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Using GIS and Remote Sensing to Map Grassroots Sustainable Development for a Small NGO in Nepal

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Abstract
Geographic information systems, through analysis and visualizations, can aid in pursuing and improving sustainable development. Thousands of Non-Governmental Organizations (NGOs) in developing countries provide a wide range of services and local organizations with fewer resources must often be more efficient to offer their services effectively. The accessibility of spatial data for assessment and, in turn, improved planning could enable these organizations to increase efficiency, thereby maximizing aid and sustainable development, as well as the number of people helped in a variety of ways. Focusing on mapping outreach and quantifying land use for a locally run NGO in Nepal, this study mapped and established a geodatabase of ongoing and completed outreach projects, as well as quantified land use using an unmanned aerial vehicle to gather high-resolution imagery at the site. The NGO, a grassroots foundation south of Kathmandu, provides workshops and funding for sustainable and empowerment projects and opportunities for learning through workshops. They were also able to provide significant disaster relief to surrounding communities following the 2015 Gorkha earthquake. We found that most programs are spatially centered near the foundation, with some programs reaching across districts. Land use at the foundation is predominantly biodynamic gardening followed by education (classrooms). We created a Story Map to share the results with the NGO and local community. The study provides baseline data for the organization that previously had none, with the goal of maximizing efficiency and ultimately increasing capacity.

Keywords
GIS, sustainable development, Nepal

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1 INTRODUCTION

1.1 Sustainable Development and GIS

Today, creating opportunities for growth in the developing world is inseparable from sustainable development. Most definitions of sustainable development include management of resources so that they last for current and future generations (see WCED 1987; Pearce and Turner 1990; Prescott-Allen 1991). Another common feature is the incorporation of the three pillars of sustainability: environmental, social, and economic, and a recognition that all three interact (EPA 2015). The use of a geographic information system (GIS) can have a wide range and high potential for applications in sustainable development with any combination of the three pillars (De Montis 2008). UN Agenda 21 identifies "improving the use of data at all stages of planning and management" as one of the most important tasks towards building sustainable development (UN Division for Sustainable Development 1992). And GIS has already been used in a wide range of sustainability development applications, as well as risk management and disaster response.

Several major aspects of GIS include data management, visualization, and analysis. Obtaining and collating spatial data in a collective geodatabase is often the first step in being able to utilize data for decision-making (Peeters et al. 2012). Further, GIS can be applied to more complex analyses and modeling (Larsson et al. 2008) for planning, monitoring, and response. Some applications of GIS in sustainable development and management include mapping changes in water usage and accessibility in urban areas in Greece (Panagopoulos et al. 2012), air pollution in an urban area (Kousa et al. 2002), wetland restoration within urban expansion in Poland (Piniewski et al. 2012), integrated coastal zone management in Belize (Mumby et al. 1995), and sustainable urban planning in Colombia and China (Bogotá Humana 2012, Wan et al. 2017). Data availability and quality, hardware, and software have all become more affordable and accessible than ever before, and therefore, the use of remote sensing (imagery) and GIS in planning is increasing (Erener 2012; De Maeyer et al. 2010).

1.2 Non-Governmental Organizations (NGO) and GIS

The increased use and application of spatial data is particularly important in sustainable humanitarian development in the developing world (Musakwa and van Niekerk 2015). However, all of the examples above are typically undertaken at the scale of a large municipality, city, or region, by organizations at the governmental, large agency, or multiple agencies scale. There are thousands of NGOs located in developing countries to provide a wide array of services. Far less research of applied GIS at the scale of a single NGO or even several small NGOs exists. Yet, local NGOs must often be more efficient to provide services successfully with far less funding. Clearly, the availability and use of spatial data for assessment and improved planning could enable small NGOs to be more effective in providing services. Visualization of the NGO's service data can increase community participation and organizational transparency, particularly in developing countries (Mollah and Nihei 2016). Furthermore, the use of GIS analysis and its visualization capabilities can help to ensure marginalized groups, including those in remote areas, are represented and specific issues or concerns are addressed and understood by the communities. The use of GIS holds the potential to ensure greater effective and inclusive engagement with local communities over development and

recovery issues occurring in their neighborhoods (Cinderby 2010). In Bangladesh the use of GIS for NGOs in the region enabled an increased understanding of the services provided and identified gaps in their allocation. Thus, the NGOs were able to prioritize which services were necessary and where to allocate them (Mollah and Nihei 2016). There are multiple ways in which GIS can improve community level results. In central Nepal, the mapping of ecosystem services for community forestry has been successful in as a management strategy to improve rural livelihoods and environmental protections (Paudyal et al. 2015) and can likely be used for other goals.

1.3 Natural Disasters and GIS

Natural disasters around the world affect, on average, more than 200 million people and displace more than 20 million people on a yearly basis (Ovesen 2016). In April of 2015, Nepal suffered two devastating earthquakes, one of which reached 7.8 on the Richter scale (Sigdel and Kafle 2015). The consideration of sustainable development in areas with natural hazards is an inherently spatial activity. GIS can therefore also be utilized to undertake different aspects of development with respect to hazards, from planning, to assessment, to response, and recovery. When incorporated into community planning, it has been shown to increase spatial thinking (NRC, 2006) and enable participants to incorporate new perspectives and therefore, find new solutions (Sieber 2006). This is particularly important with respect to addressing global problems such as poverty, disaster preparedness and relief, and climate change within a local context. This is no single solution and new ways of thinking and new perspectives are needed to solve these problems where they are occurring.

GIS has been employed in various ways over the course of 20 years of engagement in natural disasters (Tomaszewski 2015). There have been changes in the timing of the application and in technology over time. GIS is used to assist in disaster vulnerability assessment (Aryal 2012) and newer on-line capabilities have led to an Online Disaster Response Community (ODRC) that can operate short-term during a disaster (Laituri and Kodrich 2008) on a local level, in immediate response to a disaster event, and in recovery. Furthermore, advances in satellite imagery, GPS capabilities, processing, online sharing, and unmanned aerial vehicles (UAVs) have increased the accuracy and immediacy of the data as well as the accessibility for aid groups (Sieber 2006).

Long-term development and natural disaster preparedness and response should not be approached separately. Numerous recent events around the world (Sumatra, Katrina, Sandy, Japan, Nepal, Mexico, and Puerto Rico) demonstrate the need for local, geotechnical responses coupled with traditional mechanisms. Knowledge of risk is of critical importance in new development consideration and planning, as well as recovery and rebuilding. GIS mapping and analysis can increase community knowledge and therefore improve livelihoods and reduce risk (Peters-Guarin et al. 2011).

1.4 Sustainable Development, NGOs, and Natural Disasters in Nepal

Globally, the humanitarian system often remains focused more on communicating to communities, rather than creating a dialogue with them as active participants. Though, significant efforts by humanitarian actors to engage with the affected population have been undertaken (Ovesen 2016). Local NGOs have shown that an improvement in trust and common understanding can serve as the basis for *collective* problem solving (Fung Lam and Ostrom 2010). The latest data available suggests almost 40,000 NGOs are

registered with the Social Welfare Council in Nepal (SWC 2014). This created tensions within the country as the government has increasingly asserted their sovereignty over the disaster relief process (Harvey 2013).

Understanding the socio-cultural and political context in Nepal provides much needed insight into the ongoing governance and development challenges faced. Over the past six decades, Nepal has been caught in an internal struggle for peace and development (Jones et al. 2014). Commitments to respect state responsibility and to operate with the consent of the state have proved difficult for humanitarian actors to put into practice and they have tended to substitute for the state in providing aid in many settings over the past two decades (Harvey 2013). In the absence of a fully functioning government, and the growing influence of donors in Nepal and the NGOs that they support, a considerable debate within Nepal has grown (Jones et al. 2014).

As foreign donations started pouring in after the 2015 earthquake, local NGOs rushed to villages with relief. However, because the NGOs relief work was not transparent and was not being monitored, the government made an announcement that NGOs could only distribute relief through government channels. This triggered uproar and confusion (Sigdel 2015) and resulted in challenges for the government to reach out to the people in a systematic way. Across the affected districts, people were openly criticizing the government and the political party representatives for failing to help them during the disaster (Sigdel 2015). In some places it had been many years since local elections were held which meant there were no local representatives in villages and wards. After conducting interviews Sigdel (2015) found that people were greatly frustrated with the government after the disaster due to their lack of presence. Clearly, communication between local NGOs and the government is needed, and mapping the work they are undertaking one way to provide access to information on what the NGOs are doing and where it is being done.

1.5 Research Study

GIS can provide the analysis and visualizations to quantify organizational data whose goals include community development and effective humanitarian aid. Visualizing the spatial distribution and extent of NGO projects can provide an understanding of where to direct efforts and, in turn, assess how effective they are in their investments in each project. This paper focuses on mapping outreach activities and land use for a locally run NGO, the Kevin Rohan Memorial Eco-Foundation (KRMEF), located southwest of Kathmandu. We use GIS to aid in the long-term humanitarian development efforts and short-term response abilities of KRMEF. This Nepalese founded and run NGO works to sustainably improve livelihoods locally and in the greater surrounding region. Because of their existing relationships and established work, they were also able to provide immediate aid and assistance following the earthquake in 2015.

The goal of this project is multifold: 1) to create a geodatabase and map of the foundation's outreach projects; 2) to quantify the land use on the foundation's grounds, in order to provide a system whereby the organization can maintain, update, and utilize the data for assessment, decision-making, and planning purposes; and 3) to share the information. To do so, we created a presentation poster and an ESRI® Story Map of the foundation to share with the community, to show potential donors, to market to visitors, and to demonstrate to other small NGOs the concept of using GIS in action. Finally, we conclude the paper with suggestions on how to further utilize this type of information

and how to expand on it in the future both at the foundation and for other similar organizations.

2 STUDY AREA

This application of the use of GIS for community development is based on the work of the Kevin Rohan Memorial Eco-Foundation (KRMEF) located in Nepal, approximately 13 kilometers southwest of downtown Kathmandu (Figure 1). Nepal, a nearly 150,000 km^2 landlocked country of approximately 29 million people, is primarily an agriculturally based nation where approximately 25% of the population lives below the poverty line (CIA 2017). KRMEF is situated in in the village of Kharhare, with major outreach projects also in Dhading, both within the Bagmati district. The area is considered a sub-tropical, mid-hill physiographic region, with elevations ranging between 800-2400 meters (~2600-7900 feet) in elevation (Barnekow Lillesø 2005). Livelihoods are primarily based on subsistence agriculture, restaurants, and shops--including tourism (CBS 2012). The region is subject to natural hazards such as earthquakes, flooding, landslides, drought and famine (depending on the timing, intensity, and duration of the summer monsoons) (CIA 2017; DHM Nepal 2018). KRMEF, founded in 2008, has grown into a thriving center for eco-development now located on land acquired in 2015 (KRMEF 2018).

The foundation's mission includes fostering health and well-being in impoverished communities by working in cooperation with local villagers to provide services and training in eco-construction, agricultural methods, alternative energies, handicraft creation, early childhood education, medical services, and other forms of community development. It is the work of the foundation and the land use on the foundation site that is the focus of this study.

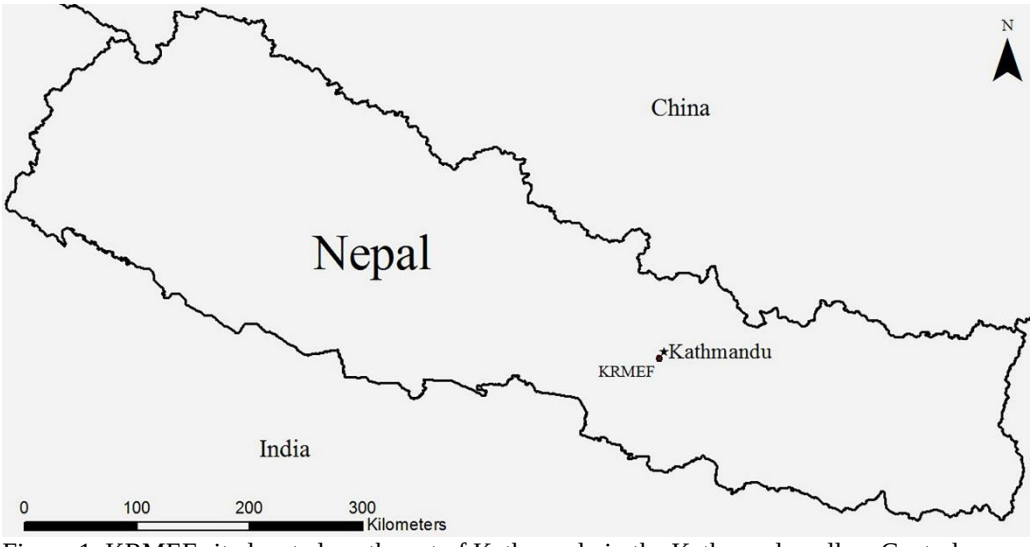

Figure 1. KRMEF site located southwest of Kathmandu in the Kathmandu valley, Central Region Nepal.

2.1 Kevin Rohan Memorial Eco Foundation Initiative Overview

The foundation currently engages with the local community through a number of initiatives. On site, there is a health clinic, school (K-2), Biodynamic farm, a Cafe, and a handicraft shop, as well as the production of organic honey, soap nut products, and biofuel. Off site, the foundation constructs bottle houses and provides trainings in several aspects of sustainable development throughout surrounding villages, as well as supports the tuition of students at their school and three local government schools. Finally, the foundation was able to provide relief and water distribution following the 2015 earthquake. Here we briefly describe each program.

A low-cost health clinic was the first program developed at the KRMEF site. Medical care is unaffordable for many villagers, so KRMEF created this program to serve the health needs of the community. A second focus was developing the Waldorf inspired educational programs, with the aim of nurturing and preparing children to serve their community in the future. There are currently 116 children attending school at the foundation and the kindergarten program includes the Khokana leprosy community, located 40 minutes away, to advocate early social development with those living in leprosy affected communities. They also added a library above the clinic for the children to use after school.

Also on site, the establishment and expansion of the biodynamic farm to grow food and share the environmentally sustainable farming methods has created a strong tie with the local community. The farm provides fresh food for Leela's Eco Cafe, which serves authentic Nepali cuisine, using eco-friendly cooking methods, while training new workers in cooking and hospitality, and helping fund the foundation projects through its proceeds. A handicraft workshop trains local women who have grown up in difficult circumstances to produce jewelry, which provides an employment program to earn a living and develop valuable technical skills. Several additional products are harvested on site and sold to fund foundation programs, such as soapnuts, whose seeds are used to make a non-toxic cleaning product and as beads for jewelry pieces at the handicraft workshop, beehives, used to harvest and sell fresh Himalayan Honey, and bio-briquettes, an easily transportable, inexpensive, biofuel made from a mixture of sawdust, shredded waste paper and cow dung.

The foundation utilizes natural building methods for many of its own structures and for the “bottle houses” built in the surrounding communities. This eco-building method uses all natural or recycled products that are locally available, including bamboo, metal, natural plaster, and glass bottles, with a cross-beam and flexible structural system in order to better withstand an earthquake including the 2015 earthquake. KRMEF also provide workshops and trainings on-site and in surrounding communities where villagers can take part in seminars to learn more about the foundation practices to implement the approach for themselves and to spread the message across their community. Furthermore, education is such a large part of the foundation’s goals that they support the tuition for 37 children at the foundation's kindergarten and in three government schools.

Finally, the foundation provided services immediately following the Gorkha earthquake in April 2015. Because KRMEF was already part of the community, they were able to quickly set up health camps and provide the distribution of clean water, shelter materials and winter clothing, aiding thousands of people in need.

2.3 Applying GIS to Foundation Projects

Much of the previous work of the foundation thus far was undertaken through word of mouth, with the majority of the knowledge and relationship-building aspects of their work falling on the founder. This is a risk for all small NGOs in that the burden of the work is more difficult to share with others and the foundation's historical data is not preserved. A geodatabase is needed to collate all the past and existing projects into one place, which can now be shared and utilized for fundraising, finding gaps in access to communities, outreach planning, and transparency. And once, created, it can be added to over time.

3 METHODS

The first objective of the project was to create a geodatabase of the data collected and to map the spatial extent of the foundation's outreach projects. To do so, we collected GPS data points at the various locations of outreach programs. Using a *Garmin GLO* (Garmin, 2018), horizontal accuracy of approximately 3 meters, and the *Map Plus* application (Miocool Inc. 2018) on an iPhone 4. While at each site, we collected specific information related to that program and the individuals receiving the aid, later included in the attribute table. The data is stored as a geodatabase (.gdb) format for ArcGIS.

We then classified each program into a specific category (Table 1), from on-the-ground observations and KRMEF staff input, and symbolized the map using these classifications. The classifications included the foundation itself, bottle house locations, health camps established both before and after the earthquake, locations where winter goods were distributed, where wells for water had been erected, the handicraft shop where the jewelry is sold in downtown Kathmandu, the leprosy colony where the soap nut beads for the jewelry workshop were made, and where they had given scholarships to students for their education when they lived too far to travel to the foundation for schooling, or after they had outgrown the program, to continue their education.

Our second objective was to quantify how the foundation land was being used. To do so, we flew a small UAV, DJI Phantom 3 Pro (DJI 2016), to capture high spatial resolution 3-band aerial imagery over the grounds, on a clear day, using a grid pattern at several elevations and nadir and off-nadir camera angles to ensure coverage of the area. We collected 16 ground control points using the *Garmin GLO* and the *Map Plus* application (horizontal accuracy ± 3.5 meters). These points were marked for the imagery using several 56 cm square brightly colored bandanas. These were deemed a reasonable and improved option for travel due to the large size of traditional 'targets' used for the control points of aerial imagery. We used Agisoft Photoscan software (Agisoft 2016) which employs Structure from Motion to create a single orthophotograph from the images. The result was an orthophotograph with 1 cm spatial resolution covering an approximately 170 meter (west-east) x 145 meter (north-south) extent. Then, we digitized and quantified land use in ArcMap 10.4 (ESRI®, 2016), a GIS software platform, classified based on the imagery and on-the-ground knowledge for the different outreach programs. The categories were determined by KRMEF staff. These were then symbolized by their associated categories (Table 2). The accuracy of the classification of the categories is based on ground-truthing and confirmation by the KRMEF staff.

Table 1. Category Classifications of Outreach Programs

Category	Program
Bottle House	Donated Eco Recycled-Bottle House Community Library Primary School
Trainings	Biodynamic Gardening Bee Keeping Waldorf Education Bottle Building
Earthquake Relief	Health Camp Sites Warm Clothing Distribution Temporary Shelter Supplies Distribution Temporary Shelter Built
Jewelry Shop	Fair Trade Handicraft Shop to support disadvantaged women
Student Scholarships	Scholarships for Secondary Education
Leprosy Colony	Partner Leprosy Community: Hired for Labor
Water Sources	Donated Water Taps: Tested clean water

Table 2. Category Classifications of Outreach Programs

Category	Program
Biodynamic Gardening	Fruit and vegetable garden
Community Outreach	Health Clinic Donated homes to teachers Seminar Hall Recycling Station Community Playground
Education	Waldorf Primary School* (Pre-Kindergarten–Year 2)
Income Generating	Eco Café Guest House Dynamic Bottle House: Guest house Bee Hives Bio Briquette Station Bio Gas Station

*Primary school typically includes kindergarten through second or third grade. In this case, they added pre-Kindergarten and up to second grade.

Finally, we aimed to present the findings of this project so that it could be seen and accessed by others, in the form of a poster and an ESRI® Story Map on-line platform (ESRI® Story Maps 2016). We created and presented the poster at Creative Collaborations, a university wide research event, and a senior seminar at University of San Diego in San Diego, California, and at the Association of Pacific Coast Geographers annual conference in Portland, Oregon. The poster is now in the possession of the foundation for display. We chose the Story Map Cascade template because it gave an

immersive experience, putting the reader 'in' the story. The interactive map platforms and photo and video media embedded in the story allow it to be shown and not just told, while the narrative sections also allow for the story to be written. To symbolize the map, the headings of the text were displayed in the correlating color of the map.

4 RESULTS

Mapping our first objective, the spatial extent of their outreach, shows that the distribution of KRMEF's humanitarian relief and sustainable development is both centered near the foundation site location and extends well beyond the local village (Figure 2). Certain outreach programs occur more locally, particularly the Jewelry Shop and Leprosy Colony partnership, but many also extend northeastward up to 30 kilometers away, such as trainings for those who cannot attend those on-site, as well as Bottle House construction and Earthquake Relief.

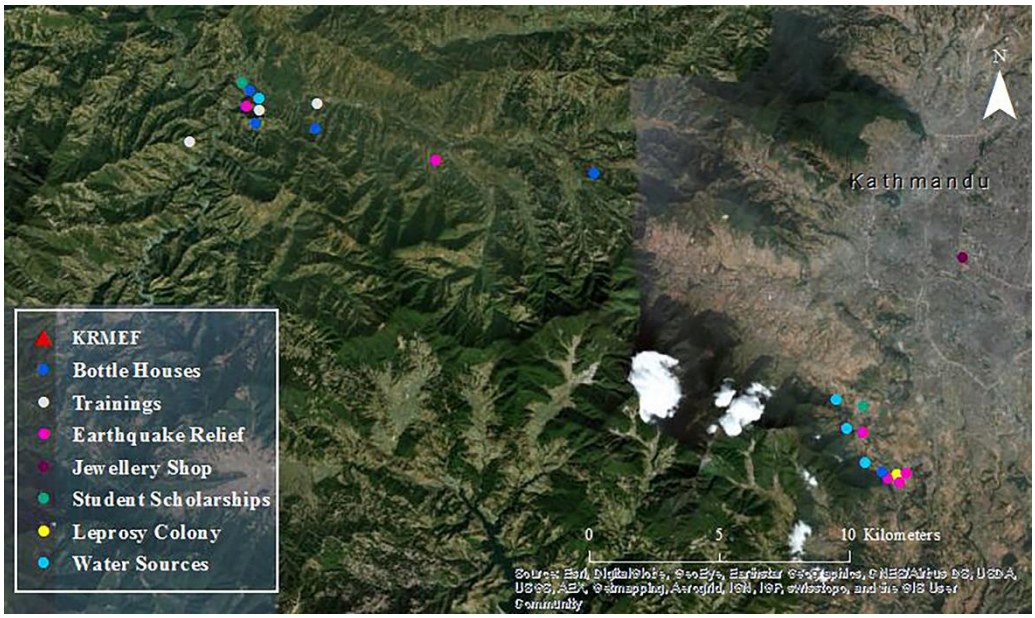

Figure 2. The spatial distribution of KRMEF's humanitarian aid and outreach programs, plotted from GPS points collected using a *Garmin GLO* (horizontal accuracy ± 3.5 meters) and the *Map Plus* application on an iPhone 4 and identified on the ground with KRMEF staff.

Our second objective, to quantify land use, identified the majority of their land area (55%) is utilized for biodynamic gardening, followed by Education (30%), Income Generating programs (10%) and Community Outreach (5%) (Figure 3). There is some overlap in the categories, as the Biodynamic farm also generates income via individual sales and through its use at the Eco Café, similarly, there are classrooms and a seminar room below the Eco Café, so we split the area to better represent the land use, based on KRMEF staff knowledge of the site usage. This highlights the work being done on the foundation grounds, while Figure 2 highlights the programs off-site, both of which consist of useful information for continued and future management and planning.

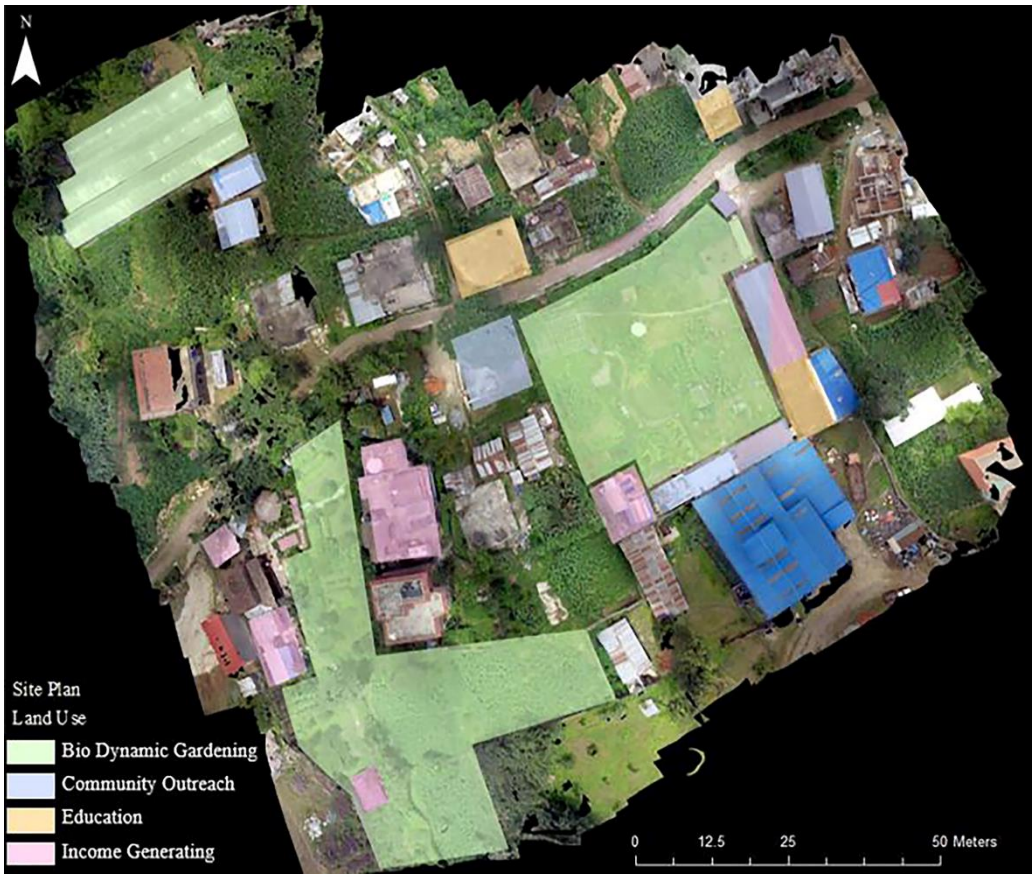

Figure 3. KRMEF Land use on site classified by outreach programs.

The poster and story map front page and link, shown below (Figures 5 and 6), have been presented in several settings to communicate both the data and the application of the methodology.

5 DISCUSSION

The process of this project and the results of the data collected, mapped, and presented for this local NGO, KRMEF, is an example of how GIS data and mapping can be utilized and expanded in the future. The geodatabase and map of the outreach projects (Figure 2) are critical to KRMEF for use in future planning, community follow-up, assessment of gaps in the communities and populations reached, and provides important information for improvement and expansion. Thus far, the foundation has used the geodatabase and map to quantify and visualize their projects in order to identify new needs and areas for future work and to organize the data on their long-term historical and current projects. For example, currently, KRMEF is working towards the creation of a satellite campus in Dhading, a severely impoverished rural area, where they began their bottle house project and recently completed a community library. Visualizing where they have focused work in the district thus far can aid as they move forward with new projects, assuring the most effective use of resources to benefit as many as possible. Similarly,

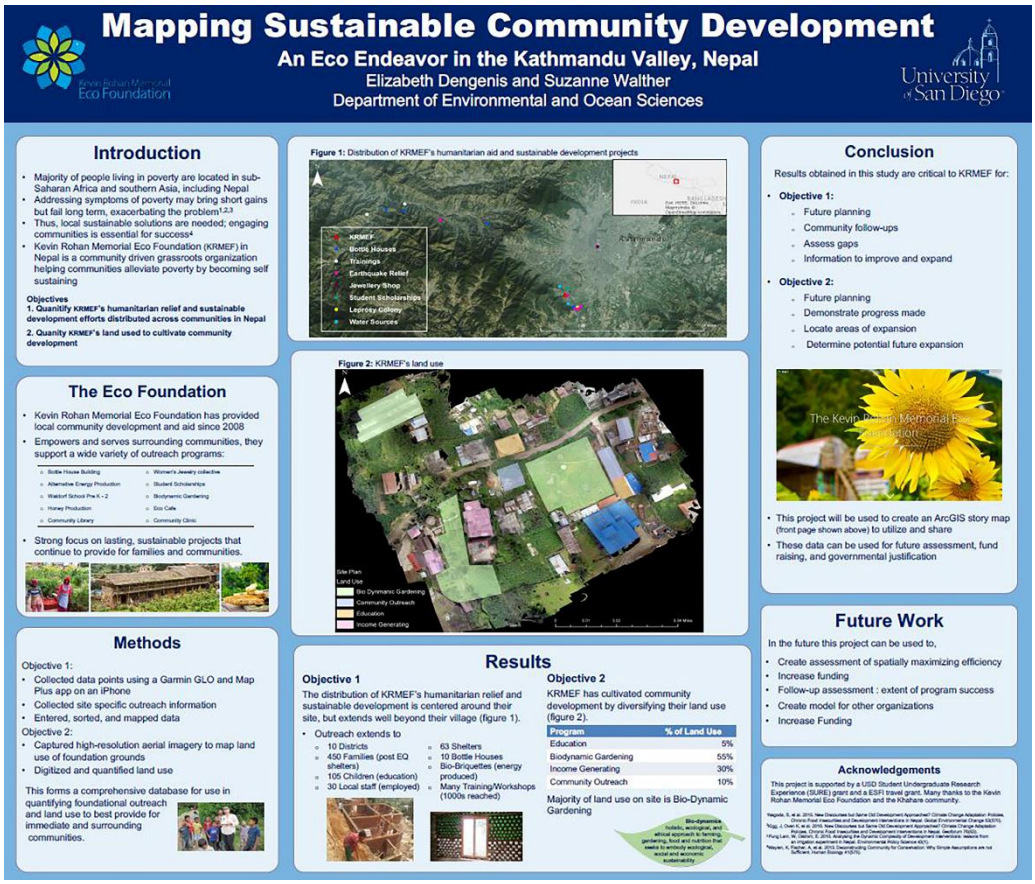

Figure 5. Poster presented in San Diego and Portland, now on display in Nepal.

Figure 6. The front page of the Story Map created of the project data for KRMEF. Link: https://www.arcgis.com/apps/Cascade/index.html?appid=4ea343ce5f48407a8b90ce8845205aa4

the spatial distribution of the different projects can help in identifying new areas to target or types of outreach for expansion in long-term planning.

Over time, KRMEF has cultivated community development by diversifying their land use on the foundation site. Figure 3, showing land use on the site, can help the foundation to make more informed decisions for future planning on land expansion and further development on the existing land area. It also enables the foundation to quantify the area of land dedicated to the different projects and the return on their investments--that is, how much of the land is dedicated to income earning projects that then ultimately support the other non-income earning projects, such as the Health Clinic, the school, etc. The aerial imagery provides a clear visual to illustrate the progress made thus far by the foundation and local community. The physical labor on the land began in 2010, and these new data allow KRMEF to highlight the work they have accomplished in six years to both the community and existing and potential donors. Additionally, the use of a small UAV is cheap, safe, relatively easy, and allows for flexibility (temporal, spatial, and spectral resolution) and is sensitive to foundation, seasonal, and community needs. It is useful in not only establishing this base data but is useful in repeated monitoring of change over time, including before and after natural disasters (Lorah et al. 2018). Thus, data can again be collected as needed in the future.

The ESRI® Story Map provides a platform to share the basic spatial data in a visual form together with a narrative of information about the foundation. It is proving to be a powerful tool in sharing information (Weiss 2016), engaging the public (Brandt 2017; Lung-Amam et al. 2017; Velkoverh 2016), developing spatial thinking skills (NRC, 2006), and understanding how to use and evaluate data (Kerski 2018). Story maps can help bring people together to improve conditions in communities (Lung-Amam et al. 2017). In this case, the story map created for KRMEF engaged input from the foundation and is "owned" by the foundation such that it can be improved upon and added to as the data, activities, and focus of the community needs and therefore, the foundation's programs, change over time.

Overall, this was KRMEF's first experience with GIS data and visualization of data via mapping and Story Maps. They found that it helped immensely to collate the data and get an overview of the sites where the foundation does developmental intervention. The data also helped visitors to see and understand the projects conducted in and around the foundation. Over all, the foundation believes that the work areas have benefited from the maps, from the main office to the many different outreach sites. Ultimately, the foundation leadership feels it can use the information to better define priorities for future planning. In particular, being able to see the collated data from all the sites has helped the foundation to plan phase-wise for the future.

Initially having very little recorded data on their work, this project has established a database for the foundation upon which to build and to assist in decision making. Nepalese NGOs must report and justify all of their spending through the national government. The database provides a foundation of records for the organization to maintain and build on in order to ease the process of governmental reporting. Moreover, while their goal is to become self-sustaining, they rely on financial donors and this kind of information demonstrates the effectiveness of their work and the distribution of their resources across the various programs. GIS applied to a local NGO working in community development and aid is a powerful tool for both increasing effectiveness of their work and potential donor contributions for future success.

Consideration of how humanitarian response either reinforces or undermines the self-recovery of communities deserves special attention; focusing on needs alone may

not be enough (Ovesen 2016). After assessing what the community believed to be their biggest struggle, KRMEF established a health clinic to gain the trust of the people with whom they hoped to engage and work amongst. Once that trust was gained, when the organization moved forward the village knew that they could benefit from the success of this foundation. With the community behind the foundation, they were able to seamlessly integrate into the community. There is no distinction between what the foundation does for itself and what it does for the community. By working with the structures in place and alongside the community from the inside, and by enhancing current systems, the foundation has had great success.

Too often when development aid is focused in a community they replace the existing systems with systems that are new and 'better', which leaves the village reliant on the outside community to provide further assistance (Fung Lam and Ostrom 2010). Instead, to aid in community recovery, interventions should focus on initiatives such as educational support for people with an emphasis on children, especially those with disabilities, who have limited opportunities for jobs, common in rural Nepal. Providing educational opportunities and support can enable people to contribute to society—financially, socially, and politically (Landry et al. 2016). These educational opportunities can come in the form of trainings; trainings offer a transfer of knowledge and experience that allow long term, improved outcomes, especially in rural villages (Fung Lam and Ostrom 2010). Understanding this, KRMEF has incorporated free community trainings in biodynamic gardening, beekeeping, and eco-architecture, using recycled bottles and mud plaster to make earthquake resilient structures, across the Nepal into their outreach efforts enabling communities to work towards reducing their own vulnerability.

Locally-based humanitarian development supplemented with the ability to potentially capture, use, and share spatial data can be extremely effective in reaching the broader community (and more) because of their existing knowledge of the local area, people, and issues, as well as their ability to communicate and rapidly respond to local long-term and short-term needs.

6 FUTURE WORK

In the future, the data collected and GIS analysis of this project can continue to be used in the assessment of spatially maximizing efficiency as well as follow-up with program success. This data can be both utilized to improve and expand future work and in marketing and fundraising efforts.

Furthermore, we plan to migrate all data to ArcGIS online so that the foundation can utilize the program to add data over time. The ESRI® Nonprofit Organization Program offers access to ArcGIS to qualified programs with humanitarian, conservation, and community services missions at no cost (administration fee assessed) (ESRI® NPOP, 2018). Thus, the foundation may be eligible for access to the software. Additionally, in the authors' next undertaking in Nepal, we plan to engage university students to collaborate with and train several KRMEF workers and members of the community in GIS basics for ArcGIS On-line and in Survey123 data capture techniques (Survey123, 2018) to enable continued data collection in a form of citizen science (Kampf et al. 2018) to add to the geodatabase and expand the map of outreach activities as well as update the land use map over time.

The use of GIS can aid in continued development as well as increase the capacity of response to local small-scale events as well as rapid local response to large-scale events. Technological advances in GIS and mobile capabilities combined with local-based solutions is crucial for effective development and disaster preparedness and response in Nepal and other developing countries.

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