Empowering Communities by Optimizing the Deployment of Neighborhood-scale Resilience Hubs: A Case Study of Maui Island

Alexander de Roode, KTH Royal Institute of Technology, Sweden
Ivo Martinac, KTH Royal Institute of Technology, Sweden

The IAFOR International Conference on Sustainability, Energy & the Environment
Hawaii 2020
Official Conference Proceedings

Abstract
As a part of an integrated planning approach to develop programs intended to support communities increasingly facing impacts of natural disasters, including those associated with climate change, neighborhoods must strengthen their local community cohesion and resilience. One way to support neighborhood-scale resilience is to create recognized and accepted local resilience hubs. These hubs are physical spaces intended to serve as a community resource during normal non-emergency periods, while also having the ability to serve as backup emergency shelters and emergency recovery hubs during and immediately following emergency events, such as natural disasters. Critical services are integrated into such resilience hubs, including back-up power supply, potable water, telecommunications, medical resources, and food provisions as complements to other support systems. This paper provides a case study of how resilience hub sites are selected and enhanced for resiliency using bottom-up community engagement methods coupled with technical resilient power feasibility studies. This methodology results in the creation of resilience hubs that are accepted, trusted and stewarded by neighborhood residents, while meeting specified community needs. The community engagement process in this study informed resilient power feasibility analyses of three targeted sites on the Island of Maui. Communities who implement this approach will increase their resilience, including their community cohesion. This study is intended to inform related research exploring how a distributed network of resilience hubs can serve as a critical component of resilient island and remote communities, which face increasing and disproportionate vulnerability to disaster impacts resulting from climate change.

Keywords: resilience hubs, resiliency, community cohesion, community engagement, natural disasters, climate change, adaptation, islands

Introduction

In general, small islands are disproportionately vulnerable and negatively impacted by the effects of shocks and stressors, including those associated with climate change (Nurse et al, 2014). This includes increased vulnerability to impacts from phenomena such as: sea level rise, increased frequency and severity of high wind events and rain storms (including hurricanes and tropical storms), wildfires exacerbated by drought conditions, inland flooding (e.g. riverine flooding) resulting from high intensity rain events, and coastal flooding associated with extreme high tides (e.g. king tides). As such, in small island communities, the development and implementation of community-based climate change adaptation measures coupled with disaster risk reduction efforts can have comparatively larger positive impacts than they would when applied to less vulnerable communities (Nurse et al, 2014). Economic sectors particularly vulnerable to the impacts of climate change include agriculture and tourism. In addition, critical "life sustaining" resources, such as fresh water supply and fisheries, can be compromised by climate change impacts such as salt water incursion into fresh water basal lenses and nearshore coral reef decline or die-off (Hay et al, 1995). A compounding effect that adds to the increased vulnerability of island communities is that, given their limited resource base and size and their relative isolation and dependency on imported resources, many residents (including those with higher levels of education and technical skills) choose to relocate to areas that offer more economic and social opportunities often coupled with a lower cost of living. This results in a phenomenon colloquially referred to as the "brain drain", wherby knowledge and technical expertise is continually lost from the region and substituted by temporary outside expertise that is expensive and often ill equipped to address the local customs and constraints of island communities (Hay et al, 1995).

In order to mitigate the aforementioned impacts of climate change and to strengthen the adaptive capacity of their communities, islands can pursue community-based and locally driven initiatives that enhance community resilience. Although several definitions of resilience exist in scientific literature, this article refers to resilience as defined by the Urban Sustainability Directors' Network (USDN) to mean "the ability of communities to anticipate, accommodate, and positively adapt to or thrive amidst changing climate conditions or hazard events and enhance quality of life, reliable systems, economic vitality, and conservation of resources for present and future generations" (USDN 2019).

One way that island communities can enhance their resilience is to develop networks of resilience hubs throughout their neighborhoods. According to the Urban Sustainability Directors' Network (USDN), resilience hubs are building structures and their associated grounds that provide services to local communities to support and enhance the quality of life of its residents (USDN 2019b). This includes the provision of services such as:

- assisting in the equitable access to and distribution of resources to the community (i.e. both physical/material-based and knowledge/information-based resources);
- facilitating communication (e.g. emergency and non-emergency telecommunication, internet access/connectivity, and emergency and non-emergency informational bulletins and advisories);

- providing low carbon or carbon neutral services that mitigate greenhouse gas emissions; and
- delivering carbon sequestration services (e.g. tree planting, regenerative community-based agriculture, aerobic composting, etc.).

Several different types of community oriented facilities can lend themselves to serving as resilience hubs. These include community centers, faith based and non-faith based non-profit organizations, and recreation, arts or cultural centers.

Methodology

The island of Maui is located in the remote Hawaiian archipelago in the middle of the Pacific Ocean, approximately 2,500 miles from the nearest continental land mass. Maui island is a part of Maui County, which is comprised of the islands of Maui, Moloka‘i, Lāna‘i, and Kaho‘olawe. Due to its remoteness, isolation, and high level of dependence on imported resources and tourism, the island of Maui is highly vulnerable to the impacts of climate change and natural disasters. The island of Maui is therefore well positioned to significantly benefit from climate adaptation and resiliency measures. Having been exposed to the concept of resilience hubs through its membership in the USDN, the County of Maui initiated an effort in 2019 to develop a resilience hub network throughout its County.

As a starting point, the local County of Maui government engaged the local community using a variety of engagement methods in order to inform its residents of the concept of resiliency and resilience hubs, as well as to solicit feedback from community stakeholders to serve as a basis for the launch of a pilot phase for developing a resilience hub network across its community. The community engagement methods were informed in part by recommendations from USDN based on its resilience hub work with other communities within the State of Hawaii and throughout North America. Additionally, community engagement methods were shaped to meet the cultural context of Maui, which is often more informal and less rigidly structured than in many other North American communities.

The community groups targeted for engagement included County of Maui officials serving across various critical departments of the County of Maui organization, including: the Office of the Mayor, the Office of Economic Development, the Department of Planning, the Department of Housing and Human Concerns, The Department of Parks & Recreation, the Office of Management, the Department of Water Supply, the Department of Environmental Management, the Department of Transportation, the Department of Public Works, the Maui Emergency Management Agency, and the Maui County Council. Participants from community groups outside of the County of Maui organization included State House Representatives, natural resource conservation respresentatives, community disaster preparedness and response organizers, local electric utility representatives, private sector representatives, non-profit sector representatives, university faculty, administrators and students, and other interested non-affiliated residents.

One of the engagement methods used was to organize and hold a training workshop session based on the USDN’s Game of Extremes methodology (USDN 2020). This training exposes participants to some of the primary decision making processes involved in addressing natural disasters. By having participants role play in roles other than their typical role in the community, participants are exposed to the difficulty of trade offs in decision making that are associated with representing different constituents than they typically do and trying to address multiple hazards and community needs with limited available resources. Participants are asked to conduct hazard vulnerability and risk assessments for a mock scenario that includes hazard events such as riverine and coastal flooding, and to then suggest climate adapation measures intended to address these hazard risks and vulnerabilities within a limited budget and under a time constraint. This training allows participants to be exposed to community planning, resource equity, and climate adaptation concepts, while providing an opportunity to view these issues from a fresh and different perspective than their own.

Having been exposed to climate resilience and community planning concepts through their participation in the USDN Game of Extremes training, the same stakeholders were invited to participate in a subsequent resilience hub workshop facilitated by USDN and County of Maui resilience and sustainability staff. During this workshop, participants were exposed to the definition of resilience hubs and to basic characteristics that resilience hubs should have. Participants were then asked to describe the attributes they would like to see in a future resilience hub within their own communities and neighborhoods. Participants were asked to categorize these attributes into three separate categories: attributes desired in a basic resilience hub, attributes desired in an enhanced resilience hub, and attributes desired in an ideal/optimized resilience hub. This categorization allows for attributes to be prioritized and assessed for feasibility based on budgetary, technical and other possible constraints. Participants were then asked to identify specific sites in their communities that they perceive as strong candidates to serve as resilience hubs. The facilitators encouraged participants to consider hazard vulnerability and risk, as well as equity, and building structure and programmatic aspects of proposed sites. For example, an infrequently used site that would be vulnerable to coastal or riverine flooding and would not provide equitable access or community services, in addition to needing major structural repairs or improvements, would not be considered a strong candidate to serve as a resilience hub. Conversly, a trusted site with a building in good structural condition located outside of natural hazard zones that is readily accessible by all members of the community and offers critical community services, would be considered a strong candidate to serve as a resilience hub. The final component of the resilience hub training consisted of identifying proposed sites on a map and then sharing with participants various online resources to assist in assessing each site for hazard vulnerability. These online resources included visual GIS mapping tools and reports to help assess hazard risks from tsunamis (NOAA 2019b), wildfires (HWMO 2019), sea level rise (NOAA 2019, PacIOOS 2019), and riverine/inland and coastal flooding (FEMA 2017, PacIOOS 2019).

Results

The following tables describe the results collected from participants who attended the resilience hubs workshops. These include results for basic desired attributes, enhanced desired attributes, ideal desired attributes, and proposed sites to be considered as candidates for establishing community resilience hubs. The desired attributes are also categorized by operating mode or condition to describe the desired attributes during normal conditions, disaster response conditions, and disaster recovery conditions.

	Normal Mode	Disruption/Response Mode	Recovery Mode
Basic	Connectivity of resilience hub site with nearby neighborhoods	Site as location or zone for distribution of critical/emergency resources	Proactive pre-established contracts for critical services (e.g. sanitation plans, debris plans, dumpsters, staging)
Basic	Programming (classes; basic trainings based on community interest and need)	Backup battery storage coupled with backup power generation	Availability of Very High Frequency (VHF) Radio
Basic	VHF, Cell Phone, telecommunications infrastructure and equipment	Solar charging stations for charging devices	Critical equipment is dedicated to the site and stays in the area rather than mobile units that are not always available
Basic	Charging stations for plug load devices (e.g. smart phone, laptop, etc.)	VHF Radio	Charging stations for plug load devices (e.g. smart phone, laptop, etc.)
Basic	Public restrooms	Spare clothing and toiletries	Trauma recovery support (PTSD, etc.)
Basic	Has an existing waste management system in place	Emergency sheltering capacity	-
Basic	Water fountain, Water bottle refill station, purified water availability	Childcare services	Childcare services
Basic	Hybrid energy systems that can also provide economic benefit during normal conditions	Purified water	-
Basic	One stop wellness (basic), spectrum of wellness offerings	Meals Ready to Eat (MRE) - locally sourced	-
Basic	Shipping container for storage and shelter	Comfort and Support (e.g. mental health counseling)	-
Basic	Storage room	Temperature regulated (cooling, heating, shading)	-
Basic	Refrigerator/cold storage	-	-

Table 1: Results from resilience hubs workshops for basic desired atrributes.

	Normal Mode	**Disruption/Response Mode**	**Recovery Mode**
Enhanced	Programming (1st Aid and CPR, other educational training, staff training for mental health and wellness)	Childcare + support	Contracts with tree trimming companies to assist with tree debris removal
Enhanced	One stop wellness (advanced: health care, proactive trauma)	Locally produced food delivered then stored on site	Location to bring all types of debris
Enhanced	Childcare on-site + children's activities	Commercial kitchen	-
Enhanced	Food generation on-site or around site	Dry + chilled food storage and other resources storage	-
Enhanced	Composting toilets	Solar dehydrating systems for food	-
Enhanced	Showers + toilets	Facility size drives sheltering capacity	-
Enhanced	Minimizing waste program	Purified water fountains and bottle refill stations	-
Enhanced	On-site composting	-	-
Enhanced	Storage for dry goods and refrigerated goods (chill)	-	-
Enhanced	Energy Microgrid and grid services options	-	-
Enhanced	Purified water	-	-

Table 2: Results from resilience hubs workshops for enhanced desired attributes.

	Normal Mode	Disruption/Response Mode	Recovery Mode
Ideal	Programming (skills training, education, jobs training, university/college connection)	Healthy, local food grown on-site	Uses for or from debris
Ideal	Health, Dental, Mental health, Trauma	Commercial kitchen	Massage and acupuncture for recovery
Ideal	Child care + programming	Excess food dehydrated and stored	-
Ideal	Community gets food from on-site year round	High tech water systems (water storage/supply; water treatment; wastewater treatment; stormwater management)	-
Ideal	Bathrooms + showers + greywater reuse	-	-
Ideal	Community solar benefits (CBRE)	-	-
Ideal	Microgrid with backup power generation for XX days (14+ days)	-	-
Ideal	Waterless toilets	-	-
Ideal	Zero-waste facility with reuse and composting (integrated waste management)	-	-
Ideal	Affordable housing and temporary housing	-	-

Table 3: Results from resilience hubs workshops for ideal desired attributes.

Molokai Community Center (Molokai)
Koele Lodge (Lanai)
Manele Hotel (Lanai)
Community Gym (Lanai)
Lahaina Civic Center
Velma McWayne Santos Community Center
UH Maui College
Haiku Cannery
Haiku Community Center
Pukalani Community Center
Keokea Community Center
Kula Hospital
North Kihei Technology Park
Kihei Charter School
Kihei High School
Kaupo Community Center
Camp Keanae
Hana Community Center
Hana Ranch
Kipahulu Community Center
Puu Kukui by Kahakuloa

Table 4: Results from resilience hubs workshops of proposed sites by participants.

Discussion and Conclusions

The development of a network of resilience hubs throughout local communities and neighborhoods of Maui County is a climate adaptation and community resilience strategy with the potential to significantly reduce natural hazard risk and vulnerability, while at the same time furthering community equity and social cohesion. This includes providing critical community services to help alleviate on-going stressors (e.g. poverty, crime, health risks, homelessness, etc.) faced by residents of Maui County during normal periods, and mitigating future shocks (e.g. hurricanes, tsunamis, wildfires, etc.) the community may face during disaster events. As a part of launching a pilot phase for the development of a resilience hub network for Maui County, the County of Maui selected three sites across the island of Maui intended to serve as use cases and testing sites to inform future expansion of the proposed resilience hub network. All three sites were identified by particpants of the resilience hubs workshops as viable candidates to serve as resilience hubs. In order to facilitate access to information and data (e.g. building plans, utility data, etc.) for the three pilot sites as well as being able to easily gain entry into the buildings and grounds of the proposed sites, the County of Maui selected three County owned community centers located on the island of Maui. These are: the Velma McWayne Santos Community Center located in Wailuku, the Lahaina Civic Center located in west Maui, and the Hana Community Center located in east Maui.

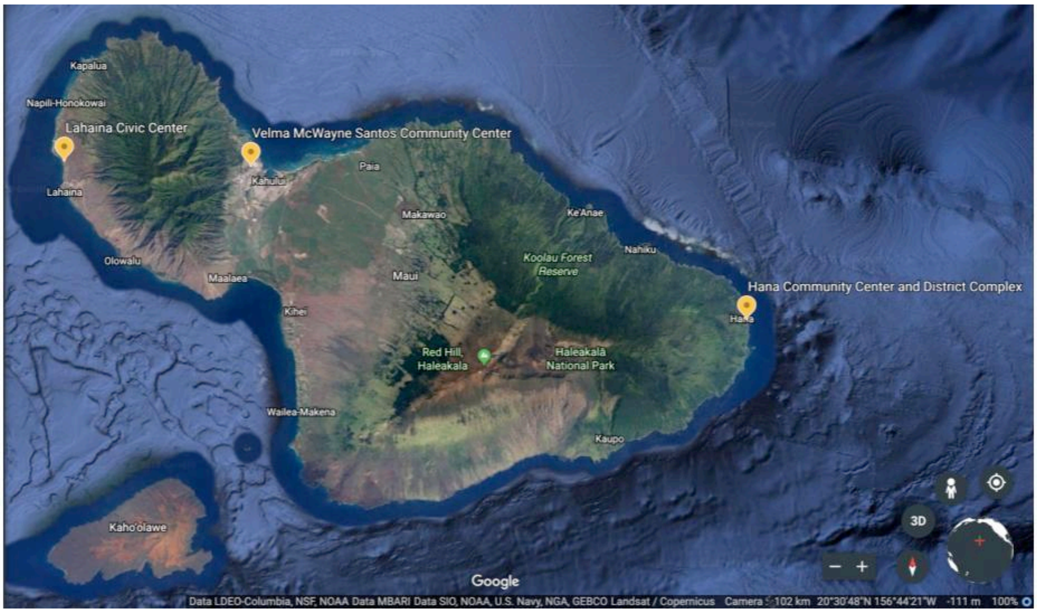

Figure 1: Resilience hub pilot sites selected by the County of Maui.

In addition to being geographically dispersed throughout the island of Maui, each of these sites offers a unique use case. The Velma McWayne Santos Community Center offers an urban high population density use case given its location in the heart of Wailuku close to local government, business and industrial centers, as well as serving many nearby multi-family and single family residential units. The Lahaina Civic Center offers a use case that serves a significant suburban resident population as well as a large visitor population due to its proximity to nearby resorts and the tourism destination of Lahaina Town. Additionally, this site is adjacent to nearby Hawaiian Homelands that are home to a large Native Hawaiian population. The site also includes first responder police and fire stations. Finally, the Hana Community Center provides a rural use case located in the remote community of Hana on Maui's east side. This community is isolated from the population centers and primary service centers of Maui, as well as being home to a large Native Hawaiian population and many homesteaders. Communities looking to pilot resilience hub sites are encouraged to use a similar approach for the selection of pilot sites, so as to disperse the pilot sites geographically and test various use cases relevant for their community context.

Currently, the County of Maui is in the process of conducting resilient power feasibility studies for each of the selected pilot sites. This will allow the sites to have power systems designed to optimize resilience during disaster response and recovery periods, by providing backup power to the sites' critical power loads. In addition, these power systems will be designed to provide optimized financial benefits during normal periods. This includes providing the sites with the ability to participate in revenue generating or cost savings electrical grid services programs (e.g. time of use, demand response, etc.), as well as providing these sites with the ability to power equipment for revenue generating activities (e.g. commercial kitchens, equipment repair, refrigeration, etc.).

The resilient power feasibility studies are being conducted in partnership with the Clean Energy Group and American Microgrid Solutions. This methodology includes data collection and analysis of the following parameters:

- Data collection (e.g. energy, electrical plans, capital improvement plans, etc.)
- Conduct site audits (e.g. energy audits to assess power demand and energy efficiency and energy conservation opprotunities; renewable energy deployment potential analysis; assess current baseline condition of facility; etc.)
- Develop power load profiles (i.e. model time of use with occupancy and programming/activities)
- Reduction of peak power loads to reduce demand charges and backup system size requirements
- Analyze utility rates to input into financial analysis and assess opportunities for rate reductions
- Analyze utility rates and associated charges
- Evaluate energy incentives (including energy efficiency rebated and renewable energy tax credit opportunities)
- Assess emerging incentive structures (e.g. ability to participate in demand response or time of use programs)
- Assess rate escalation potential over time
- Assess electric and other energy meters and develop optimized solutions (e.g. submetering)
- Model proposed solutions
- Conduct a technical and economic feasibility analysis
- Compare modeled system performance with actual real world system performance (i.e. groundtruthing)
- Optimize power system resilience based on site hazard vulnerability and risk assessment

As described by the Clean Energy Group (Clean Energy Group 2014) and American Microgrid Solutions, this resilient power feasibility study methodology provides users with a "spectrum of resilient power options" that can accommodate various budgets, regulatory environments and site conditions. Users are able to weigh the benefits of increased resilience during power outages against the social, environmental, and financial/economic benefits provided by resilient power systems during normal operating conditions. One end of this resilient power spectrum could be a power system that does not provide inherent economic or social benefits during normal operating conditions, while providing highly reliable and extended backup to critical loads during power outages. On the other end of the resilient power spectrum, a power system could provide net zero energy for a site during normal conditions by completely offsetting any grid purchased power, while not providing reliable backup power during power outages. As described by the USDN (USDN 2019c), a hybrid resilient system is the optimal power system for most resilience hub applications. In addition to being connected to the existing electrical utility grid when avaibale, hybrid resilient power systems combine both renewable power generation (e.g. photovoltaic system) and conventional power generation technologies (e.g. diesel backup generator that could be operated using biodiesel fuel), while also providing energy storage technologies (e.g. lithium-ion battery storage system). This suite of power generation and storage technologies, coupled with grid interactive charge controllers and inverters, allows for an optimal balance between power resiliency and economic viability.

With increasing climate change associated threats being faced by island communities and by many other parts of the world, developing locally driven resilience hubs networks is an adaptation and resiliency measure that can yield significant benefits to such communities. These include benefits to communities during normal periods as well as during disaster response and recovery periods. Communities interested in pursuing resilience hub initiaitives can benefit from the community training and engagement methodologies developed and promoted by the USDN that are described in this article, and adapting them to their local contexts. Future research will provide additional technical analysis of power and building structural systems, as well as findings from the current resilience hubs pilot program underway in Maui County and its associated resilient power feasibility studies described in this article.

Acknowledgements

The authors would like to recognize the important contributions of the Urban Sustainability Directors Network (USDN) in informing this research. In particular, the work of USDN Chief Resilience Officer Kristen Baja significantly informed the foundation of this research effort and the methodologies used. In addition, input from the Clean Energy Group, American Microgrid Solutions, the County of Maui and the University of Hawaii all contributed significantly to informing this research.

References

Clean Energy Group. (2014). Evolution of a New Clean Energy Strategy to Meet Severe Weather Threats. Accessed January 9, 2020 https://www.cleanegroup.org/ceg-resources/resource/resilient-power-evolution-of-a-new-clean-energy-strategy-to-meet-severe-weather-threats/

Federal Emergency Management Agency (FEMA). (2017). Flood Map Service Center Accessed January 9, 2020 https://msc.fema.gov/portal/home

Hay, J., Kaluwin, C., & Koop, N. (1995). Implications of climate change and sealevel rise for small island nations of the south pacific: a regional synthesis. *Weather and Climate, 15*(2), 5-20. Retrieved February 9, 2020, from www.jstor.org/stable/44280015

HWMO. (2019). A Collaborative, Landscape-Level Approach to Reduce Wildfire Hazard Across Hawai'i 2018-19 Vegetation Management Rapid Mapping Assessment and Collaborative Action Planning Maui Report. Accessed January 9, 2020 https://www.hawaiiwildfire.org/s/Maui_compressed.pdf

NOAA. (2019). Sea Level Rise Viewer National Oceanic and Atmospheric Administration, Office for Coastal Management. Accessed January 9, 2020 https://coast.noaa.gov/slr/#

NOAA. (2019b). Tsunami Aware National Oceanic and Atmospheric Administration, Office for Coastal Management. Accessed January 9, 2020 https://tsunami.coast.noaa.gov/#/

PacIOOS. (2019). Pacific Islands Ocean Observing System Hawaii Sea Level Rise Viewer. Accessed January 9, 2020 http://www.pacioos.hawaii.edu/shoreline/slr-hawaii/

Nurse, L.A., R.F. McLean, J. Agard, L.P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E. Tompkins, and A. Webb. (2014). *Small islands*. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on ClimateChange[Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi,Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White(eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1613-1654. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap29_FINAL.pdf

Urban Sustainability Directors Network (USDN). (2019). *Resilience Hubs. Shifting Power to Communities and Increasing Community Capacity.* Accessed January 8, 2020 http://resilience-hub.org/wp-content/uploads/2019/07/USDN_ResilienceHub.pdf

USDN. (2019b). *Guide to Developing Resilience Hubs.* Accessed January 8, 2020 http://resilience-hub.org/wp-content/uploads/2019/10/USDN_ResilienceHubsGuidance-1.pdf

USDN. (2019c). *Powering Community Resilience:A Framework for Optimizing Resilience Hub Power SystemsProject Report*. http://resilience-hub.org/wp-content/uploads/2019/07/USDN_ResilienceHubTech_Final.pdf

USDN. (2020). Game of extremes website. Accessed February 11, 2020. https://www.usdn.org/projects/climate-trainings.html

Contact email: deroode@hawaii.edu