

APPLYING THE STAPLEE CRITERIA TO DEVELOP NATURAL HAZARDS MITIGATION ACTIONS: CASE STUDY AND LESSONS LEARNED IN NORTHERN PUERTO RICO

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ABSTRACT

A key strategy to identify risks associated with natural disasters is the use of appropriate criteria that allow protection of life and property from future hazard events. With the effects of climate change increasing it is important to effectively identify the vulnerability of communities, as well as properties of the municipalities that are exposed to natural hazards. Using the correct criteria could provide a base for the development and implementation of mitigation measures aimed at reducing the loss of life and property. Implementing these measures could help reduce the economic and social impact of the natural hazards that affect communities in Puerto Rico. The use of inadequate planning in the design of mitigation activities may not be enough nor sustainable in the long term, when addressing natural hazards in regions like the Caribbean. Hurricanes, earthquakes, tsunamis, droughts, flooding and coastal erosion have already claimed the lives of hundreds of people and throughout the last decade, have caused over \$100 billion in damages across the region. Based on this scenario, a case study is featured using the United States Federal Emergency Agency's (FEMA) STAPLEE Criteria. STAPLEE is an acronym for the seven criteria used to conduct a feasibility review. These criteria are: Social, Technical, Administrative, Political, Legal, Economic, and Environmental feasibility. After describing the method, the paper focuses on the reliability of the process and the results obtained in a coastal municipality in northern Puerto Rico. Twenty-three mitigation actions were developed to address the most pressing natural hazards affecting the municipality. The use of the criteria addresses the challenge developing the appropriate mitigation actions at the local level while complying with the archipelago-wide approach developed by the state government of Puerto Rico.

Keywords: multi-hazard mitigation in Puerto Rico, FEMA, community resilience, climate change, planning, coastal hazards.

1 INTRODUCTION

On 20 September 2017 at 10:15 a.m., the worst natural disaster on record to affect the archipelago of Puerto Rico, and the islands of Dominica and US Virgin Island made landfall causing catastrophic destruction and the loss of thousands of lives in these countries. According to the United States Federal Emergency Management Agency (FEMA), total losses from the hurricane were estimated at over US \$91 billion, and it is considered the third costliest tropical storm on record [1]. The main island of Puerto Rico suffered major infrastructure damage and a major humanitarian crisis; most of the island's population suffered from flooding and a lack of resources, compounded by a slow relief process. The storm caused the worst electrical blackout in US history, and in June 2018, thousands of homes and businesses were still without power [2]. At the peak of the storm, the maximum sustained winds reached 175 mph (280 km/h) and dropped over 30 inches of rain in a period of 24 hours. The hurricane caused approximately 25 landslides per square mile, damaging state, and municipal roads across the island affecting the recovery efforts for months (Fig. 2) [3].





Figure 1: Satellite image of Hurricane María over the archipelago of Puerto Rico. (Source: NASA.)

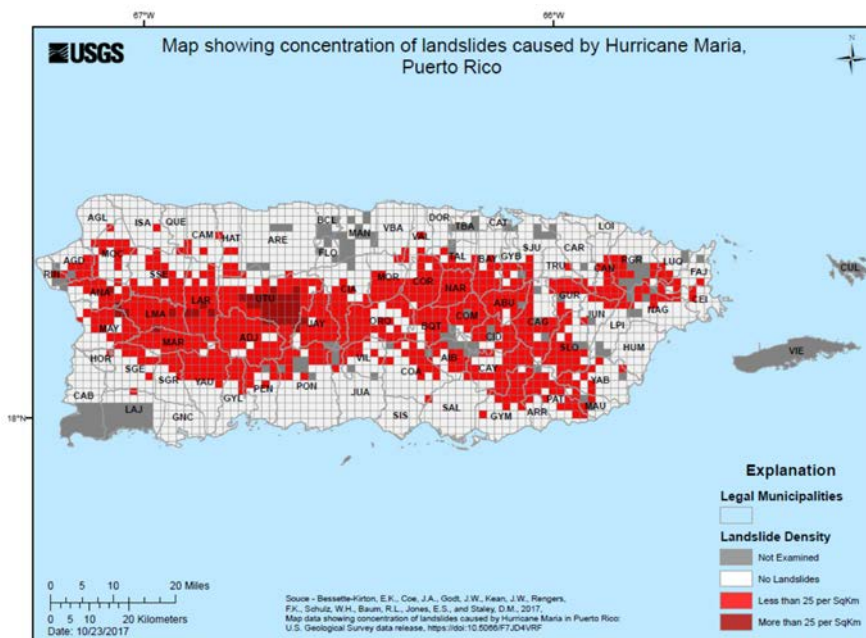


Figure 2: Map showing concentration of landslides caused by Hurricane María. (Source: USGS.)



According to the authors the hurricane's wind, storm surge, and rain disrupted most of the island already weak infrastructure that was damaged by Hurricane Irma two weeks before Hurricane María. The system impacted all 78 municipalities damaging dams, bridges, coastal barriers, highways, and critical buildings including police departments, hospitals, fire departments, shelters, schools, among others. The passing of the tropical disturbance presented the state and local governments with a unique opportunity to develop strategies aimed to create more resilient communities facing natural hazards like hurricanes, severe droughts, heavy rains, earthquakes, and coastal erosion (Fig. 3).



Figure 3: The flooded interchange between state road PR#2 and expressway PR#22 in the town of Vega Alta.

2 APPLYING THE STAPLEE CRITERIA FOR LOCAL STRATEGIES

In 2003 the United States Federal Emergency Management Agency (FEMA) created a process known as STAPLEE. The acronym stands for Social, Technical, Administrative, Political, Legal, Economic, and Environmental, and it is being used by communities in the United States and the territory of Puerto Rico to explore the opportunities and constraints of each proposed mitigation actions as part of a more comprehensive plan to address all known natural hazards. This planning tool will produce an outcome to support and assist local governments and communities in determining priorities for hazard mitigation [4]. Not all processes are the same as every community has different needs or infrastructure conditions. According to the federal agency, when applying STAPLEE, it is vital to consider important questions relevant to each criterion. The criteria are defined as followed.

2.1 STAPLEE: Social

From the local point of view, the local government, community, and other stakeholders – considering each planning situation – must support the overall implementation strategy and specific mitigation actions. Therefore, evaluating the projects in terms of community acceptance to avoid unwanted results. For example, obtaining feedback to determine if the proposed action adversely affects any segment of the population, disrupts established neighborhoods, breaks up voting districts or cause the relocation of lower-income people.

Other important variables include community values, cultural resources, and if the proposed actions will be in harmony with social, cultural, and religious beliefs and customs.

A key component in the development of a mitigation strategy aimed to increase resilience of a community is the technical component of the proposed action.

2.2 STAPLEE: Technical

During the planning phase is critical to determine if the proposed action is technically feasible by examining whether the action will help to reduce losses in the long term, it has minimal secondary impacts, if it is a whole or partial solution, or not a solution at all. The proposed action shall consider whether it is effective in avoiding or reducing future losses, if it may create more problems than it solves, if it solves the problem at hand or addresses only symptoms of the problem. Also, if the proposed action involves construction, is it technically feasible to build. The successful implementation of a proposed action requires proper assessment of the management, staffing, funding, and maintenance resources needed.

2.3 STAPLEE: Administrative

During the planning phase, the community representatives shall assess carefully the Administrative evaluation criteria to determine the staffing required, funding, and maintenance requirements for the mitigation action. This review will help in determining if the community or local government has the personnel and administrative capabilities necessary to implement the action or whether outside help will be necessary. During the process, local representatives are required to assess if the local government has the capability (staff, technical experts, and/or funding) to implement the action, or can it be readily obtained? Also, a key element is to evaluate if the municipal government provides the necessary maintenance to a proposed action. Around the world, politics have a profound impact in the implementation of initiatives, projects, or ideas where funding is required. During the planning phase and discussion of the proposed project, looking into the local politics is important to improve the possibilities of success.

2.4 STAPLEE: Political

The involved personnel should understand how the community and state political leadership – as per their particular planning situation – feels about issues related to the environment, economic development, safety, and emergency management. Through years, Puerto Rico has seen important projects fail because of a lack of political acceptance or will. It is important to ensure that a designated member of the planning team consults with the board of supervisors, mayor, city council, administrator, manager, or other political offices of local governments. Also, the process of mitigating political issues may help avoid political pitfalls. It is recommended to identify whether there is local political support to implement and maintain the proposed action, if politicians have participated in the planning process, who are the key stakeholders, and is there enough public support to ensure the success of proposed actions.

2.5 STAPLEE: Legal

One key component of the stakeholder's meetings is to determine whether the community has the legal authority to implement the action, or whether new laws or regulations are needed. The personnel will identify the unit of government undertaking the mitigation action,



and include an analysis of the interrelationships with local, regional, state, and federal government. Sometimes, it will be required to enable legislation to allow the local government to take the proposed action. It has been identified that the legal authority plays a large role later in the process when the community determines how to implement mitigation activities and to what extent mitigation can be enforced. Having a legal counsel is very important to answer questions regarding jurisdiction to implement a proposed activity. Specially is there a technical, scientific, or legal basis for the mitigation action, or if there are laws, ordinances, and resolutions in place or are any amendments to current laws, ordinances, or resolutions necessary.

2.6 STAPLEE: Economic

It is well known that economic prosperity ebbs and flows, so when it comes to mitigation actions, if funding is available, communities are more likely to implement them. However, the flip side is also a reality, so if mitigation actions require indebtedness, then the actions often remain unimplemented. In recent times, as Puerto Rico faces great economic challenges due to strict financial requirements by the Oversight Management Board (PROMESA), all economic considerations must include the current economic base and projected growth. It is very important to consider an outside source of funds to implement a mitigation action which is helpful for those with budgetary constraints. During the planning phase, staffers need to consider if the funds are currently available to implement the action. Also, it is critical to consider what benefits will the action provide to the community or the region, as well if the associated costs seem reasonable and potential benefits. Furthermore, some proposed actions can put a burden on the tax base, affecting future investment due to compromised future earnings.

2.7 STAPLEE: Environmental

The last part of the method covers potential environmental impacts from the proposed mitigation actions. Most municipalities desire sustainable and environmentally healthy communities, and, when using federal funds, there are various statutes that need to be considered, such as the National Environmental Policy Act (NEPA). When considering proposed actions, it is very important to evaluate possible negative environmental consequences to assets, such as, threatened and endangered species, wetlands, environmental justice, and other protected natural, cultural, or religious resources.

When working with stakeholders it is vital to include health departments, conservation commissions, environmental or water resource agencies, building officials, historical preservation groups, environmental groups, and wildlife management agencies. The idea is to assess the potential effects of the proposed action on the environment (land, water, residents, and endangered species) or if the action complies with local, state, and federal environmental laws. However, mitigation actions may benefit the environment. For instance, acquisition and relocation of structures out of the floodplain, sediment and erosion control actions, and stream corridor and wetland restoration projects, all offer benefits to land, species, or other environmental aspects.

Once the process of identifying potential mitigation actions, the rating of such proposals will help selecting those with better possibilities of being funded or implemented. The process is known as relative-rating where quantitative values are assigned to determine priority (low, medium, or high). The process usually includes a template to assign values to proposed actions to help in the decision process [5].



3 THE MUNICIPALITY OF VEGA ALTA MULTI-HAZARD MITIGATION PLAN 2019

The Multi-Hazard Mitigation Plan of the Autonomous Municipality of Vega Alta [6] was prepared and adopted on 22 May 2012, following the provisions of 44 CFR Parts 201 and 206 and in compliance with the “Disaster Mitigation Act” of the year 2000. As of May 2019, the Plan is being revised by the Municipal Review Committee with the assistance of the Central Office for Recovery, Reconstruction and Resilience (COR3), ATKINS Global® and EcoStahlia Environmental Consultants, LLC [7]. The plan outlines that once the revision is completed, the local government will issue an Executive Order adopting the new mitigation actions to be implemented. After the plan is adopted, it will be sent to the Regional Director of FEMA, with the concurrence of the Agency for Emergency Management and Disaster Management of the Commonwealth of Puerto Rico (AEME) for final approval.

4 METHODOLOGY

During a three month period, a series of workshops and public meetings were organized with the assistance of the Municipal Government of Vega Alta, the Central Office for Recovery, Reconstruction and Resilience (COR3), ATKINS Global® and EcoStahlia Environmental Consultants, LLC. Power Point® presentations, and tables based on the STAPLEE process were used to collect specific information on how a proposed action met the communities’ needs. After each presentation, question and answer sessions were recorded to allow the attendees to classify the proposed actions as high, medium or low priority. Responses were annotated for further analysis. Each proposed mitigation project was evaluated following the STAPLEE criteria. The actions were considered for natural and man-made hazards including coastal erosion, hurricanes, droughts, landslides, fires, flooding, and climate change. The process provided stakeholders with different levels of knowledge of the issues the opportunity to offer facts in order to minimize bias; for example, photos of flooded areas. Also, responses to the information and questions from the staff were used to obtain data that was used to prepare maps to educate others of specific hazards or changes within their areas. The STAPLEE methodology, using the relative-rating method (high, medium and low priority), provided the grounds to select the most important mitigation strategies to be implemented in Vega Alta. Feedback was obtained from members of the Municipal Review Committee as well as from residents of the eight wards of the City of Vega Alta (Fig. 4). The results from the committee members were compared with those obtained from public meetings to adjust any difference or to propose new strategies based on the needs identified by residents for a specific area. Variables like time, cost vs. benefits ratio, potential support from the state or federal agencies as well as complexity of the proposed actions were analyzed to obtain a priority list with projects aimed to be completed in a five-year period. In order to allow more residents to comment on the proposed mitigation strategies, the draft document was made available by having a hard copy located in the town’s public library. An email address was offered to receive any comments from residents of Vega Alta or neighboring towns (Fig. 5).

5 RESULTS AND DISCUSSION

According to the Federal Emergency Management Agency, any proposed mitigation strategy shall include a section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure (Requirement §201.6(c)(3)(ii) [8], [9]. The plan shall include a mitigation strategy that provides the



Worksheet #4 Evaluate Alternative Mitigation Actions step 2

1. Fill in the goal and its corresponding objective. Use a separate worksheet for each objective. The considerations under each criterion are suggested ones to use; you can revise these to reflect your own considerations (see Table 2-1).

2. Fill in the alternative actions that address the specific objectives the planning team identified in Worksheet #1.

3. **Scoring:** For each consideration, indicate a plus (+) for favorable, and a negative (-) for less favorable.

When you complete the scoring, negatives will indicate gaps or shortcomings in the particular action, which can be noted in the Comments section. For considerations that do not apply, fill in N/A for not applicable. Only leave a blank if you do not know an answer. In this case, make a note in the Comments section of the "expert" or source to consult to help you evaluate the criterion.

Goal: _____
 Objective: _____

STAPLEE Criteria	S (Social)	T (Technical)	A (Administrative)	P (Political)	L (Legal)	E (Economic)	E (Environmental)
Considerations for Alternative Actions	Community Acceptance Effect on Segment of Population	Technical Feasibility Long-term Solution Secondary Impacts	Staffing Funding Allocated Maintenance/Operators	Political Support Local Champion	State Authority Existing Local Authority Potential Legal Challenge	Benefit of Action Cost of Action Contributes to Local Goals Outside Funding Required	Effect on Land/Water Effect on Endangered Species Effect on HAZMAT/Waste Sites Consistent with Environmental Goals Consistent with Federal Laws

Figure 4: STAPLEE criteria worksheet template.



Figure 5: Description of the public comments process for the Vega Alta Multi-Hazard Plan.

jurisdiction's blueprint for reducing potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools. Thirty residents participated in the public meetings. The review committee did not receive comments or questions by email. During the discussion process 24 mitigation actions were proposed by the Municipal Review Committee, and stakeholders for adoption. Some of the proposed mitigation actions included retaining walls, raising road levels, and improving stormwater drainage structures. These projects covered flooding, coastal erosion due to climate change, coastal flooding due to tsunamis and hurricanes, and landslides. Mitigation strategies also included public education, property protection, non-structural projects like watershed protection plans, retrofitting emergency buildings and existing infrastructure maintenance. As examples, structural projects included installing better drainage systems to manage storm waters at downtown Vega Alta, and non-structural projects included the development of watershed management plans to protect the Honda Creek which crosses the center of the city. Based on federal guidelines, the criteria to establish the most important projects included location of the proposed action, hazard to be mitigated, priority, lead agency, funding source, completion date, and status as of 2019 (Fig. 6). With the assistance from two contractors (Atkins Global and EcoStahlia), the Municipal Mitigation Review Committee proceeded to analyze the proposed actions taking into consideration the STAPLEE criteria for the establishment of viability. As part of the analysis, the committee compared the location of critical infrastructure and how it was going to be protected by the proposed mitigation action. For both, the federal, and state governments, critical infrastructure includes hospitals, police and fire departments, power generation plants, sewer treatment facilities, and potable water plants.

During the discussion, the stakeholders brought their concerns for potential impacts to community integrity, and permanent disruption of daily activities. Many residents asked



Figure 6: Staff of the Municipal Review Committee assessing some of the proposed actions.

questions regarding the availability of funds considering the financial struggle Puerto Rico currently faces with PROMESA [10]. A recurrent element in the analysis was the commitment by both the state and federal governments to allocate the necessary funds to specific mitigation strategies as the costs of implementing the plan will exceed the \$80 million dollars. An example of a proposed action includes the elevation of 2 km of the state road #647 estimated in approximately \$4 million dollars. Residents understand that the local government has limited resources and depend on external financial support to implement the more complex mitigation strategies. Nevertheless, most stakeholders were fully aware of the need for strategies aimed to keep hazard problems from getting worse. In the municipality of Vega Alta, flooding and landslides are considered major hazards for thousands of residents due to the existence of many surface water bodies, including the Cibuco River and Quebrada Honda, both prone to major flooding during tropical storms and hurricanes. Compared to previous plans, the 2019 revision includes non-structural mitigation strategies including the design of landscape projects instead of concrete channels or levees to minimize the impact to water bodies.

The updated plan also includes public education and awareness activities that are used to advise residents, elected officials, business owners, potential property buyers, and visitors about hazards, hazardous areas, and mitigation techniques they can use to protect themselves and their property. Public campaigns to encourage the acquisition of flood insurance by local residents were included in the plan. Although public education and outreach strategies may not result in a quantifiable reduction of damages, there is a relationship for the probable future and the cost of each measure that were considered when mitigation actions were planned. Once the plan is adopted by the municipality, the use of decision-making tools like the Analytic-Hierarchy Process (AHP) may help the community deal with the complex decision process of implementing these strategies (Table 1) [11].

6 CONCLUSIONS

Although local capability for mitigation can vary significantly between communities, developing and implementing a sound Multi-Hazard Mitigation Plan provides as described in Section 5, a great opportunity to establish policies and performance standards that address identified hazards. Also, according to the authors, establishes the base for more resilient communities capable of recovering after major natural hazards events (Fig. 7). In the development of multi-jurisdictional hazard mitigation plans, local governments with limited capacity or capability may use the planning process to develop cooperative agreements, mutual aid agreements, or service agreements that enhance their capacity to undertake mitigation activities. The Municipal Government of Vega Alta, Puerto Rico supported by the Central Recovery and Reconstruction Office of Puerto Rico (COR3), ATKINS Global® and EcoStahlia Environmental Consultants, LLC, updated their 2012 Multi-Hazard Mitigation Plan using FEMA's STAPLEE criteria as one of the methodologies to identify potential mitigation strategies to address natural hazards in a five-year period. Although a low participation from the communities was observed, the planning process identified valuable information as well as complex challenges for three key stakeholders; local, state, and federal government. New approaches to address natural hazards like flooding, climate change, and coastal erosion were presented by different members of the community, offering opportunities to foster resilience without compromising the economy and the environment. However, the forecast from the Center for a New Economy points to a complex economic future presenting a major challenge to local, state, and federal administrators to identify the necessary financial resources to implement many of the actions presented in the plan [12].



Table 1: Example of table prepared by the Municipal Committee describing proposed mitigation actions.

Category	Sector Strategy/activity	Hazard	Priority	Lead agency	Funding source	Completion date	2019 status
Proposed mitigation actions							
P-1	Cerro Gordo Debris removal from the creek bordering Cerro Gordo Community	Flooding and pollution	High	DRNA OPM MAVA	State and Federal	2024	Partial debris removal has been completed
P-2	Highway PR2 Maintenance to the storm water system	Flooding	High	DTOP-AC OPM del MAVA	State and Federal	Continuous	On-going effort by MAVA without support from state government
P-3	Santa Ana Community H-H study to determine water flow impacting road	Flooding	Medium	OPM MAVA	Municipal	2024	Has not started
P-4	Urb. Extensión Santa Ana Increase road elevation to control flood level	This approach is too expensive and the inconveniences to residents was considered a major issue. The flooding problems in the community have been associated with the lack of maintenance to the Honda Creek and potential storm water discharges from the San Juan Cement Processing Plant.					
P-5	Morán Community, and Breñas Sink holes improvement and clearing	Flooding	Medium	DRNA-OPM MAVA	State and Municipal	2024	Has not started



Figure 7: In some parts of the island, winds from Hurricane María destroyed concrete structures entirely.

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