisted due to the lack of proper education and often late preventative techniques which have set farmers up for failure on how to restrict locust outbreaks.

Locusts are a unique pest in the sense that their behaviors are either characterized as solitarious or gregarious. Solitarious locusts are innocuous and don't pose a threat to agriculture. However, when locusts undergo phase change they become gregarious and tend to favor highly dense populations which can later cause dramatic effects. It is critical to identify these early threats, the time before locusts undergo this phase change and begin to congregate in high numbers, to effectively prevent an outbreak from occurring in the near future.

Locusts threaten the viability of Senegal's society and the integrity of their ecosystems because they eat the crops and the fruit, leaving what used to be a thriving agroecosystem dead and barren. As a plague can fit up to 80 million locusts in a square mile and can consume its own weight in food per day, a swarm of such size eats as much as 2,500 people eat every day (Food and Agricultural Organization, 2004). Locusts are not only a famine and starvation threat to the local area; they also have the ability to migrate great distances. This means that they are a potential hazard to agricultural production and food security on an international scale.

These agricultural pests have a wide-reaching influence on human and social well-being. De Vreyer and colleagues (2015) note that during Mali's 1987-1989 desert locust plague, schools experienced a 25% reduction in student enrollment. The plague caused such severe impacts on the community that families could no longer afford to put their children through school. The desert locust alone (*Schistocerca gregaria*) impacts more than 60 countries and the livelihood of one out of every 10 people on the planet (Symmons & Cressman, 2001). This contributes to the notion that locusts are not only a local issue but have far reaching impacts that affect individuals all across the world.

Lastly, outbreaks prevent equitable opportunities for livelihood and economic activities, especially for those living in poorer regions. For instance, farmers living in Kaffrine depend on crop sales to make a living. Therefore, these farmers are less resilient to shocks, such as plagues, that can devastate entire economic systems (Baro & Deubel, 2006). When a plague strikes a village with little plague preparedness, not only does it lose all the earnings from crop sales, it needs to begin allocating funds for emergency pesticide spraying. Research from Cressman et al. (2016) shows that the outbreak of the desert locust in Africa in 2003-2005 (figure one) caused \$2.5 billion in crop destruction and cost an additional \$450 million in emergency aid to stop the plague.



Figure One: Desert Locust Outbreak. (2012). Retrieved from Food and Agriculture Organization & The Desert Locust Information Service.

If not addressed in a timely manner, excessive amounts of unhealthy pesticides are sprayed, which contaminates any remaining crops and puts farmers, herders, their families, the larger crop consuming population, and other species at risk.

To best assist Senegalese farmers, I was kindly brought onto the team by the directorship of GLI, Dr. Arianne Cease and Dr. Rick Overson, to best assist the Community Outreach Specialist, Alana Burnham, with a variety of tasks related to the project they have been developing. GLI is an Arizona State University (ASU) based initiative that, “engages key actors in locust research and management to develop research, partnerships, and solutions for transboundary pest management in agroecosystems around the world” (Global Locust Initiative, n.d.). Having access to GLI’s extensive network of professional researchers, government and non-government agencies, and farmer groups around the world had allowed for me to efficiently aid Burnham.

The project was initiated from a grant issued to GLI by the United States Agency for International Development (USAID) and the Office of U.S. Foreign Disaster Assistance (OFDA) to help Senegalese farmers prevent locust plagues. The main reason why this project has such traction is because previous outbreaks have destroyed food and crop production in Senegal and the greater Africa region. Locals have requested assistance to generate early detection methods and are aware that locust control requires a collaborative effort. It is important to note that the identification booklets are to be considered a part of a much larger USAID project. To illustrate, GLI has coordinated with Gaston Berger University (UGB) and the Senegalese Plant Protection Directorate (DPV) to implement on-the-ground solutions by testing soil amendments through nitrogen fertilization as a tool to keep locusts at bay.

After doing some personal research, I have learned early detection and intervention that includes “control as a preventive strategy has proven to be effective and has led to a dramatic decrease in outbreak frequency and duration over the last 40 years” (Lecoq, 2005). With GLI’s access to subject matter experts on early warning systems, locust physiology and preventative approaches with knowledge on how to best communicate about pest control with farmers, the initiative leveraged this and integrated it with its understanding of working with foreign cultures.

Next, the GLI team had referred to identification booklets, such as the Australian Plague Locust Commission (APLC, 1998) “Field Guide to the Locusts and Related Grasshoppers of Australia,” to analyze how transferable they were to Senegal. Although the social context and literacy levels may differ from Australia to Senegal, much of the educational material included within each of the booklets is similar since they convey the latest techniques for monitoring and managing locust plagues. It is important to note that the team has accounted for these differences and has employed particular techniques, which will be described in detail later, to ensure no barriers were encountered.

The booklets are a sustainable solution considering they educate individuals and empower a community-based approach to preventing the early signs of a locust plague. It is important to note that the booklets went through an iterative design process meaning stakeholder feedback was taken into consideration throughout the creation of the booklet. The GLI team had collaborated with Senegalese and international entomologists and pest management experts to shape the booklet. Burnham had then planned and provided the project communities time to ask questions, pose comments, and provide feedback during the piloting phase. This then allowed her time to make necessary changes to the booklet to ensure the material is presented in the best possible format. In order to account for the language barriers as well, the booklets include translations in three different languages: English, French, and Wolof.

In all, being able to identify the early signs of a locust plague enables the community members to exercise pest management strategies, such as targeted small-scale spraying or egg and habitat control. Therefore, the identification booklet was designed to complement the management booklet that further describes certain prevention strategies. The prevention strategies were also demonstrated to the community during training workshops that were led by Burnham, Fatou Bintou Sarr, Dr. Mamour Toure from UGB, Alioune Beye, and DPV technicians. These individuals had ensured that these measures are applicable to the area surrounding the five villages as the farmers have access to these lands where locusts begin to congregate. The strategies will then be implemented to prevent an outbreak of locusts located in their fields.

Literature Review

Coupled Human and Natural Systems (CHANS) is a framework that addresses interactions between stakeholders and ecosystems and has been leveraged to better understand how locusts interact with their surrounding environment (Cease et al., 2015). A characteristic of CHANS is that it links individuals through time and space. If these dynamic links are not accounted for, they result in intertemporal and spatial externalities that force costs onto future and distant stakeholders while allowing current individuals to reap

existing benefits (Cease et al., 2015). As Cease et al. (2015) explain, these human-locust-livestock-nutrient interactions (figure two) are needed to illustrate the concept of CHANS and critical intervention points within the system.

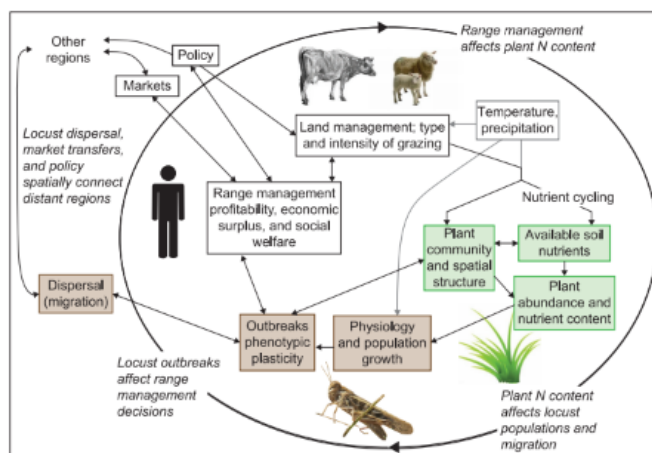


Figure Two: Human-Locust-Livestock-Nutrient interactions. Adapted from “Living with Locusts: Connecting Soil Nitrogen, Locust Outbreaks, Livelihoods, and Livestock Markets,” by A. Cease et al., 2015, *Bioscience*, 65 (6), 551

There are currently over 20 different species of locusts that have the capability of wreaking havoc on multi-national economies. The complications that these locusts present consist of “overwhelming challenges to society’s capacity to observe, document, plan, collaborate, act, and so forth,” therefore contributing to locust plagues as a sustainability problem (Wiek, 2015). Considering locust plagues have been a prominent issue that have not received the necessary attention, several organizations now realize the demand for increased educational material to help stakeholders identify the early threats. To illustrate, the Department of Agriculture’s Australian Plague Locust Commission recognizes the importance of locust plague prevention by replacing intense pesticide spraying with early detection and intervention methods, such as small-scale targeted spraying, biocontrol agents, and other prevention procedures (Cease et al., 2015). The United Nation’s Food and Agriculture Organization Locust Watch also raises awareness about locust plagues. This is being done by employing concerted monitoring and other prevention programs proven to be effective by decreasing the frequency and severity of locust plagues. An additional benefit of these programs is an increase of funding: approximately \$400 million from governments and international aid agencies to control the 2003-2005 desert locust plague in Africa (Van Huis et al., 2007; Brader et al., 2006).

The identification booklets are seen as “an upsurge prevention strategy” (Bennett, 1976; Magor, 1994). This is because the material included in the identification booklets aims to reduce the population size during the appearance of the first gregarious, migratory locusts (Lecoq, 2001). These preventative measures are targeted at dominant pests, such as the Senegalese locust (*Oedaleus senegalensis*). The reason the measures are targeted towards the Senegalese locust is because “some locusts, such as the desert locust, originate

in remote areas and only become an economic problem when they migrate to agricultural lands. In these scenarios, there may be minimal potential for mitigation because initial outbreaks are dependent on factors not heavily influenced by people. However, other locusts, such as the Senegalese locust, originate in human-dominated (usually agricultural) landscapes, where there is considerable potential for mitigative and adaptive responses” (Cease et al., 2015).

This form of prevention, often referred to as ‘pro-action,’ consists of approaches to early detection and intervention that aim to prevent outbreaks from reaching plague levels (Showler, 1997). As Lecoq et al. (1997) explain, without early detection and intervention, the issue with locusts will only grow more complex and difficult. Skaf et al. (1990) and Roy (2001) show that the approach GLI took has previously contributed to the reduction of plague frequency and intensity. As shown in figure three in the [appendix](#) (FAO 1994b; Scherer & Lié Fong Hong, 1995), decreased probability of plagues in the 1960s can be attributed to the increase of public knowledge and implementation of proper control procedures to keep locusts at bay (Lecoq, 2001).

In general, this form of proactive control is still the most effective option as it is the least expensive and harmful to the environment (Lecoq, 2001). Moreover, this approach to increasing farmer education and implementation of proper control measures in breeding areas is directly correlated to successful plague prevention (Showler, 1991). Addressing institutional arrangements and knowledge regarding prevention strategies is critical in the long-term if countries want to sustainably control locust outbreaks and reduce the need for external aid or monetary support (FAO 1994a, 2001; Martini et al., 1998; Showler, 1997; Showler & Potter, 1991).

Utilizing identification booklets as educational material is based around the transition knowledge to increasing timely stakeholder action regarding preventative techniques to fend off the early stages of a plague. As Ceccato et al. (2007) show, plagues occur due to insufficient enforcement of preventative techniques and slow, often late, responses by institutions. However, by increasing stakeholder knowledge regarding the early threats of a plague and including the plant protection directorate contact information in the booklet, farmers can directly request small-scale spraying in the case of an emergency.

If completed properly, targeted small-scale spraying, as well as egg and habitat control, or other methods, can successfully prevent a plague. Furthermore, going back to the concept of CHANS, this strategy strengthens community awareness and understanding of human-locust-livestock-nutrient interactions. Farmers, and communities that are located in plague prevalent areas, realize there is an issue in need of being addressed. Due to that, there is buy-in, or affirmation, from these stakeholders to intervene in upstream drivers to begin solving the issue. By having whole community prevention strategies around early detection awareness, there is an opportunity to influence stakeholders’ norms and actions and transition them into a more effective preparedness mindset.

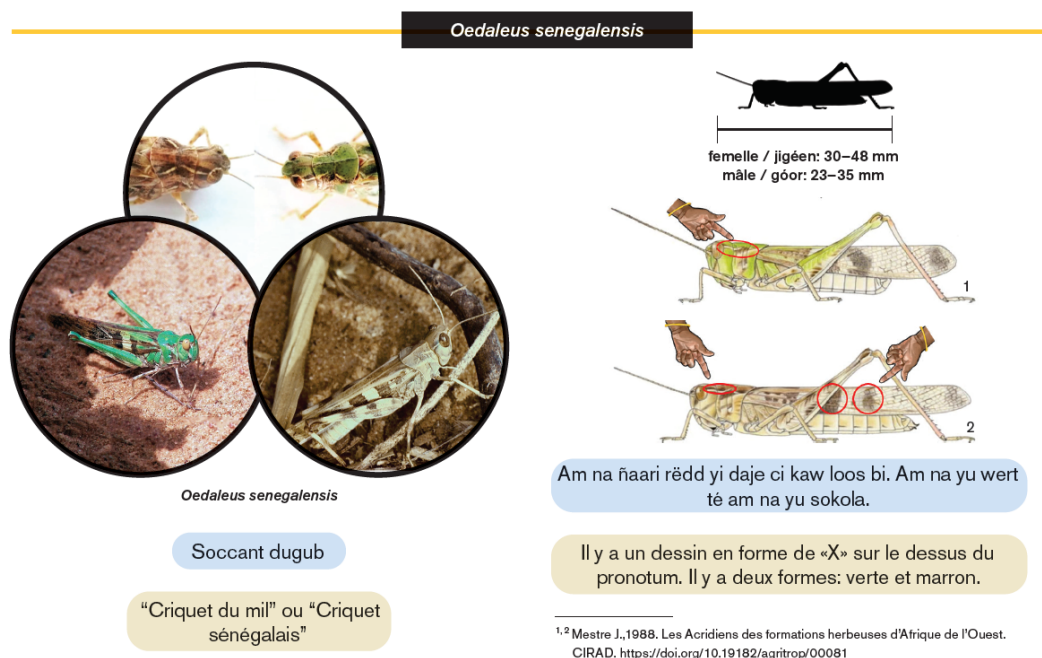
Leveraging disasters for change is an applicable theory of change since it focuses on using disasters as a catalyst to lead communities towards desirable outcomes (Brundiers & Eakin, 2018). By implementing the identification booklets into a farming community that has previously been affected by a plague, it allows them to rebuild their society in a more

sustainable fashion. Utilizing this window of opportunity, where vulnerability and hazards create a disaster, instills a desire for the stakeholders to increase their knowledge about the early threats of a plague to ensure an outbreak doesn't devastate them again.

Project Approach and Intervention Methods

Identification booklets prove to be an effective method of early detection by reducing plague frequency and duration (Lecoq, 2005). For that reason, GLI had decided to pursue identification booklets comprised of material to educate farmers about possible prevention techniques. Lecoq says increasing stakeholder awareness is critical because it shows attempts to reduce and prevent plagues are possible (Lecoq, 2005). Burnham had then shown me research of other successful booklets and studies, such as Green Senegal's (2010) "Agroforestry Nurseries," and the Program for Appropriate Technology in Health's (1996) "Developing Health and Family Planning Materials for Low-literate Audiences." Other guides, such as the U.S. Department of Health and Human Services Center for Disease Control and Prevention's (2010) "Simply Put," and Communication for Change's (2012) "Writing Text to Reach Audiences with Lower Literacy Skills" are helpful sources to better understand how to present information in text for low literacy audiences.

Each source listed above touches upon the importance of informative graphic design as a Social and Behavior Change Communication (SBCC) tool that can aid people with lower literacy in understanding the ideas and material presented (Communication for Change, 2012). In other words, including descriptive visuals alongside text, like those in figure four below, helps low literacy audiences comprehend the messages.



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Figure Four: Descriptive Illustrations Adapted from Identification Booklet
Illustrations created by Kara Brooks (www.instagram.com/kara._brooks)

In particular, our team had drawn knowledge from the APLC “Field Guide to the Locusts and Related Grasshoppers of Australia,” described earlier, as well as the “Simply Put” guide, for creating easy-to-understand Senegalese booklets. We referenced the APLC booklet because it shares a similar outline. As for the “Simply Put,” it provided step-by-step approaches to make the message clear and best develop a user-friendly booklet that the audience will understand.

As part of my own studies to fulfill culminating experience requirements, and be able to properly convey locust plagues as a sustainability problem to the MSUS committee, I utilized certain tools described below to structure my personal research. The tools that I am referring to are the Transformational Problem-Solving Framework which incorporates the Problem Structure Framework, Vision Structure Framework, and the Strategy Process Framework. The Transformational Problem-Solving Framework helped me with all of the different processes from characterizing the issue to resolving the problem by implementing a strategy (Wiek, 2015). There are five different stages to this framework: identifying the problem, analyzing the problem, creating a solution vision, building out the solution strategy, and finally implementing this strategy. Within each of the five stages, there are five different tools that were used in order to move forward, and at the end of each stage an output is produced that builds upon the previous.

To achieve the overarching goals of my MSUS research, there are several steps that must be accounted for, starting with gathering critical information. Several of the GLI team, such as Dr. Cease, Dr. Marion Le Gall, Burnham and others, had frequently visited the area to continue building better connections with the national DPV leadership, local DPV technicians, local politicians, community members and so on. During visitations the GLI team had made efforts to ensure the key contributors were engaged with the project process. From there, those listed above completed additional visitations to Senegal to address locals’ feedback. Other information included in this particular phase that I needed for MSUS requirements included identifying a cohesive project plan, the roles and responsibilities of those involved, as well as an outline with deadlines for each task.

From there, I completed the analysis phase. I first identified the problem through five different sustainability features and the need for solving through three different criteria. I used the Problem Mapping Framework (figure five in [appendix](#)) to specifically identify what the root causes of the issue are, what actions and technologies are immediately causing the issue, and the effects the issue has on key stakeholders. This was a critical step in the process as it depicted where possible intervention points were located within the system.

The next step was to synthesize this information and search for relevant methods to structure my work. To fulfill this MSUS research phase, I created a personal Work Breakdown Structure and GANTT chart to ensure tasks that I was assigned were completed in a timely manner. Additionally, the GLI team and I regularly stayed in contact and had held occasional check-in meetings to ensure deadlines were met and to discuss the project.

The Vision Structure Framework (figure six in [appendix](#)) showcased how the booklets and increased education influenced the root causes, the immediate causes, as well as the effects on relevant stakeholders. By exercising the Vision Mapping Framework, I was

able to discover why the strategy GLI chose was implemented to accomplish a desirable future state.

In the following stage, also known as “building the strategy,” I illustrated the seven guiding factors (the point of intervention, actions, actors, resources, assets, tactics, and expected outcomes) within the Strategy Process Framework (figure seven in [appendix](#)) that enabled me to better help Burnham develop the booklets. I showcased how the approach would aid in fixing the current state of the problem and help the farmers arrive at the sustainable vision. This has been completed using evidence of leveraging disasters for change. As stated earlier, the Senegal region has low resilience as it has been devastated by previous plagues, therefore creating a window of opportunity to act on. Once again, these frameworks were utilized as personal reference and are separate from work to the USAID project.

Outcomes/Findings

It is important to note that since the original outline there has been several changes that had been made to the structure of the booklet. One of the most notable changes in my opinion had been the decision to split the original material into two different booklets. This now means that there is a management booklet as well as a pest identification booklet. With this change, the material covered in the identification booklet had shifted slightly. As of now there are a total of four different sections in the booklet. Section one summarizes the booklet and acknowledges the international cooperation between partners to bring this project to life. Section two explains locust anatomy and the informative symbols used throughout the book, with particular focus on features used to identify species. Section three covers each of the 13 different species. For each species, there are pictures and illustrations, descriptions of where each species lives and what it eats, and details of other important characteristics (size, life cycle, etc.). Lastly, section four provides the contact information for relevant DPV bases, in case community members identify large number of pest species.

Additional changes that were made include the language selection, image conception and development, the addition of topics to each booklet, altering the focus of the ID booklet, the selection of photos and illustrations for use in the ID booklet, the selection of species to be included and so on. Another change that should be included was the creation of the species name in Wolof and symbols for illiterate audiences. This attests to the notion that projects transform and change as time goes on to fit the needs of stakeholders.

Other valuable outcomes worth mentioning are from the workshops led by Burnham, Sarr, Dr. Toure, Beye, and others. During each (which can be seen below), results of the on-the-ground nitrogen fertilization experiment were discussed, the completed control and management booklets were handed out and discussed, and parts of the identification booklet were shown to receive feedback before moving forward with printing.



Dr. Mamour Toure presenting slide on *Oedaleus senegalensis* to farmers in Gniiby during the results and identification presentation



Fatima Sarr presenting to women's group located in Nganda



Women's group leader in Nganda reading the control and management booklet

Figure Eight: Training Workshops in Senegal

When the identification booklet material was presented in Senegal, Burnham and Sarr had taken notes about the constructive feedback from the Senegalese community. For instance, they had led activities during the workshop that portrayed material from the identification booklet. Individuals would gather in groups to discuss symbols developed by Dr. Cease, Burnham, Brooks, and the ASU OKED marketing team that describe the habitats in which each species live, the diets of each locust, which season each species is spotted in, and so on.



Alana Burnham presenting symbol during Gossas farmer training



Gossas farmers discussing symbols during group activities at training workshop



Gossas farmer looking over illustrations during training workshop

Figure Nine: Training Workshop Activities & Pictures

The community's attention to specific details was fascinating to see. Individuals commented on aspects such as what the environment looked like in each illustration, where the locusts appeared to be placed to show whether they lived in grasslands or trees, what the weather and crops looked like in the dry or rainy season, and much more. With this feedback, Burnham had returned to the ASU OKED marketing team to adjust those illustrations to get them more dialed in to reflect feedback that was given by the community. These changes have been made and can be seen in the final booklet.

Overall, the project has been successful, but for now GLI is waiting to return to Senegal to distribute the material to the community. Unfortunately, due to COVID – 19 the distribution of the finalized version of the identification booklet has been postponed.

Recommendations

Personally, there were no large recommendations that I made to GLI or the client that greatly affected the outcome of the project. However, there were a few smaller suggestions I made that were considered.

First, a recommendation I had made was to only provide one picture and illustration for each of the 13 species included in the identification booklet, unless there were multiple morphs of one locust. Before this recommendation, there were several pictures and illustrations per each species and including all would have made the pages very crowded,

hard to read, and would have added to the page length. Due to this, I suggested to only chose pictures and illustrations that were clear and critical for identification purposes.

In addition, I was approached by Burnham and asked to record the trip and workshops to utilize for news or other publicity purposes. I was provided media equipment to journal our trip in Senegal and to capture significant pictures and videos of the Senegalese community during the workshops. We now have hundreds of pictures and videos that can be shared to help portray the work we completed.

Another recommendation that was made was from an idea brainstormed by the MSUS committee regarding a one-page document, or flyer, that had all the pertinent information on it and could be passed out to the general Senegalese community. Ideally, the document would encompass the most important or hazardous locusts in the area, the most relevant information about the species, and the control and management strategies. However, this idea was not followed through with as the original material had already been separated into the control and management booklet and the identification booklet. Additionally, this suggestion did not receive much traction due to bandwidth, strict timeline, and difficulty prioritizing which material would be showcased on the flyer. Even with this being said, I believe that the project was successful in all aspects. In conclusion, the recommendations that were considered had added value to the entire experience and the project as a whole.

Conclusions

The results from the training workshops provided an insight into the success of the project. This can be seen by the Senegalese community's ability and dedication to learning fast as well as their commitment to continue utilizing these methods to prevent locust outbreaks. For example, during the training workshops, Dr. Toure had presented on identification techniques to help distinguish different species from one another. This was helpful for the farmers to be able to know how and what to look for during the identification process. Being able to identify different species is critical for prevention purposes as it suggests the potential severity of which species might be on the verge of an outbreak. It is also significant to identify which species are seen as it will help the DPV prioritize which fields need to be sprayed first to deter an outbreak.

Overall, the project will be completed once the 500 completed identification booklets are passed out to the farming community in Kaffrine. Unfortunately, this project cannot be taken over by future students. However, if a student wishes to replicate this project for species within a different region, I would be more than willing to pass along the contact information to individuals that would be able to help or answer any questions that they might have.

Appendices and Acknowledgements

In conclusion, having worked on this project has opened my eyes to so many experiences and learning opportunities. I would once again like to express my deep gratitude to the GLI directorship, Dr. Arianne Cease and Dr. Rick Overson, for providing me this wonderful opportunity; to those that I had the pleasure working under/alongside: Alana Burnham; and those that I met during this experience: Fatou Bintou Sarr, Dr.

Mamour Toure, Alioune Beye, Cheikh Ndao as well as several others. In all, the hard work that's been completed is valuable in the sense that it seeks to improve Senegalese livelihoods, increase millet yields, as well as strengthen global food system sustainability.

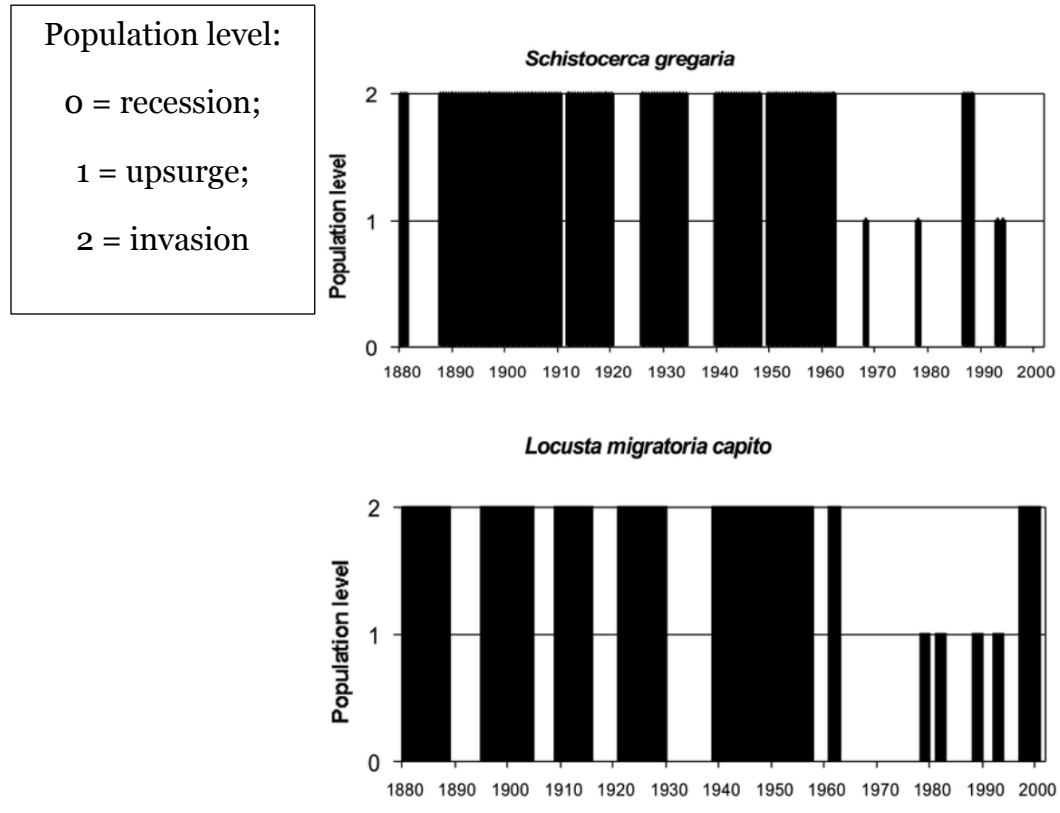


Figure Three: Plague and Recession Periods of the Desert Locust and of the Malagasy Migratory Locust, 1880–2000 (source of data: *Schistocerca gregaria*, FAO 1994b; *Locusta migratoria capito*, Scherer & Lié Fong Hong 1995).

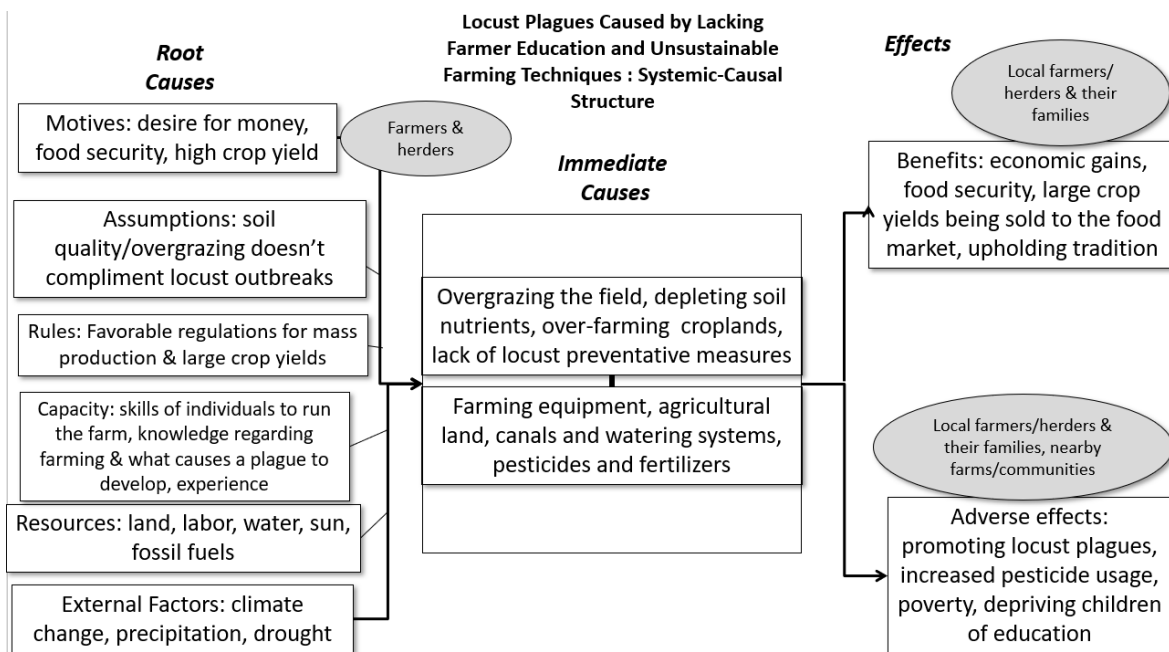


Figure Five: Problem Mapping Framework

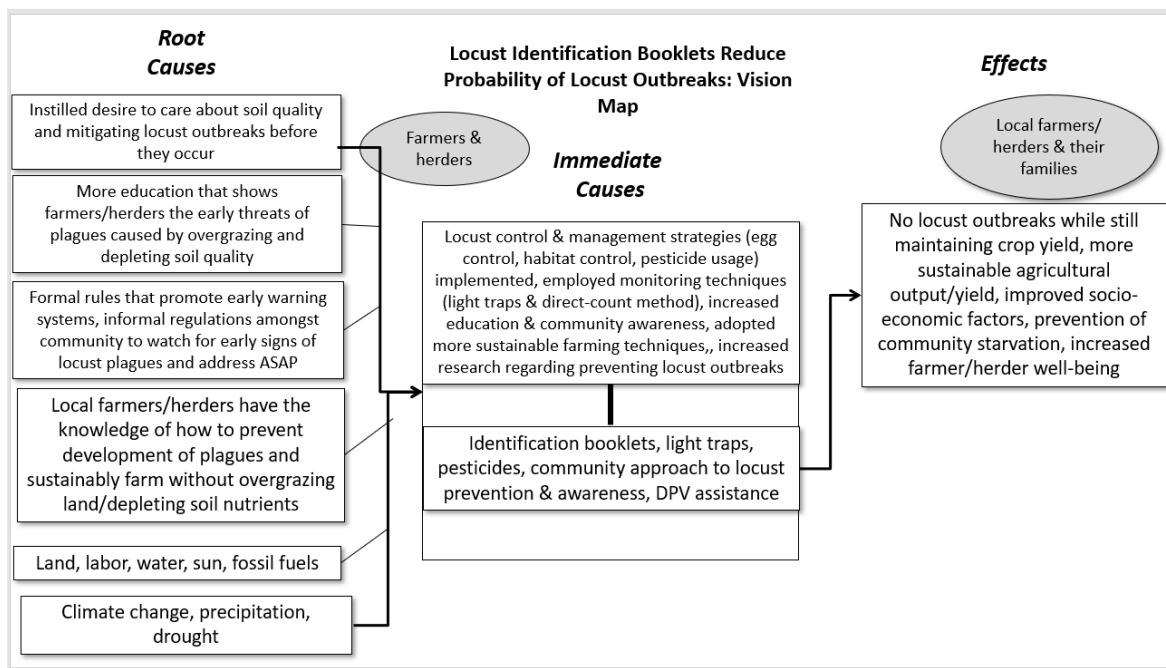


Figure Six: Vision Structure Framework

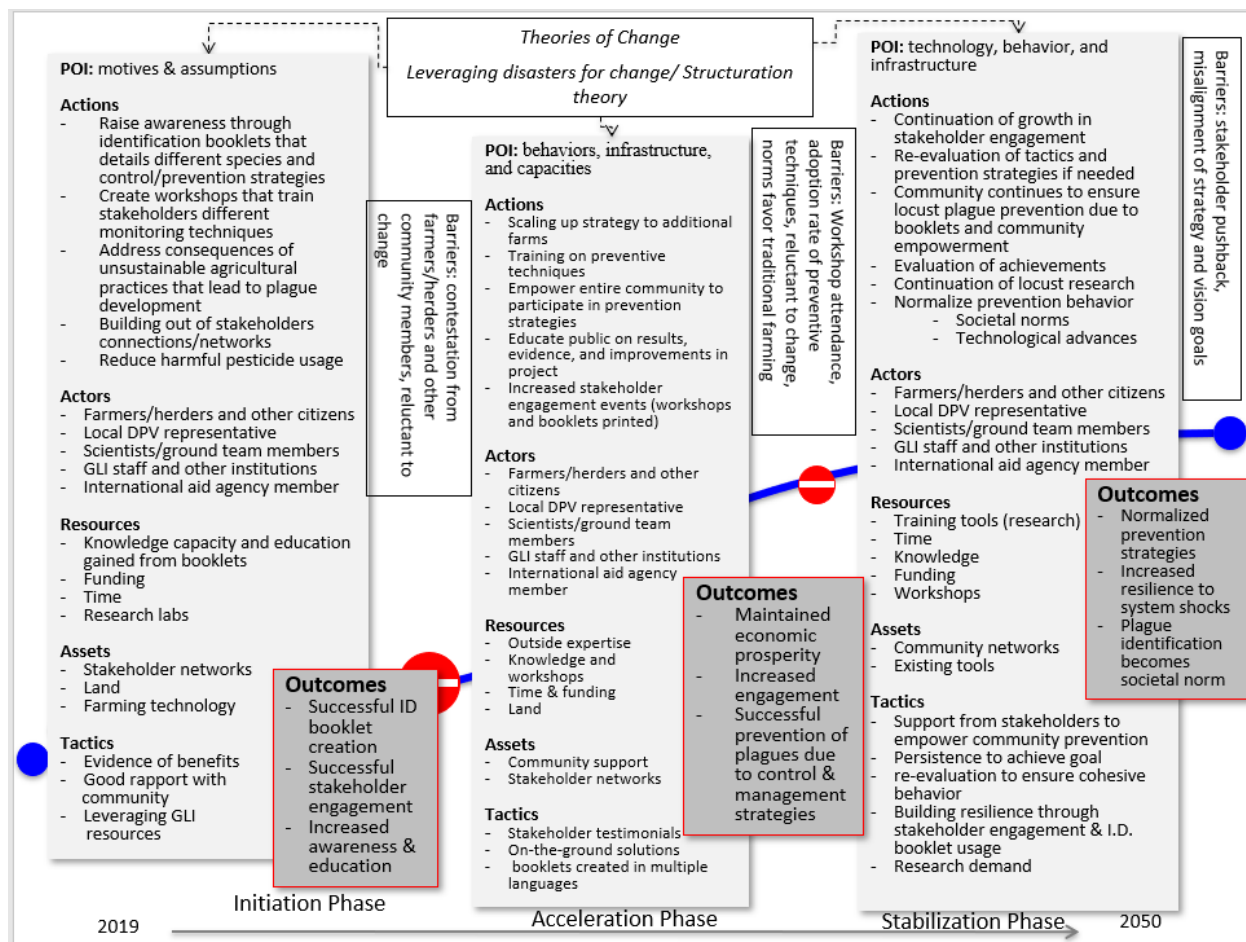


Figure Seven: Strategy Process Framework

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