Evaluation of Geodesign as a Planning Framework for American Indian Communities in the Southwest United States

by

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ABSTRACT

The overarching aim of this dissertation is to evaluate Geodesign as a planning approach for American Indian communities in the American Southwest. There has been a call amongst indigenous planners for a planning approach that prioritizes indigenous and community values and traditions while incorporating Western planning techniques. Case studies from communities in the Navajo Nation and the Tohono O'odham Nation are used to evaluate Geodesign because they possess sovereign powers of self-government within their reservation boundaries and have historical and technical barriers that have limited land use planning efforts. This research aimed to increase the knowledge base of indigenous planning, participatory Geographic information systems (GIS), resiliency, and Geodesign in three ways. First, the research examines how Geodesign can incorporate indigenous values within a community-based land use plan. Results showed overwhelmingly that indigenous participants felt that the resulting plan reflected their traditions and values, that the community voice was heard, and that Geodesign would be a recommended planning approach for other indigenous communities. Second, the research examined the degree in which Geodesign could incorporate local knowledge in planning and build resiliency against natural hazards such as flooding. Participants identified local hazards, actively engaged in developing strategies to mitigate flood risk, and utilized spatial assessments to plan for a more flood resilient region. Finally, the research examined the role of the planner in conducting Geodesign planning efforts and how Geodesign can empower marginalized communities to engage in the planning process using Arnstein's ladder as an evaluation tool. Results demonstrated that outside professional planners, scientists, and geospatial analysts needed to assume the role of a facilitator, decision making resource, and a capacity builder over traditional roles of being the plan maker. This research also showed that Geodesign came much closer to meeting American Indian community expectations for public participation in decision making than previous planning efforts. This research demonstrated that Geodesign planning approaches could be utilized by American Indian communities to assume control of the planning process according to local values, traditions, and culture while meeting rigorous Western planning standards.

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CHAPTER 1

INTRODUCTION

"Geodesign is not a planning method strictly for designers but a method that empowers a community to engage with science and make decisions of all kinds." – Jack Dangermond

Planning in the contemporary world is increasingly becoming more complex and must take into account the many diverse urban, environmental, and cultural systems present within the design landscape. Too often planning efforts ignore science, neglect public outreach efforts for marginalized communities, or fail to account for complex interconnected systems. Geodesign claims to be a planning framework that can account for this complexity by embracing the ideals championed by Ian McHarg (1969) of designing with nature by harmonizing the use of land with the surrounding environment. This planning approach embraces the powerful capabilities of geospatial analysis with interactive visualizations to create a design environment that allows planning professionals, scientists, and the people of the place to design with geographic knowledge. Geodesign offers an opportunity for marginalized communities to contribute their perspectives and knowledge of their environment, control the planning process, and advance their planning efforts with the support of powerful geospatial assessments.

The 1950's began a Federal policy of termination and relocation of American Indian communities that resulted in the terminated recognition of over 100 sovereign dependent tribes and bands and the relocation of over 750,000 American Indians from the extreme poverty of the reservations to urban areas around the United States (Fixico, 1990). This threat to tribal sovereignty within the United States led to the red power movement that emphasized tribal self-determination (Smith, 2014). The planning practices within American Indian communities prior to the 1970's had been top down planning approaches from the Federal government and marred by outside exploitive industries that do not account for community values, cultural significance of the land, and did not raise the standard of living for the tribal communities. After the 1970's many American Indian communities asserted their treaty rights and pushed for greater self-determination in their planning efforts (Fixico, 1998). Yet, the federal planning legacy has left many tribal nations ill prepared to conduct planning efforts that are community based and utilize traditional knowledge held within the tribe for planning purposes. Indigenous planners are calling for a planning approach that can incorporate western planning methods underneath non-western values and local community traditions. Over the past 10 years Geodesign has primarily been utilized in either urban or peri-urban environments for planning efforts, more work is needed in tribal communities to determine if Geodesign can empower indigenous communities to overcome traditional planning barriers and give ownership of the planning process to the local community for the local community.

1.1 Problem Statement

American Indian communities possess sovereign powers of self-government within their reservation boundaries in the context and limitations of the "trust" relationship with the Federal government. This sovereignty includes the power to manage natural and cultural resources as well as land use planning for future infrastructure development, economic opportunity, and housing development, but with significant involvement and overview by the Federal government (Cornell & Kalt, 1998; Zaferatos, 1998). Nevertheless, many challenges exist in exercising this power, such as conflicting visions for tribal land between tribal, state and federal governments; historically limiting acts by the Federal government on tribal sovereignty; insufficient land use planning experience within tribal communities (Gardner & Pijawka, 2013); and limited conceptual frameworks for planning that integrates indigenous knowledge with western planning approaches (Fixico, 1998; Galbraith, 2014; Gardner & Pijawka, 2013; M. Hibbard, 2006; Matunga, 2013; W. H. Pacific, 2008; Walker et al., 2013). Traditional planning efforts in American Indian communities have been largely top down efforts by the Federal government that often fail to account for indigenous values. Recent planning efforts within American Indian communities have been hindered by limited community planning experience and technical capacity especially with geospatial technologies, data scarcity, and analysis within these communities, resulting in limited implementation of plans which as a consequence reduce housing quality and quantity, limit economic opportunities, and threaten environmental and cultural safeguards. Lack of implementation of plans in these communities has also resulted from lack of funds for capital projects, weak consensus on project priorities in strategic plans for project development, amongst other factors (Gardner & Pijawka, 2013).

In addition to these capacity and participatory barriers, climate change and the increasing frequency of severe weather events are a significant threat to many tribal communities, particularly for those that are data scarce (Dalton et al., 2018). This data scarcity is primarily due to many Tribal communities not having the technological and economic assets to collect information about their environment and having limited federal support (Openshaw & Goddard, 1987; Thakur & Sharma, 2009; Williams et al., 2014). The lack of available data on the magnitude of these hazards often results in inadequate improvements in infrastructure and resiliency plans. This limitation in planning to attenuate future risk makes these areas less resilient to future disasters and reduces their ability to recover (McEwen & Jones, 2012).

The Geodesign planning approach originates from the Landscape architecture field and seeks to merge the strengths of scientific analysis, particularly from geography and GIScience with the creativity inculcated within the design professions to design communities through an interdisciplinary and collaborative approach that conforms to the unique character of the local-natural environment (Foster, 2016; McHarg, 1995; Steinitz, 2012). Geodesign has been increasingly recognized as an interdisciplinary planning approach that merges multiple specialty fields and perspectives through the use of computer information systems, geospatial analysis, planning expertise, and local knowledge and community values to guide the planning process (Foster, 2016; Tulloch, 2017). By using Geodesign as a community-based approach, this dissertation argues that communities can reclaim the planning process, build planning capacity, and mobilize local knowledge to address traditional planning barriers within these communities.

The goal of this research is to evaluate Geodesign as a planning framework as holistic and empowering planning approach for American Indian communities. To conduct this evaluation four case studies were completed (three in the Navajo Nation and one in the Tohono O'odham Nation) that tested the flexibility of the planning approach in four unique geographic, economic, and cultural contexts. The following section, Chapter 2, discusses the background literature that relates to public participation, Geodesign, resiliency, and planning in American Indian communities as well as the dissertation plan. The remainder of the dissertation is organized as three distinct but interrelated research articles. The first article, Chapter 3, evaluates Geodesign as an inclusive planning approach that can incorporate indigenous values in land use plans while the second, Chapter 4, explores Geodesign as a community-based planning approach that creates flood risk resiliency in data scarce areas, and the third, Chapter 5, identifies the roles of the planner in conducting Geodesign planning efforts in marginalized communities and evaluates participatory decision making using Arnstein's ladder. The final chapter of this dissertation is Chapter 7, the conclusion, in which the major findings from each chapter are summarized and future research directions are recommended.

Why Geography?

The Geodesign framework, approach, and methods have largely been developed and certainly influenced by the Geographical sciences through its emphasis on understanding the relationships between physical / environmental factors and social – settlement patterns and their mapping. Geodesign is a portmanteau of geography and design and merges the strengths of the locational sciences associated with the field of Geography with the creativity of the design disciplines to quantify earth's bio-physical and human-environmental processes and assess land use decisions and impacts on these systems (Li & Milburn, 2016). Geographical approaches to systematically evaluate geologic, ecologicial, environmental, and social processes are the basis of the Geodesign approach that separate it from other design strategies (Foster, 2016). Geodesign does not only seek to understand how and why the world works but to achieve a full understanding of how proposed decisions affect the environment and to design from this knowledge to minimize future risk to both natural and social systems while maximizing societal benefits (McHarg, 1995; Steinitz, 2012). Geodesign assumes that with accurate empirical spatial data that environmental processes of the region under study can be accurately modeled, a 'mirror of nature', and thus potential design scenarios can be accurately understood and predicted (Gregory et al., 2009).

To accurately model nature, Geodesign relies on Geographic Information Science (GIScience) and Geographic Information Systems (GISystems). GIScience develops and explores the theoretical underpinnings in the application of GISystems (Anselin & Getis, 1992). GISystems is computer technology traditionally used to create, store, edit, manage, and analyze data that is tied to a physical location on the earth (Goodchild, 2007). These capabilities allow GIS (GISystems + GIScience) to create a representative model of real world phenomena and to simulate potential design outcomes based on how the spatial data relates to one another. This is called spatial analysis (Longley et al., 2003). This application of spatial analysis allows geographers to convert spatial data into information useful for decision support (Steinberg, 2006). Geodesign relies on interactive spatial analysis, particularly land suitability analysis and hazard modeling, to quantify and assess both physical and social geographical processes to determine land use changes that fit within the local environmental and social constraints (Malczewski, 2004).

In addition to a reliance on GIS and geographical approaches for understanding physical and social systems this research leverages tenets within critical and postmodern geography when using Geodesign in American Indian Communities. Critical Geography prioritizes the rejection of empiricism, the need to both expose instances of inequality and the methods that promote inequality, increase the visibility of underrepresented groups, a commitment to progressive politics, and the removal of representations of space as modes of oppression and inequality (Blomley, 2006; Peet, 2000). Postmodernism in geography emphasizes the need to understand the local social, historical, and cultural perceptions of place and space and the unique knowledge about place and space that can be gained from subaltern communities (Bhabha, 2004; Duncan, 1996; Said, 1979; Tuan, 2001). This research does not embrace all the tenets of postmodern and critical geography, particularly the rejection of empiricism, but does prioritize the need to orient representations of space in land use decision making to local culture, incorporate the local knowledge of the geographic area and the cultural values tied to the land, and empower historically subaltern groups in land use decision making for land that they historically and currently inhabit.

This application of Geodesign in American Indian communities essentially required communities to make land use decisions based on their geographic knowledge of their environment using scientific evaluations of climate, geology, ecology, and existing infrastructure assessments as well as local experiential data resources guided by local values. Unfortunately, for many of these communities, systematically collected geographic data is unavailable, particularly data related to geohazards. This lack of data increases the vulnerability and reduces the resiliency of the community against natural hazard events (Burton et al., 1993; Kasperson & Pijawka, 1985). Using the Geodesign approach, these community's utilized volunteered geographic information through participatory GIS to organize the communities local geographic knowledge of hazards to assist in accounting for natural hazard risks in their communities. These efforts empower these communities to both mitigate and adapt to natural hazards that have historically threatened their communities while promoting economic growth, infrastructure development, and improved housing for a higher quality of life.

CHAPTER 2

BACKGROUND LITERATURE AND RESEARCH GOALS

The goal of this background literature is to provide a synthesis of the fields that support Geodesign as it relates to planning in American Indian Communities. This includes a background on Geodesign, planning theory, public participation, planning in American Indian communities, resiliency, data scarcity, and participatory geographic information systems. Conventional methods for planning approaches within American Indian communities are discussed as they have fallen short in addressing both technical and cultural requirements. The benefits of using community based participatory research and participatory GIS methods in planning are also outlined. This background literature provides the context for the research objectives and goals for the dissertation which will be outlined at the end of the chapter.

2.1 Related Work

2.1.1 Planning Theory

Geodesign as a planning approach has been used to support positivist planning and is a powerful tool for rational planning efforts (Eikelboom et al., 2015; Kuby et al., 2018; D.J. Lee et al., 2014; Van Der Hoeven et al., 2016). Within the Geodesign approach clear goals are set throughout the planning process, scenarios are developed to account for competing priorities, powerful quantitative analysis is used for decision support and decision making, and at the end of the planning process an implementable plan is developed with costs calculated. The majority of Geodesign planning projects are guided by quantitative deterministic, probabilistic, and/or judgement approaches that are completed through a systems analysis viewpoint. A shortcoming of rationalist planning theory is that it does generally ignore marginalized communities in the planning process and has rightly been criticized for its reductionist tendencies towards goal setting, social values, quantification of environmental process, and ignoring of pluralist interests of a community by centralizing the planning process thus becoming susceptible to powerful special interests amongst other critiques (Allmendinger, 2002; S. S. Fainstein, 2014; Friedmann et al., 1973; Grabow & Heskin, 1973; Irving, 1993). There are opportunities afforded by Geodesign's flexibility to incorporate strengths from other planning theories such as incremental and transactional theories, within formal planning process in Geodesign applications by utilizing stakeholders with diverse objectives to collaboratively plan and to seek out local values through volunteered geographic information which has been done in Geodesign classroom exercises (Borges et al., 2015; Kalvelage et al., 2018).

Planning theories that challenge traditional rational planning prioritize confronting centralized power dynamics in planning, diversifying voices heard in the planning process, understanding the experiences of persons living in the planned area, and through social activism (Arnstein, 1969; Fischer, 2016; Iris M. Young, 2000). Fainstein (2014) argues that any planning effort that excludes people affected by planning decisions is unfair. To promote equity in planning and spread the benefit of planning equally to all communities planners have recommended diversifying the planning field with planners that do not belong to the dominant social group (J. M. Thomas, 2008), educate planners to prioritize equity over efficiency (Marcuse, 2012), and engage in planning efforts that recognize the plurality of objectives in diverse cities and communities (Campbell, 1996; Healey, 2010; Iris M. Young, 2000). These efforts largely stem from Lefebvre (1968) idea of the 'right to the city' which contends that the city should be a co-created space prioritizing common good over individual rights. Planning movements that are pertinent to this research, have resulted from these efforts which include environmental equity, which calls for the dispersion of environmental risk equally across the population (Zimmerman, 1993), collaborative planning that engages diverse stakeholders in making planning decisions (P. A. Fisher & Ball, 2003), and community based planning that uses local knowledge as the guiding vision for planning decisions (Elwood & Leitner, 1998; Grengs, 2002).

2.1.2 Public Participation

Over the past fifty years, planning theorists have argued that the communities affected by planning decisions, particularly those that are a minority viewpoint or historically marginalized should be informed and consulted in planning efforts and have the opportunity to express their values in government decisions (Burke, 1979; Fagence, 1977; Slotterback & Lauria, 2019). This communication model between planners and the community should be an inclusive dialogue that formulates public interest through continuous discussion on decisions that affect the local community (Dryzek, 1990; Healey, 1996; Innes & Booher, 1999; I.M. Young, 1995). Many local governments in the United States and Canada require community engagement to democratize the planning process and redistribute planning power to citizens (Arnstein, 1969; Day, 1997; S. Fainstein & Fainstein, 1985). It is believed that engaging the local community in planning efforts can build goodwill and trust in the process and develop a sense of local ownership of the plan (Fagence, 1977; Oulahen & Doberstein, 2012). The values expressed through citizen participation provide planners with more accurate public opinion on proposed policies and local information about a community that may not be readily available to the planner (Blue et al., 2019; Day, 1997; Rich, 1986). In addition to these benefits, greater public participation can identify unique solutions for planning problems, build planning capacity within a community, empower a community to engage within local decision making, create trust between planners and the local community, and develop social capital (Berry et al., 1993; Laurian & Shaw, 2008; C. W. Thomas, 1998). Tribal communities have historically been marginalized in the planning process and had limited input in planning decisions (M. Hibbard, 2006; Ward, 1992; Zaferatos, 1998). Through greater public involvement in planning efforts and decision making, tribal communities can plan their communities in alignment with their values and traditions and develop resilient planning traditions.

2.1.3 Planning in American Indian Communities

The literature is limited for planning in American Indian communities. There are four principal books that relate to planning in American Indian communities: Ted Jojola's *Reclaiming Indigenous Planning*, Susan Guyette's *A Guide for Native American and Rural Communities: Planning for Balanced Development*, Hosmer's collection *Native Pathways,* and Robert Miller's *Reservation Capitalism: Economic Development in Indian Country.* Few scholars are contributing articles related to American Indian planning, the most prominent of this select group include Zaferatos, Jojola, Matunga, Hibbard, and

Biles with other articles typically depicting development initiatives on Tribal lands or arguing the benefits of indigenous methods.

Jojola et al's. *Reclaiming Indigenous Planning*, is a collection of case studies that explore development initiatives and hurdles in planning for indigenous communities in Canada, United States, and New Zealand. The four most relevant articles in this work is Jojola's *Indigenous Planning: Towards a Seven Generation Model*, Matunga's *Theorizing Indigenous Planning,* Proctor and Chaulk's *Our Beautiful Land: The Challenge of Nunatsiavut Land Use Planning*, and Kingi et al.'s *Iwi Futures: Integrating Traditional Knowledge systems and cultural values into Land-Use Planning*. Kingi et al. explore two development areas for the Maori people in which consultants work with land owners to optimize economic opportunities available in coastal and rangeland areas. The primary gap in this planning initiative as identified by the authors is the ability for the community to actively participate in the planning process. The use of consultants who leveraged GIS and optimization formulas were unable to effectively leverage community participation nor increase the overall community capacity for planning (Kingi et al., 2013). Proctor and Chaulk explore the difficulties in planning in the Nunatsiavut community and the weaknesses and strengths in Land Use Planning with a Co-Management approach. They identify differences in Western and Indigenous values as a major hurdle that needs to be addressed between both the Canadian government and Inuit communities (Procter & Chaulk, 2013). Jojola's article identifies the method in which an indigenous community transfers cultural knowledge and how the preservation of this cultural knowledge is critical to developing plans that honor the culture and empower the community (Jojola, 2013). This is significant because it outlines the need to reclaim a cultural planning mindset, which could potentially be incorporated in a Geodesign approach. Matunga outlines the general colonizing pattern that resulted in the seizure of indigenous lands by European colonizers and the planning epochs that characterize indigenous planning history. The important contribution of this work is both the planning history and the method that he outlines for indigenous communities to honor their culture but to also evaluate and potentially incorporate Western planning methods into their planning approaches. Matunga provides a pathway for Indigenous and Western planning methods to support each other (Matunga, 2013). These works call for Western planning approaches that can be placed under the Indigenous planning tradition and utilized as needed. This is something Geodesign is ideally suited because of its ability to incorporate stakeholder values in the design process. Geodesign places stakeholder values as the primary controlling factor of the planning process and with active participation stakeholders within the community can contribute ideas and build a community consensus in plan making. The emphasis on participation and lack there of in past planning efforts is another common theme in this work's collection of case studies and can potentially be addressed through Geodesign.

Both Miller and Hosmer primarily focus on economic development initiatives for American Indian communities. Miller's focus is on describing the historical context of economic systems in American Indian communities as well as depicting the adverse living conditions experienced by reservation inhabitants. This work is significant because it provides both long and short term economic strategies that could increase overall quality of life on native lands (Miller, 2013). Hosmer's work is a collection of articles describing economic development initiatives in American Indian communities from the twentieth century. The economic opportunities explored vary from casino development, fisheries, business development, and natural resource extraction (Hosmer & O'Neill, 2004). Guyette's work is meant to be a primer on developing small scale projects for American Indian communities. This work follows the development process for a cultural resource center for the Pueblo of Pojoaque and outlines how a community can replicate this process (Guyette, 1996). Donald Fixico also writes about economic development on Tribal lands, however, his primary research focus is on Federal Indian policy (Fixico, 1990), Tribal Resource exploitation (Fixico, 1998), and differences in Western and Indigenous thought (Fixico, 2009).

Zaferatos and Hibbard's research primarily explores the political difficulties in planning for Native American communities. Zaferatos explore the history of tribal governance and the jurisdictional powers of tribal governments over native lands including the potential approaches to obtaining Tribal objectives over federal and private opposition (Zaferatos, 1996, 1998). Much like Zaferatos, Hibbard explores the political difficulties in planning for American Indian communities and acknowledges the modest literature available in indigenous planning and encourages planners to closely examine the problems and opportunities within land and resource management in Indigenous communities (M. Hibbard, 2006; Michael Hibbard et al., 2008).

Gardner et al (2013) in a report title *Recommendations for Updating Community Based Land Use Plans,* evaluates community based land use planning in the Navajo

Nation and identifies challenges in planning for Navajo Nation chapters which affect American Indian planning efforts in general. The barriers identified in this report can largely be divided into barriers in promoting sovereignty and self-sufficiency and barriers in effective plan making. The barriers identified to limit self-sufficiency include the propensity of chapters in the Navajo Nation to turn to consultant groups, limited data sharing, and limited public participation in plan making (Gardner & Pijawka, 2013). The technical barriers listed toward effective planning in these chapters include limited use of GIS and Land Suitability Analysis as well as a limited focus on land designations for community plans. The reliance on consultants in creating these land use plans means that the skillsets required to update these plans and to start new planning initiatives are not passed on to the community. The limited participation through visioning sessions and active community plan building resulted in plans that were not embraced by the community and saw limited implementation. The limited use of GIS and land suitability analysis in these plans resulted in considerable loss of capital when plans where developed because of unforeseen geographic hazards such as floodplains or unstable soil types (Gardner & Pijawka, 2013).

When employed as a bottom up planning approach Geodesign can potentially overcome many of these planning barriers. As a bottom up planning approach Geodesign can be leveraged to incorporate community values and visions for planning projects inherent within indigenous planning initiatives and directly involve community members in all steps of the planning process building internal capacity and repeatability. The foundation of Geodesign is ‘changing geography by design’ and relies on GIS and land suitability analysis to provide decision support when creating designs (Steinitz, 2012). By involving the community in a Geodesign process the plans that are developed have already built upon community consensus and are more likely to be utilized. Geodesign's flexible planning framework can equip these communities to leverage effective Western planning methods underneath their cultural values and traditions to create plans that meet the standards of both.

2.1.4 Data Scarcity

A significant planning barrier within many tribal communities is data scarcity. Data scarcity in the planning sense, refers to areas that do not have enough data be it environmentally or demographically to accurately forecast community needs or assess risk from environmental hazards. This data scarcity is primarily due to many communities not having the technological or economic assets to collect information about their environment (Openshaw & Goddard, 1987; Thakur & Sharma, 2009; Williams et al., 2014). Reliable and robust data are essential for modelling environmental risks and for assessing environmental hazards. Data scarcity reduces the reliability of predictive models and inaccurate assessments can be environmentally and financially costly (Ritzema et al., 2010). To overcome data scarcity communities have used citizen science to create more robust data sets (Buytaert et al., 2014; Buytaert Wouter et al., 2016), participatory GIS to utilize local knowledge of an area (Maheu, 2012; Singh, 2014; White et al., 2010), connecting environmental principles to known biophysical data to infer environmental information (Townsend et al., 2014), rapid reconnaissance of an area (Ritzema et al., 2010), and triangulating simulation models (Ireson et al., 2006). Many of these methods rely on community involvement and local participation to supplement existing data. This limitation in planning to attenuate future risk makes these areas less resilient to future disasters and reduces their ability to recover (McEwen & Jones, 2012). Many American Indian communities do not possess natural hazards data for their communities and must overcome this limitation to effectively plan for their communities.

2.1.5 Resiliency

Resiliency emphasizes implementing strategies and structures that strengthen the community to resist adverse events or circumstances and quickly return to the desired state of the community (MacKinnon & Derickson, 2012). The four foundations of community resiliency are economic capital, social capital, environmental capital, and adaptive governance (Buckman & Rakhimova, 2015). These foundations of resilience directly correlate to how well a community can prepare, reduce the impacts, and recover from adverse events. Recently, the literature suggests an approach to resiliency planning through community participation. Economic capital in resiliency refers to the diversity of the economy and how well a community can withstand losses in markets or shocks to its economy. A community that has strong economic capital has numerous income revenues that can keep the community financially healthy in the event that one industry is adversely affected and the capital to invest in resiliency infrastructure. Also, this concept refers to economic resources available to rapidly rebuild infrastructure and other resources in the event of a disaster (Sherrieb et al., 2010). Social capital refers to citizen engagement and cohesion, the strength of the bonds between community residents, and the links to other communities and organizations for support. A community with strong social capital will have strong community bonds and active social organizations that will aide community members affected by adverse events, and make connections within and outside of the community (Magis, 2010; Putnam, 2001). Environmental capital is the ability of the surrounding environment to support the community. This means that environmental processes that historically have made communities more resilient to natural disasters are strengthened and preserved (Buckman & Rakhimova, 2015). Finally adaptive governance is the ability of the governing structures to adapt to ecological, economic, political, and social changes in a meaningful way that can accommodate and plan for both long and short term disruptions (Olsson et al., 2004; Quay, 2010).

2.1.6 Geodesign

Literature relating to Geodesign is limited because of the relatively recent formalization of the planning approach and in regards to American Indian planning literature has not been utilized by an American Indian community to develop a land use plan. There are five textbooks about Geodesign. The first is Carl Steinitz *A Framework for Geodesign: Changing Geography by Design,* Shannon McElvaney's *Geodesign: Case Studies in Regional and Urban Planning,* and Zwick et al.'s LUCIS series *Smart Land Use Analysis: The LUCIS Model* and *Advanced Land-Use Analysis for Regional Geodesign Using LUCISplus.* Lee et. al.'s *Geodesign by Integrating Design and Geospatial Sciences*, and Van Der Hoeven et. al. *Geodesign: Advances in Bridging Geo-Information Technology, Urban Planning, and Landscape Architecture*. The journal articles related to Geodesign generally relate to either researchers: attempting to place Geodesign in the existing theoretical framework (Batty, 2013; Davidson, 2014; Foster, 2016; Goodchild, 2010), devising education programs for Geodesign (T. Fisher, 2016; Paradis et al., 2013), or evaluating Geodesign tools (Eikelboom & Janssen, 2015). There are also a handful of articles that analyze Geodesign case studies, however, they relate to optimization algorithms in Geodesign (Eikelboom et al., 2015; Janssen et al., 2008) or top down planning using the Geodesign framework (G. Huang & Zhou, 2016). The use of the Geodesign framework has increased over the past five years, particularly in the development of energy and infrastructure where it has been utilized to design green infrastructure (Cerreta et al., 2016), identify locations for alternative fuel stations (Kuby et al., 2018), transmission line placement (Moreno Marimbaldo et al., 2018), and biomass supply chains (Hu et al., 2017). Applications also include developing mitigation strategies for climate change and natural disasters (Kim, 2017), conservation planning (G. Huang, 2017; G. Huang & Zhou, 2016; Perkl, 2016), and natural resource management (Nyerges et al., 2016). The primary difference between many of the case studies in both the journal articles and books listed above is that they are primarily focused on an urban environment and hail from a Western cultural and planning mindset using expert led top down planning approaches.

Steinitz's *A Framework for Geodesign* is the standard primer for any Geodesign course. This work provides an outline of the eight main Geodesign planning approaches: Anticipatory, Participatory, Sequential, Constraining, Combinatorial, Rule based, Optimized, Agent based, and Mixed; and how they could be applied to any given situation. This book also dives into real world case studies and how the above approaches might be applied. Finally the work concludes with remarks on the future of Geodesign and how to educate future Geodesign practitioners (Steinitz, 2012). The most applicable Geodesign approach for this dissertation is the participatory approach exemplified by Osa Region of Costa Rica. This case study demonstrated both the strengths and weaknesses of the participatory approach first in plan building through stakeholder (local and non-local) participation and in reconciling diverging planning visions. The remaining Geodesign approaches and case studies outlined in Steinitz's work rely on a professional design team to develop plans guided by stakeholder priorities, which is significantly different from the proposed Geodesign planning approach for this research.

Lee et. al and Van Der Hoevan et. al. share Geodesign experiences from a European perspective and provide Geodesign case studies from the 2013 & 2014 European Geodesign summits (D.J. Lee et al., 2014; Van Der Hoeven et al., 2016) . McElvaney's work is a collection of case studies that the author has identified as planning initiatives that generally follow a Geodesign planning approach (S. McElvaney, 2012). The strength of these works are that they show the flexibility of the Geodesign approach, but do not show indigenous planning applications. The Zwick et al. book is a primer on land suitability analysis, smart land use planning, and conflict resolution in land use designations using GIS and University of Florida's LUCIS software (Zwick et al., 2015).

Geodesign approaches, principles and methods are not uniformly applied in practice because they are required to address projects that vary in size, scale, culture, content, and timeframe. Geodesign employs a methodological approach that can be adjusted on an as needed basis to accommodate the needs of a specific project (Steinitz, 2012). Of the eight general design approaches within Geodesign (Anticipatory, Participatory, Sequential, Constraining, Combinatorial, Rule based, Optimized, agent based, and mixed), participatory design complements the goals and practices of participatory GIS (Steinitz, 2012). Traditional participatory GIS makes GIS technologies available to disadvantaged communities to empower them to create spatial data and enhance a community's capacity to manage, analyze, and leverage spatial information for decision support (G. Brown et al., 2017). By leveraging participatory GIS in a participatory Geodesign project participants are able to contribute local knowledge and experiences in the form of spatial data for decision support and to create and contribute designs for planning initiatives for their community.

Optimized land use plans have been completed by American Indian communities often through the use of consultants, however, this method did not transfer planning skillsets to the community nor did it effectively engage the community in participating in the planning process (Gardner & Pijawka, 2013; Kingi et al., 2013). Further Janssen et al. discovered that when utilizing optimization models and professional designers given the same criteria that the final land plans vary widely. They argue that this demonstrates that the optimization in land use planning is good for identifying one of many optimal solutions (Janssen et al., 2008). Huang argues that developing nations should utilize Geodesign as a planning framework because it encourages public participation and incorporates multiple stakeholder viewpoints in planning. Yet, his research is a top down approach that includes a planning team developing plans that are later approved by stakeholders (G. Huang & Zhou, 2016). This article is valuable in that it demonstrates the flexibility of Geodesign and its incorporation by Non-Western cultures, but does not leverage a participatory approach. Public participation is important in planning in American Indian communities and Geodesign can provide the opportunity for these communities to build the community capacity for planning. Geodesign offers the opportunity for stakeholders to be involved in every step of the design process including the GIS analysis, visioning sessions, community assessment data development, and in the plan creation process. By making planning a community effort the internal capacity of planning in these communities is amplified.

2.1.7 Participatory Research

Participatory research is a method favored in many academic fields, and has achieved much success when working with American Indian communities. Community-Based Participatory Research is a participatory research methodology that involves targeted community members, organizational representatives, and researchers as equal partners who share ownership, decision making, and contribute expertise in a research project (Windsor, 2013). Traditionally leveraged within the public health field, it is a transformative participatory based research method that connects scientific theory to practice through community engagement and social action to impact a target community and increase overall health (Wallerstein & Duran, 2010). By making the community a stakeholder and equal partner within the research and intervention, the researcher can gain trust from the community and with this trust gain new perspectives into community perceptions of the problem under study (Windsor, 2013). It is an effective public engagement method to empower the community into action and compels a community to take ownership and address areas of concern within the community. Not only is it an effective research technique for scientists to conduct it provides a clear road map for community participants to alleviate barriers within the community (Israel et al., 2010).

Due to the success of CBPR in public health initiatives there has been an increasing effort to apply these methods in other disciplines (Windsor, 2013). Some initiatives in CBPR have attempted to use its methodologies as a decolonizing force in conducting research in American Indian communities (Stanton, 2013). This has been done in response to Deloria's critique that much of the existing research on American Indian communities does not actually benefit those communities (Deloria Jr., 1969). Efforts to include these communities as equal partners in designing and owning the research will greatly increase the enthusiasm for the research and overall community participation in Geodesign efforts (P. A. Fisher & Ball, 2003). A prominent example of successful investment in community participation is Biles article *Public Housing on the Reservation*. The article describes various housing initiatives in American Indian communities that are unsuccessful and successful. He found that the most successful housing initiatives had the greatest public participation in informing the Federal government on housing preference and location (Biles, 2000). With the federal dollars consistently being allocated to programs to which are intended to increase the standard of living in these communities Geodesign provides an avenue for American Indian communities to outline the desires for their community through a planning approach that prioritizes community preferences and cultural values and meets federal planning standards.

Traditional participatory GIS makes GIS technologies available to disadvantaged communities to empower them to create spatial data and enhance a community's capacity to manage, analyze, and leverage spatial information for decision support and land use planning (G. Brown et al., 2017). It is a participatory approach to spatial planning that is geared towards empowering communities into engaging in long lasting spatial decision making processes (Dunn, 2007). An important concept within participatory GIS is to make geospatial technologies accessible to a community in a way that they can interact with the technology, understand the long term implications of the spatial data contributions, and to engage in decision making processes through spatial data contribution for their communities (Elwood, 2006; Radil & Jiao, 2016). Participatory GIS is typically used to visually engage a community and advocate for community involvement in space and place making projects as well as to tap into local knowledge that can be incorporated into decision making criteria (Mukherjee, 2015). One of the underlying questions of the dissertation is to see if Geodesign does provide what the above found that 1. Local contributions through spatial data development improves acceptance of plans over non-participatory planning and 2. Geodesign enhances decision making, builds trust and empowers and through this enhances planning capacity.

Elwood (2006) argues that participatory GIS can ameliorate uneven access and use of geospatial technologies to indigenous communities and to engage the community in contributing to spatial knowledge. She is careful to emphasize the importance in assessing the reliability of this data and its impact on GIScience (Elwood, 2006). Dunn contends that participatory GIS transforms the way that these communities view their environment and allows them to contribute information to preserve significant areas and contribute to decision support within their communities creating culturally hybrid datasets (Dunn, 2007). The gap in much of the participatory GIS is its real world application for American Indian communities, which is limited in action and how the data is leveraged (Chapin et al., 2005). Most of the participatory GIS data generated with American Indian communities is used as decision support material for a planning or resource management projects outside of Tribal authority (federal or private initiatives). This research seeks to evaluate the Geodesign planning framework to empower American Indian communities to create spatial data for decision support in their own projects and to map the future of the community by actively participating and contributing spatial data to land use plans.

2.1.8 Summary of Literature

There is a call from indigenous planners for American Indian communities to reconnect with the planning traditions that existed within the community prior to European incursions and the existing literature in American Indian planning and participatory research reveals the need for a planning approach that can both utilize western scientific methods and engage American Indian communities in a participatory planning process that captures the overall community vision, establishes a foundation of compromise between community members and outside stakeholders, builds internal planning capacity, and overcomes traditional planning barriers such as data scarcity, limited technical and planning capacity, and limited community-based decision making. These planners argue that a classical traditional planning ethos should be established and that the community should be allowed the opportunity to incorporate Western methods within the traditional value system. Geodesign offers the opportunity for communities to use both scientific assessments and local knowledge/values to guide the planning efforts for their communities.

2.2 Research Objectives and Dissertation Plan

Public participation in planning efforts is reminiscent of traditional consensus building methods typically present within the classical tradition of indigenous planning and should be the working model to effectively engage communities in future, effective planning initiatives. Research shows that most effective Federal planning initiatives, particularly in housing, on Tribal lands have been those that directly involved the affected community in the planning process. It has been demonstrated through Community Based Participatory Research within American Indian communities that greater ownership and involvement in a project increases overall enthusiasm for participation and engagement and that local knowledge sources can be used to supplement data scarce areas.

The overarching objective of this dissertation is to evaluate how Geodesign planning approaches can be used as an empowering planning alternative for American Indian communities that promote self-sufficiency, tribal sovereignty, and internal planning capacity and creates land use plans that are economically, socially, and environmentally resilient, culturally sensitive, and incorporate community values. Three related research questions broadly evaluate Geodesign as a planning approach for American Indian communities.

1. How effective is the Geodesign framework as a land use planning approach for American Indian communities that can integrate indigenous values, traditions, and priorities that are supported by western planning approaches?

2. How can Geodesign be utilized to empower a data scarce American Indian community to utilize local knowledge to validate and improve remotely sensed predictive flood models to create a flood-resilient community-based land use plan?

3. How effective is the Geodesign framework as a community-based land use planning approach using Arnstein's Ladder as a participatory evaluation metric and what is the role of the planner in this approach?

2.2.1 Dissertation Plan

The research objectives in this dissertation are addressed by three independent but related research papers. These papers are unified by examining case studies of Geodesign applications in American Indian Communities. The first paper is titled "Evaluation of Community-Based Land Use Planning Through Geodesign: Application to American Indian Communities". There are significant planning barriers in many American Indian communities including issues in public participation, technical capacity, implementation, and repeatability. This paper is an exploratory case study evaluating how Geodesign can incorporate indigenous and local values into a community-based land use plan and overcome traditional planning barriers in these communities.

Data scarcity is a severe limitation in developing resilient land use plans against natural hazards. The second paper, titled " Resiliency-Based Community Planning in

Data Scarce Areas: Flood Risk Assessment Using Geodesign in the Tohono O'odham Nation" studies the context in which Geodesign can empower data scarce communities in engaging in resilient land use planning against natural disasters. This requires collection of both qualitative and quantitative data to assess how Geodesign can support adaptive governance in the face of flood risk and contribute to furthering economic capital, social capital, and environmental capital in indigenous communities.

The third paper, titled "Evaluating Geodesign for Community Based Tribal Planning: The Role of Planners in Marginalized Communities" examines the planners role in facilitating successful Geodesign land use planning efforts in indigenous communities. Many indigenous planners argue for the need of a systematic planning approach for incorporating western planning approaches underneath local values in planning efforts. This study provides a methodology for planners in conducting community based planning through Geodesign in indigenous communities and demonstrates through Arnstein's ladder that Geodesign approaches reduce the 'gap' between where public participation should be in marginalized communities planning efforts and the actual public participation in planning practice for these communities.

CHAPTER 3

EVALUATION OF COMMUNITY-BASED LAND USE PLANNING THROUGH GEODESIGN: APPLICATION TO AMERICAN INDIAN COMMUNITIES

3.1 Introduction

American Indian communities possess sovereign powers of self-government within their reservation boundaries in the context and limitations of the "trust" relationship with the Federal government. This sovereignty includes the power to manage natural and cultural resources as well as land use planning for future infrastructure development, economic opportunity, and housing development, but with significant involvement and overview by the Federal government (Cornell & Kalt, 1998; Zaferatos, 1998). Nevertheless, many challenges exist in exercising this power, such as conflicting visions for tribal land between tribal, state and federal governments; historically limiting acts by the Federal government on tribal sovereignty; insufficient land use planning experience within tribal communities (Gardner & Pijawka, 2013); and limited conceptual frameworks for planning that integrates indigenous knowledge with western planning approaches (Fixico, 1998; Galbraith, 2014; Gardner & Pijawka, 2013; M. Hibbard, 2006; Matunga, 2013; W. H. Pacific, 2008; Walker et al., 2013). Traditional planning efforts in American Indian communities have been largely top down efforts by the Federal government that often fail to account for indigenous values. Recent planning efforts have been hampered by limited community planning experience and technical capacity especially with geospatial technologies and analysis within these communities, resulting in limited implementation of plans which as a consequence reduce housing quality and quantity, limit economic opportunities, and threaten environmental and cultural safeguards. Lack of implementation of plans in these communities has also resulted from lack of funds for capital projects, weak consensus on project priorities in strategic plans for project development, amongst other factors (Gardner & Pijawka, 2013). This paper evaluates the efficacy of the Geodesign framework as a land use planning approach for American Indian communities that can integrate indigenous values, traditions, and priorities supported by western planning approaches in addition to a bottom-up community-based method.

The word 'indigenous' is Latin in origin and means "born of the land." Its underlying importance is that the customs, traditions, and perspectives of the people this term applies to are shaped by their environment and land. To create something from the indigenous perspective is to create something that is tied to the unique physical, emotional, and spiritual relationship of the people to the land (Cardinal, 2001). Indigenous values are not a monolith in that not all values ascribed to "indigenous" are shared in all indigenous worldviews; however, there are notable differences between western and indigenous worldviews (Cajete, 1999; Little Bear, 2000; Simonds & Christopher, 2013; S. Wilson, 2001). In relation to land use planning, important indigenous values include 1) the importance of local sovereignty in that indigenous communities have the authority to govern themselves on their land and make decisions that are community-based and should be made to benefit the community, not the individual (Brayboy et al., 2012; Galbraith, 2014); 2) Knowledge is generated in many forms and that indigenous ways of knowing are legitimate ways of knowing which includes oral traditions, community and experiential based knowledge (Robinson et al., 2016; Whyte, 2017); 3) that the land is sacred and should be preserved for future generations (Hansen & Antsanen, 2018; Jojola, 2013); 4) and that everything is intrinsically related, that people, the environment, and society, past and future are connected, not compartmentalized (Basso, 1996; Cajete, 1999; Kovach, 2015). It is the above indigenous values that this case evaluates in terms of being utilized in Geodesign.

An integral component of the Geodesign planning process is combining community knowledge with spatial data and technologies to create inclusive and holistic plans (Janssen et al., 2015). The application of GIS-based land suitability maps together with local knowledge of the land, ecosystems and experience can become an effective tool in land use designations and is the object of the Geodesign process we explore here. Public participation and engagement in planning is reflective of traditional indigenous planning, visioning, and consensus-building methods which we hypothesize is provided in a Geodesign workshop which has as its goal a formal land use plan (P. A. Fisher & Ball, 2003). Furthermore, community-based participatory research within American Indian communities has shown that greater ownership and involvement in a project increases overall enthusiasm for the project and acceptance of a land use plan (Biles, 2000; Cornell & Kalt, 1998; M. Hibbard, 2006; Wheeler et al., 2016; Zaferatos, 1998). As we shall see this was the case in developing the Geodesign plan for Dilkon in the Navajo Nation and is a basis for successful plan-making within a Geodesign approach.

The remainder of this paper will introduce Geodesign as a planning approach, the geographic, economic, and cultural contexts of the American Indian community that participated in the case study, a description of the Geodesign process as implemented, and an evaluation of the Geodesign process as an effective planning approach for an indigenous community**.** Specifically, the study evaluates the following topics as they relate to Geodesign for indigenous planning:

1. How does Geodesign promote community-based decision making in designing and approving land use plans?
2. In what ways does Geodesign incorporate both technical and participatory requirements within community-based land use planning?
3. To what degree does Geodesign integrate the indigenous values of:
    a. Local governance
    b. Utilization and respect of alternate ways of knowing such as oral and experiential knowledge in decision making.
    c. The recognition of the land as something sacred and preserved; not something to be dominated.
    d. The interconnectedness of the people and the environment both past and future.

What is Geodesign

Geodesign is gaining legitimacy as an efficient and holistic planning approach that integrates multiple disciplines and perspectives as part of the planning process and permits community participants to make decisions on land use designations and to reach consensus among conflicting views utilizing participatory GIS (L. Huang et al., 2019; Tulloch, 2017). Applications of the Geodesign concept and approach have greatly increased over the last five years. Geodesign, for example, has been used in developing mitigation strategies for climate change and natural disasters (Kim, 2017). Within the area of infrastructure and energy efforts, Geodesign has been utilized to arrange biomass supply chains (Hu et al., 2017), green infrastructure development (Cerreta et al., 2016; Neuenschwander et al., 2014), transmission line placement (Moreno Marimbaldo et al., 2018), and locations of alternative fuel stations (Kuby et al., 2018). Geodesign has also been used in conservation planning (G. Huang & Zhou, 2016; Perkl, 2016) and natural resource management (McCall & Minang, 2005; Nyerges et al., 2016). Expanded use of the Geodesign approach can be attributed, in part, to its nurturing a creative, collaborative environment for simulating alternative futures and evaluating impacts and making land use decision based on optimization and suitability analysis (Slotterback et al., 2016; Steinitz, 2012). Geodesign utilizes spatial data to generate interactive land suitability analysis maps and optimization models that incorporate best practices and stakeholder values for land use planning objectives (Li & Milburn, 2016). The web-based framework allows stakeholders to work in real time, sharing plans and impacts of those plans over the internet, permitting direct proactive participation with responsive decision support materials (Janssen et al., 2015). We hypothesize that the Geodesign planning process is a viable approach for American Indian land use planning as it lends itself to participatory processes, consensus-based planning decisions, and provides a sense of sovereignty through community-based decisions that can incorporate traditions, culture, local knowledge, and belief systems. Specifically, it 1) promotes discussion in designing land use scenarios and engages community stakeholders in contributing to the design process, 2) empowers stakeholders to evaluate and approve feasible and actionable land use plans for their communities, and 3) supports consensus-based planning that embraces community values and needs (Kapyrka & Dockstator, 2012; Steinitz, 2012). Using Geodesign software[1], community stakeholders, government officials, planning professionals, and geographic scientists conceptualize, visualize, and analyze projects and land uses that are designated for specific geographical areas, conduct planning analyses, create community-based plans, review their long term impacts, and evaluate plans based on earlier visioning goals and strategic objectives (Ervin, 2016; Wissen Hayek et al., 2016).

The Geodesign planning approach or framework as devised by Steinitz (2012) goes through three iterations in the design process, as is shown in Figure 3.1. The first iteration is dedicated to understanding the study area which includes identifying its geographic extent as well as understanding how environmental, political, and cultural processes currently operate. The primary purpose of the first iteration is to determine the purpose of the design and how the landscape, environmental resources, and development processes and policies within the project area operate and can be improved. The second iteration identifies the methods in which principle factors within the study area can be quantified and assessed in order to evaluate if the design area and its systems can meet the objectives for the area. For example, if the goal of the Geodesign workshop is to mitigate flood risk by 50% in residential areas, this iteration would develop the models and criteria for determining communities at flood risk, the level of risk, and the methodology to determine what degree flood risk resilience has been established with in any proposed

[1] ArcMap for Land Suitability Analysis and GeodesignHub for the workshop.

plans. This stage provides the data for decision making. The final iteration is creating the land use design/plans/scenarios and presenting them to the stakeholders for acceptance and prioritization. As new information is gained from the stakeholders and participants these three phases are modified and repeated (Nyerges et al., 2016; Steinitz, 2012, 2014).

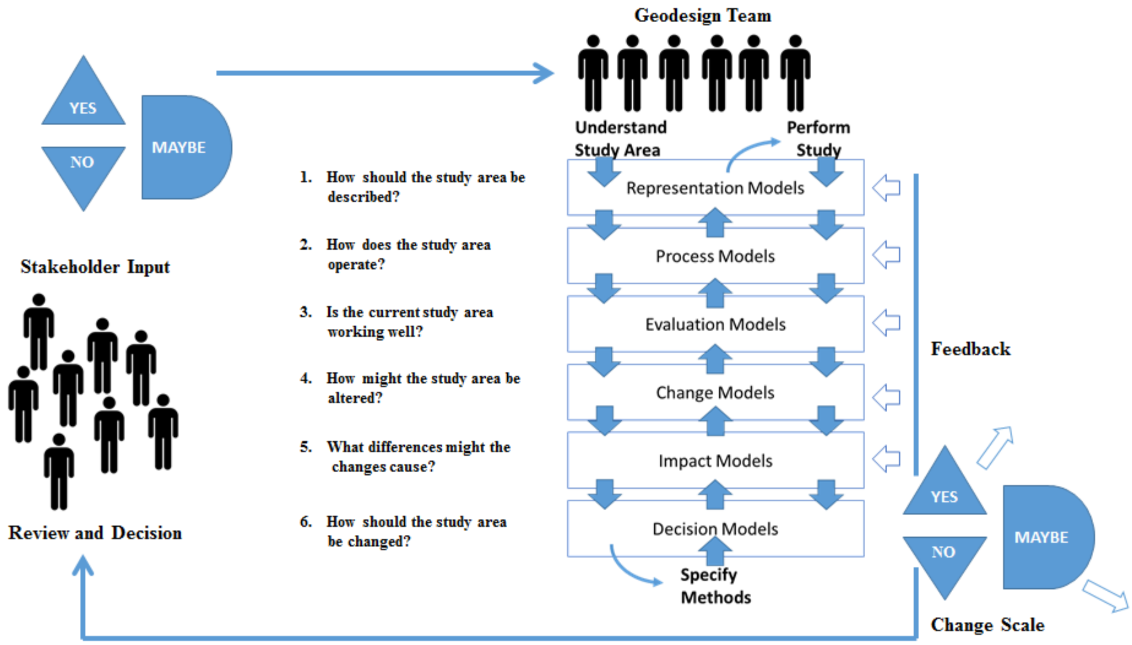

Figure 3.1: This diagram is created from the Geodesign Framework proposed by Carl Steinitz (2012).

3.2 Case Study

Based on *visioning session* results[2] Dilkon has an active and engaged community that wants to compete for economic, housing, and public service development funds. However, the Chapter's last, and only land use plan was completed in 2001 for certification but has not been updated (Dilkon Chapter, 2001). An updated plan will help the community acquire funding for development and is required every 5 years by the

[2] A workshop with community members that identifies goals and objectives prior to the land use plan effort.

Navajo Nation. For example, Tribal communities that have prioritized projects and community support have a better chance of meeting funders' requirements (Gardner & Pijawka, 2013; W. H. Pacific, 2008). Thus, there was strong community and leadership support to update the land use plan. The use of Geodesign to update the communities land use plan represents the first time that the Navajo Nation used this planning approach for developing a land use plan.

Navajo Nation's Local Governance Act

The Navajo Nation, located in Southwestern United States, has consistently pushed for greater self-sufficiency, tribal sovereignty, and local power sharing. As part of these efforts, the Nation implemented *The Navajo Nation Local Governance Act of 1998* (LGA). This first-of-a-kind legislative policy defined the separation of powers within the Navajo Nation government, provided legislation for greater local authority and decision-making powers, and delegated significant governmental authority for local matters to the Navajo Nation Chapters (Navajo Nation Local Governance Act, 1998). Chapters are politically and geographically defined subunits of the Navajo Nation who possess a local government. Chapters possessing local governmental authority are known as "certified" Chapters. Currently, there are 110 Chapters in the Navajo Nation, but not all are "certified" (Navajo Nation Local Governance Act, 1998).

A critical component of achieving certification and control of 'local governance' includes the development of a community-based land use plan (CBLUP) that meets official planning criteria and is approved by the Navajo Nation Council's Resources and Development Committee. According to the LGA, CBLUPs must be updated every five years and demonstrate a) "guiding principles and vision as articulated by the community," b) clear evidence that natural, cultural, human resources, and community infrastructure have been accounted for, and c) land carrying capacity is considered. The LGA also asks for a clear *community-based participation plan* that will lead to a consensus-based land use plan which will show land designations that anticipate and meet the future needs of the community. This ensures that a Chapter possesses a vision for the future, and that the land use plan considers important aspects such as infrastructure elements, culture, traditions, and sustainability which are called for. These requirements fit with the indigenous principles identified earlier in the paper which emphasize the importance of managing the land in a way that it is available for future generations, local sovereignty, and that community will and community knowledge is vital in indigenous plan-making which is incorporated in this Geodesign planning approach.

Implementation of the Navajo Nation Local Governance Act (LGA)

Fifteen years after the passage of the LGA, Gardner et. al. (2013) were asked by the Navajo Nation to review existing CBLUPs and recommend approaches for meeting the 5-year update requirement. They discovered that few Chapters had implemented any part of their land use plans and very few Chapters developed the required 5 year plan update. The final report argued that a lack of community participation in developing the plans and the limited use of geospatial technologies and land suitability analysis, among other capacity limitations, prevented successful implementation (Gardner and Pijawka, 2013).

In addition, the lack of follow-up in implementing plans due to funding issues resulted in diminished community involvement in planning.

WH Pacific, a consulting firm that worked with the Navajo Nation's Western Agency in the late 2000s, corroborates these planning limitations identified in the Gardner et. al. report. They further argued that competing and conflicting priorities within Chapters, a cumbersome land withdrawal process from grazing towards development, limited technical expertise for planning, incomplete community infrastructure and outreach plans, and piecemeal funding mechanisms severely hampered integrated community planning efforts within the Navajo Nation (W. H. Pacific, 2008). Limited community infrastructure relates both to physical amenities but also socio-cultural resources within the community to preserve culture and transfer community knowledge from one generation to the next. Many youth have moved away from the reservation for economic opportunities and a higher quality of life (Fixico, 2008). Over 50% of the Navajo tribal members now live outside of the Navajo reservation and unemployment within the Navajo Nation currently sits at 52%. This separation of generations prevents community traditions and local indigenous knowledge from being shared and transferred (Gardner & Pijawka, 2013; W. H. Pacific, 2008). Through effective planning strategies, including education resources, that promote economic development and improve local amenities, this higher standard of living will encourage younger generations to stay within the community increasing social and cultural resilience.

Complicating the issue further are past planning efforts led by the Federal government and private contractors on and off tribal land that prioritized optimized infrastructure development or material extraction, ignoring and destroying areas sacred to native communities. These practices have impacted American Indian communities' ability to preserve important sites and teach future generations to respect these places. Identifying impacted areas so that communities can plan for their preservation is a critical element in their community plans that can be dealt with in Geodesign workshops where such issues can be internally discussed (Necefer et al., 2015; Ward, 1992).

Land withdrawal for Chapter use is also an issue. The land withdrawal process in the Navajo Nation is much like eminent domain in the United States; private land is transferred to the Chapter for public use, but withdrawn land is most often taken at the expense of grazing permit holders who have the right to appeal and these lands are considered both cultural and economic assets. These appeals can extend project timelines beyond funding timeline requirements and put development on hold for long periods of time. This study argues that using a Geodesign approach can overcome many of these planning barriers especially those that result from cultural traditions resulting in agreed-upon Chapter land use designations based on community discussion and consensus – building grounded in geographic science, in addition to adhering to objectives and criteria found in the LGA planning requirements, many of which are basic land use planning principles.

Geographic Context

The case study centers on the Dilkon Chapter of the Navajo Nation (Figure 3.2). The Chapter is in Northeastern Arizona on the southern border of the Navajo Nation. It encompasses roughly 380 square miles with the town of Dilkon comprising 16.8 square miles. According to the 2016 American Community Survey, Dilkon Chapter's population is just over 2,000 people (99% Native American) with approximately 60% living in the town of Dilkon. Dilkon is a regional center for commercial and public services in the Navajo Nation, containing the Dilkon Courthouse, a regional Navajo Utility Authority and Housing Authority, and a commercial center with a large grocery store, gas station, and restaurant (Yurth, 2013b).

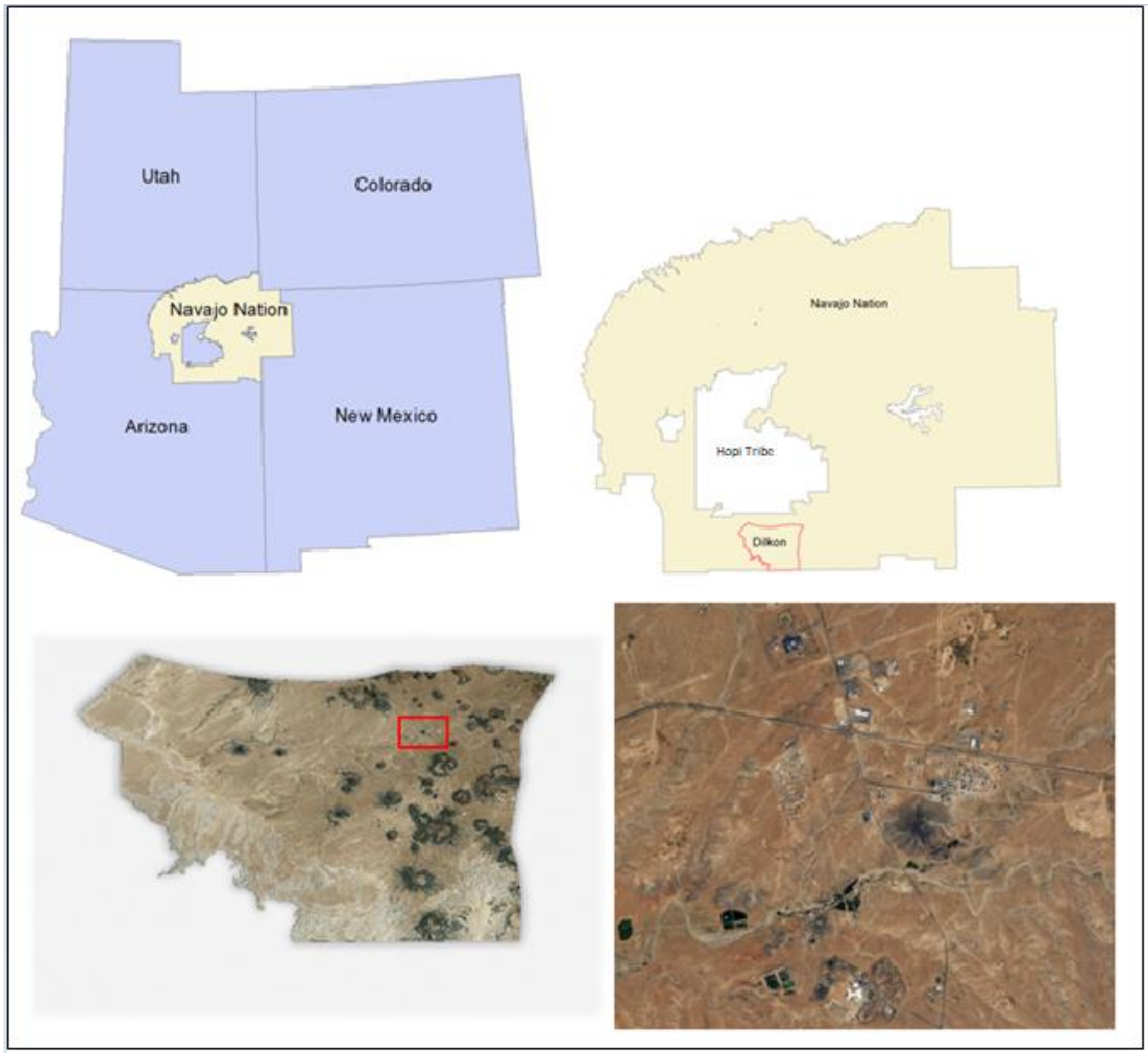

Figure 3.2: Top Left: Map of the four corners region of the Southwestern US with Navajo Nation Tribal Lands designated. Top right: Map of the Navajo Nation with Dilkon Chapter outlined in red. Bottom left: Satellite image of the Dilkon Chapter with the town of Dilkon Surrounded by a red square. Bottom Right: Satellite image of the town of Dilkon.

3.3 Research Plan

The methods applied in this research are principally evaluation methods, that asks if the Geodesign approach, technologies, and framework supports and enhances land use plan-making in Native American communities. The evaluation methods include both data collection and analysis. The data collection explores methods and rationale for collecting both quantitative and qualitative data through surveys, key informant interviews, and field notes. As a case study the analysis section discusses how the data were triangulated from multiple qualitative sources and analyzed to answer the research objectives (Yin, 2015).

3.3.1 Geodesign Process

The Geodesign process utilized in this case study consists of three phases that incorporate the Steinitz (2012) Geodesign iteration model. This includes:

1. Community Visioning and Engagement Sessions
2. Pre-Workshop Data Collection and Land Suitability Analysis
3. The Geodesign Workshop

Each of these phases informs the next phase within the process. For example, visioning sessions, where stakeholders can identify goals and needs within their community inform which pre-planning assessments need to be completed to inform and be used in the decision making in the Geodesign workshop. The assessments gather information about the characteristics of the environmental, biophysical, housing, infrastructure, and population and analyze how these data and projections impact future development or policy. For example, in this case study homes missing critical infrastructure such as running-water or electricity were identified and mapped so that they could inform stakeholder decision-making in the Geodesign workshop. This information can in turn be connected to spatial data and used for a land suitability analysis (Matta & Serra, 2016). Demographic trends can help show the need for new home development and school expansion. The land suitability analysis for example used existing land uses, environmental data, environmental hazards, infrastructure, and cultural values attached to the land when determining its future needs and suitability for specific uses. For each land use category the study area was evaluated for its suitability, given its barriers and constraints. Information that was considered for this analysis were landscape elements such as the slope of the land, soil type, distance to nearest infrastructure, vegetation, existing land use, cultural significance, and risk from environmental hazards, amongst other information specific to the land use to determine its suitability (Rodríguez-Merino et al., 2020; Surwase et al., 2019). The land use suitability analysis for this workshop followed a weighted-overlay analysis structure, which means not all factors in the analysis have the same importance to determine the suitability of an area for a specific use. This assigns the cost of a given area for conversion to a new land use designation. The areas of lowest cost or impact for development are given the highest value as ideal areas for specific or the most suitable land use designations while the lowest value is given to those with the highest cost (Ağaçsapan & Çabuk, 2019; Malczewski, 2004). During the Geodesign workshop phase, land suitability analysis results were used by participants, aided by experts, to create designs and planning scenarios for land use. These scenarios were discussed among participants and a land use plan was agreed upon. The land use plan developed in the workshop should become an integral part of the community's long-term strategic plan for adaptation and the process can be repeated as the community continues to change and develop.

The Dilkon Geodesign workshop itself engaged participants in 6 stages (Figure 3.3). Stage 1 provided participants information on the purpose of the workshop, community goals identified in the earlier visioning sessions, and introduced participants to the software, Geodesignhub. Geodesignhub is a planning software specifically designed to facilitate the sharing and creation of plans on geographic data, interacting with land suitability analysis results, comparing and negotiating plans, and develop implementation timelines. Throughout the workshop, participants from Dilkon Chapter used Geodesignhub to interact with land suitability maps to create land use designations, develop initial land use plans, and build consensus for a final plan to move forward on. Participants were able to develop their designs on the interactive land suitability analysis maps and satellite imagery and the impacts and costs of the plan were calculated. The second stage of the workshop included small group discussions and development of a particular land use designation based on participants' and stakeholders interest and/or area of expertise. This involves the rapid development of land use proposals based on a specific land use and their spatial allocation. The land suitability analysis is utilized in this second stage in particular with the opportunity to consult with experts both within and outside of the community. Each land use designation is created within the software and shared through the internet with all of the participants for their review, discussion, and feedback. The land use designations are color coded based on the land use, includes a general description of its purpose, and includes the size and location of the land use designation. This is all shared amongst the participants through the internet during the workshop.

In stage three the participants are redistributed into stakeholder groups that represent specific interests. These groups used the land use designs from Stage 2 to develop the first set of community-wide land use plans. The groups then present their land use plan to identified groups that could merge plans and come to a compromise. This process is repeated in stages 4, 5, and 6 until a final plan is developed and approved.

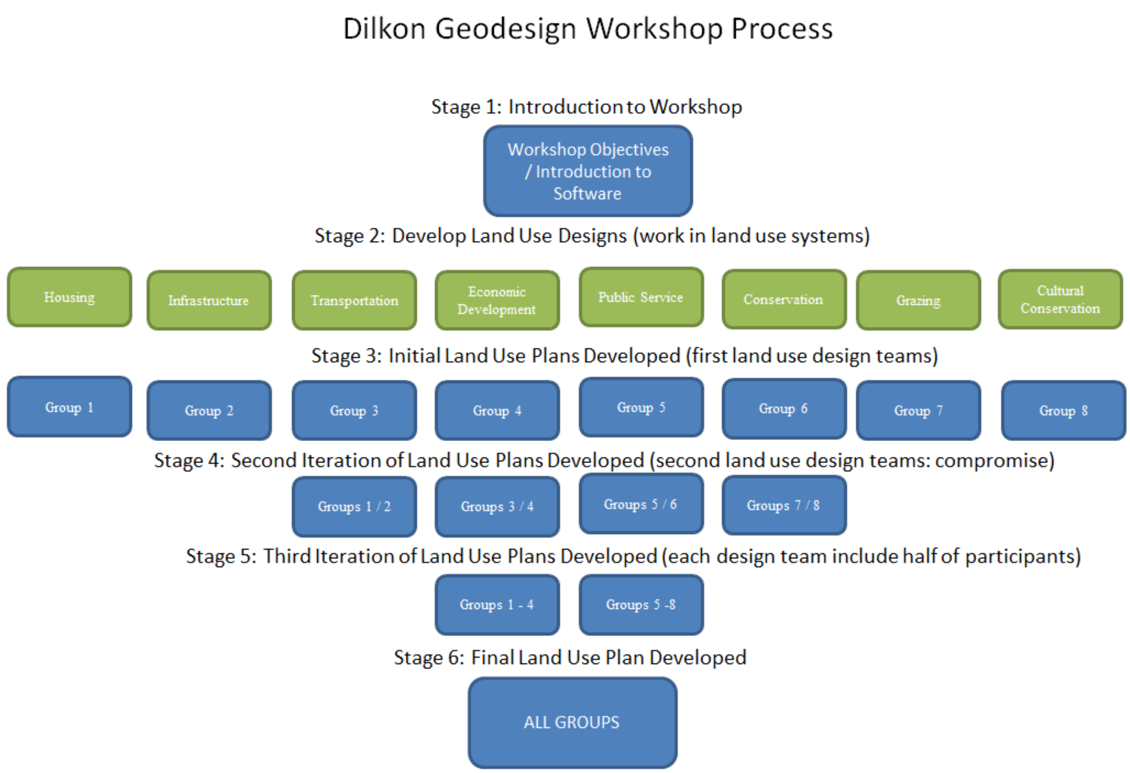

Figure 3.3: Geodesign workshop format implemented in Dilkon Chapter, Navajo

3.3.1.2 Workshop Participants

Over 40 stakeholders from the Dilkon Chapter were invited to participate in the Geodesign workshop, with 30 attending the 2-day workshop. There were four planners and two GIS professionals from the Navajo Nation along with three planners and two GIS specialists from outside the Navajo Nation engaged in the workshop to assist workshop participants. These planning and GIS experts were available for discussion on land use decisions, assisted in facilitating the workshop, and provided technical assistance when needed. The Chapter manager identified the stakeholders and invited Dilkon community members to the Geodesign workshop to participate and make land use planning decisions (Nyerges et al., 2016; Rivero et al., 2015; Steinitz, 2012). Invitees included Chapter officials, ranchers, community development professionals and local residents all of whom are key stakeholders and representatives of the community. These participants contributed local expertise in the planning process as well as detailed knowledge of historical landmarks, ecology, environmental hazards and traditional knowledge. Six government experts attended and participated in the process representing Navajo Nation government policy leadership and planners, but the actual land use designations were made by local participants to support local sovereignty and governance.

3.3.2 Evaluation Methodology

(a) Participant Surveys

A survey is designed to assess thoughts, perceptions, and opinions that can either be limited in generalizability or representative of a population depending on sample size (M. Q. Patton, 1999). Three surveys were administered at the beginning, middle, and end of the Geodesign workshop. The surveys primarily utilized both Likert-scale questions and open ended questions. The Likert-scale questions use a 5 point scale of strongly disagree (1) to strongly agree (5) with the purpose to discern participant level of agreement about statements concerning elements within the Geodesign process. These Likert-scale questions provide statistical insight on participant perceptions of Geodesign as a planning approach that effectively incorporates community values (Carifio & Perla, 2008). The first survey included open ended questions that asked the expectations for the workshop, what the participant hoped to contribute, and the vision for the community. The second and third surveys given at the end of day one of the workshop and at the end of workshop asked open ended questions that identify how each respondent was able to contribute in the Geodesign workshop, how conflicts were resolved in the Geodesign process, and if they planned on supporting the plan developed in the Geodesign workshop. The end of the workshop survey asked Likert-scale questions which included 1) Do you feel that your voice was heard in the Geodesign process 2) Do you believe that the plan developed today can be implemented in the future 3) Do you believe that the Geodesign plan developed today honors and reflects your culture and respects traditions / values 4) Would you recommend Geodesign as a planning method to other American Indian communities? The purpose of these questions were to evaluate perceptions of Geodesign's ability to incorporate indigenous values and to support consensus based planning.

This survey perception/attitudinal research uses a non-probability sampling structure that combines both the convenience and purposive sampling methods. Purposive sampling relies on the professional judgement and knowledge of a local authority to create an accurate sample (Etikan et al., 2016). The 'convenience' sampling method takes samples from what is available to the researcher (Field et al., 2006; Uprichard, 2013), which in both instances are the participants of the Geodesign workshop. In this case study, surveys were given to all available participants to provide data for the evaluation which included 18 for the initial survey and 14 for the final survey, respectively. The Geodesign facilitator also completed a thematic analysis of the qualitative data that utilized quotes from survey respondents. Themes were identified from these extracted quotes and then reviewed by three university researchers including a researcher from the Navajo Nation (J. Patton, 2002).

(b) Field Notes

Field notes are recorded observations by researchers either during or immediately after an event under study (Yin, 2015). In this case study field notes from four participants from the Geodesign workshop including the facilitator, planning professional, and two technical assistants. The facilitator provides insight into the general running of the workshop, the planning professional on the role of the planner in discussing potential land use ideas with stakeholders, and the two technical assistance who were embedded in multiple design teams. This information is used to create a narrative about the implementation of Geodesign workshop which triangulated workshop experiences from multiple perspectives.

(c) Key Informant Interviews

The goal of an interview is to discover unique insights from the interviewees perspectives from an event or experience (Leech & Onwuegbuzie, 2007; M. Q. Patton, 1999). In this case study, two key informant interviews were conducted three months after the conclusion of the Geodesign workshop in order to evaluate if community perceptions of the Geodesign workshop remained consistent with experiences immediately following the workshop (Weiss, 1998). Key informants are interviewees who have in depth knowledge of the community and can provide insight for an event from a local perspective (Marshall, 1996). The key informants for this research include the Chapter Manager and a member of the Chapter Land Use Planning Committee, both of whom participated in both days of the Geodesign workshop and received informal community feedback at the conclusion of the workshop. The 45 minute interviews were conducted by the facilitator of the Geodesign workshop whose recorded audio was later transcribed. The interview was semi-structured with the overall purpose to identify opportunities for improvement in conducting Geodesign workshops in American Indian Communities, how community vision was incorporated in the Geodesign workshop, and the support within the community for the land use plan developed by community members.

(d) Triangulation

This research follows a case study approach that focuses on the collection of qualitative and quantitative data (Yin, 2015). Data collected and analysis methods are depicted in figure 3.4. Qualitative data for the Geodesign evaluation included answers to open ended survey questions given throughout the workshop, interviews of technical assistants and participating experts, recorded video of the workshop, notes from the workshop facilitator, and information taken from interviews of key informants from Dilkon Chapter. The data collected from these sources was organized, analyzed, and interpreted through a thematic and inductive analysis (Clarke & Braun, 2017; Lorelli S. Nowell et al., 2017). A 'thematic analysis' enables the researchers to also triangulate multiple data sources and identify themes and patterns to provide some insight in answering the evaluation questions related to Geodesign and indigenous planning (Cavanagh, 1997). It is a method to validate a finding using disparate findings and data. The primary quantitative data utilized for this evaluation included five-point Likert scale questions on surveys collected at two points during the workshop (Norman, 2010). Surveys were administered prior to the start of and at the end of the workshop in order to measure evolving stakeholder perceptions and experiences of the Geodesign process (Weiss, 1998). The data collected from these surveys were analyzed through descriptive statistics (Boone & Boone, 2012; Joshi et al., 2015).

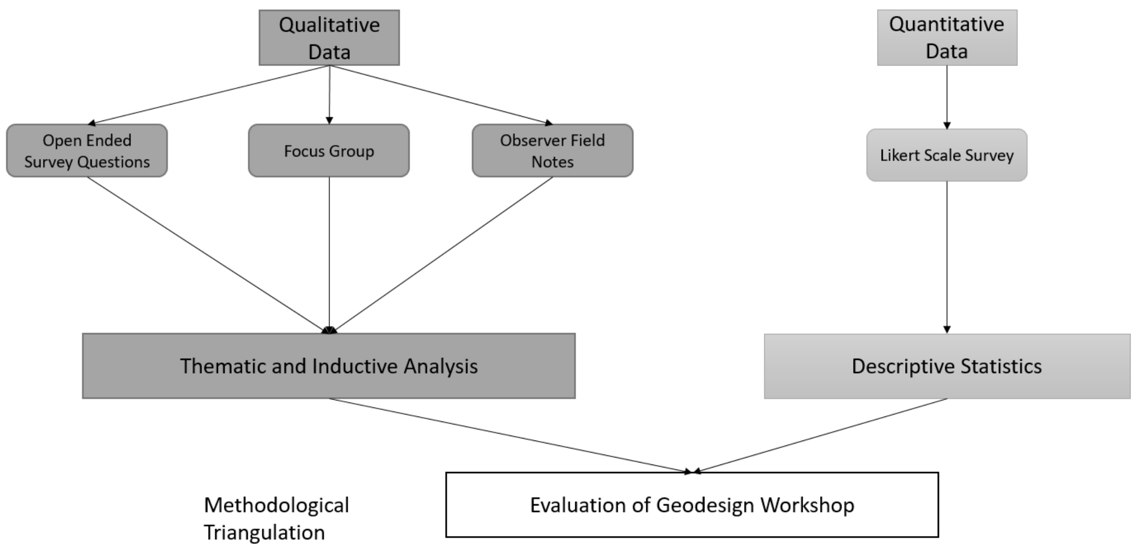

Figure 3.4: Methods and data collection for the evaluation of the Geodesign workshop.

Triangulation analysis is used both in qualitative and quantitative research in case studies to verify findings by using multiple data sources, methodologies, or observers (Yin, 2015). In this research, data triangulation and methodological triangulation are used to validate answers to the research questions. Data triangulation will compare the findings of multiple qualitative data sources to validate similar findings and results as they relate to the research question (Leech & Onwuegbuzie, 2007; J. Patton, 2002; Weiss, 1998). Methodological triangulation in this research utilized both quantitative and qualitative approaches (Jick, 1979; Leech & Onwuegbuzie, 2007).

3.4 Results

Geodesign Empowers Communities to Create Consensus-Driven Land Use Plans

A significant hurdle for many Native American communities is developing a land use plan that incorporates community values and traditions, is built on consensus, and is supported by geospatial analysis. The results of the Geodesign workshop showed that Dilkon Chapter completed a land use plan that started with eight different visions of land use demarcations, and through negotiation resulted in one consensus-driven community-based land use plan. The plan (Figure 3.5) confirmed a pending hospital location and identified roads that should be paved to improve access to land that participants identified for economic development. This plan includes an additional 120 acres of land allotted (mostly in the center of town) to accommodate secondary economic development opportunities generated by the hospital. The additional acreage increases the land available for economic development by more than 5 times what was allotted in the earlier 2001 plan. To complement the incoming hospital Dilkon designated an area for secondary needs such as a morgue, a satellite facility to train nurses and medical assistants, and temporary housing for families.

Participants also planned for sustainability by allocating 475 acres of public service land for a solar field southwest of the town in addition to a community park surrounding Dilkon Hill. This community park was spontaneously and creatively generated by the community in the workshop as they discussed what land use could greatly benefit the community's youth. Additionally, roughly 160 acres was allocated for housing of which most of this was set aside to accommodate a growing population and residential needs of future hospital staff. Outside of town, just under 5,000 acres was designated for conservation. Areas for conservation included land traditionally viewed as important to the Dilkon Chapter and which the community desired to prevent future development. Geodesign has the ability to provide empowerment through consensus driven decisions about land uses including protection of places that provide cultural significant.

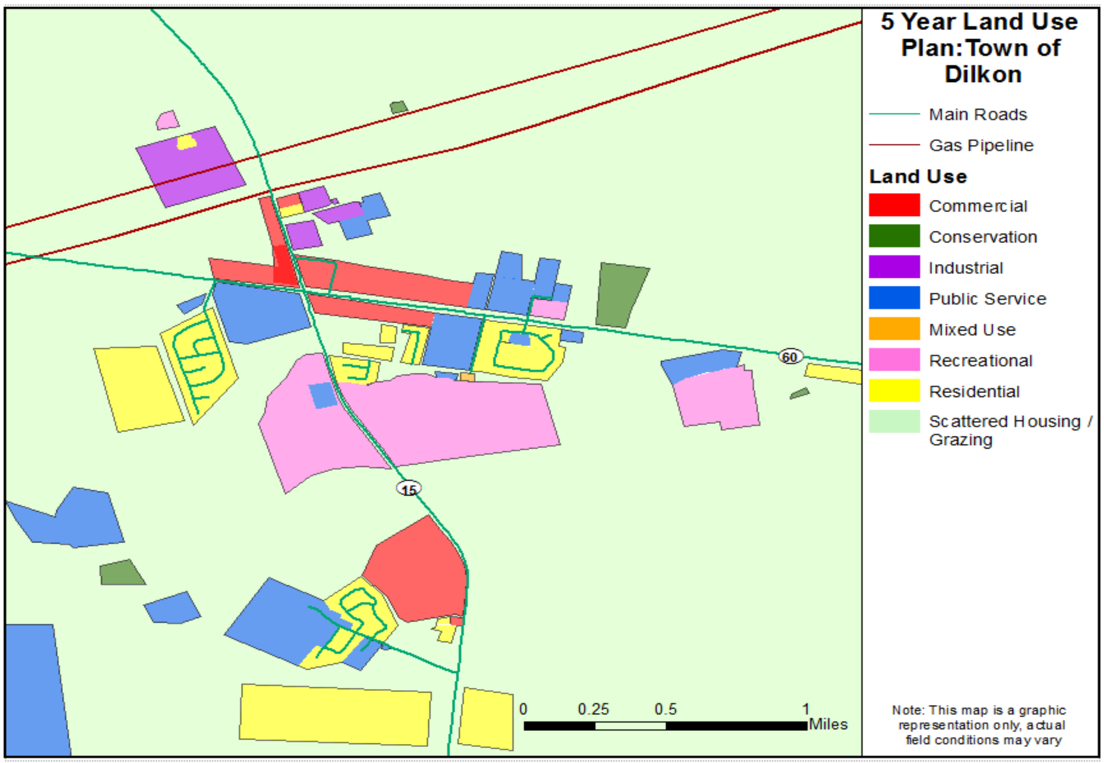

Figure 3.5: Five-year Community Based Land Use Plan for Town of Dilkon developed in the Geodesign workshop.

This completed land use plan places importance on the criteria for plans as required by the Navajo LGA for local community-based governance. The LGA requires that all CBLUPs: 1) contain a clear participation plan that demonstrates that the resulting land use plan derives from community members and Navajo Traditions; 2) account for cultural, environmental, and demographic resources; 3) incorporates ‘land carrying capacity’ in its considerations; and, 4) shows land designations that anticipate and meet the future needs of the community. The plan requires land uses that specifically meet community needs as specified by community members. The accepted plan is community based through consensus derived decision making and further supported through geospatial analysis.

The first requirement was partially met through community visioning sessions conducted by the Chapter prior to the Geodesign workshop and through the workshop itself. Visioning sessions offered community members an opportunity to voice their goals, needs, and vision for the Chapter’s future including strategic goal-setting. Geodesign enabled community representatives to build upon this information and develop a consensus-based land use plan. The second and third requirements were met through the pre-planning assessments, land suitability analysis, and the workshop. These assessments were able to determine the natural resource and conservation potential within the community and determine the overall carrying capacity through spatial analysis. GIS and planning professionals, working with the Dilkon Land Use Planning Committee, conducted the assessments and gathered the necessary spatial data to create a robust land suitability analysis that could be validated by local knowledge of the area. Geodesign facilitates the contribution of local knowledge to both be reflected in the final land use plan and to validate the land suitability analysis (Figure 3.6). This transparency with stakeholders and inclusion of local knowledge built trust in the planning process which in turn further facilitated community contributions. The fourth requirement was met by the final CBLUP, which emphasized diverse land use designations grounded in the land suitability analysis. No land use recommendation made it into the final plan that was not listed as suitable or feasible.

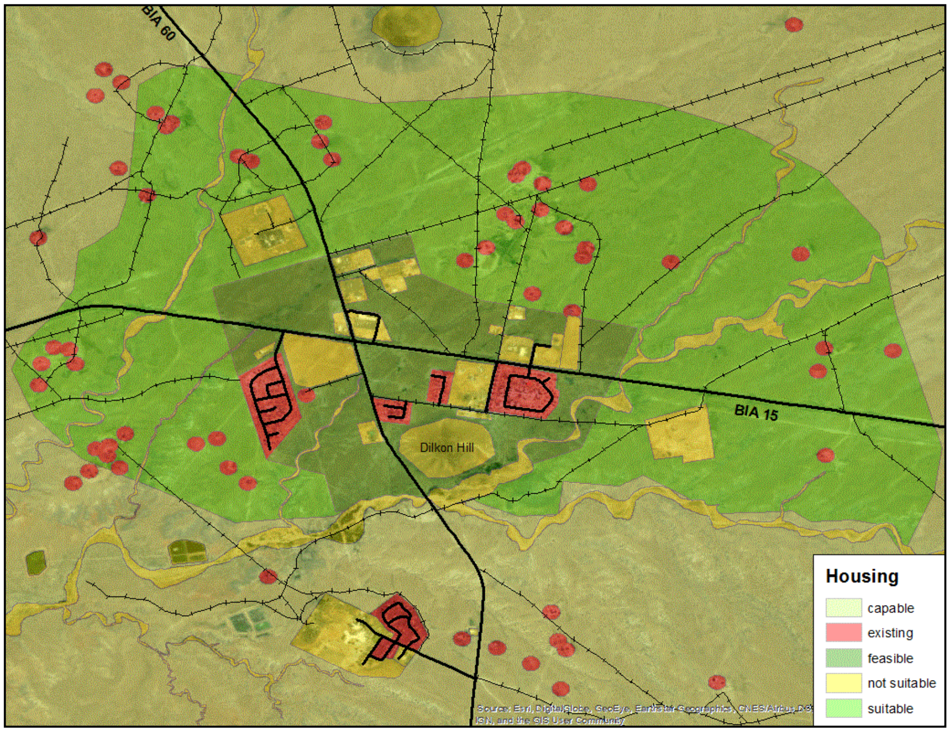

Figure 3.6: Land suitability analysis for housing in town of Dilkon.

Survey Results

The purpose of open-ended questions in these surveys was to capture the unique insights and perceptions of community members that participated in the Geodesign workshop. The first survey was completed just prior to the start of the Geodesign workshop and was completed by 18 Dilkon community members. The open-ended questions included:

1. What are your expectations for the Geodesign Workshop?
2. What do you hope to contribute in the Geodesign workshop?

3. What is your vision for Dilkon community for which the land use plan is being done?

There were three main themes identified within these expectations of the workshop participants which included the expectation to learn, the expectation to create a land use plan, and the expectation that the participants would work together to reach consensus. Within the learning theme participants identified that they expected to "learn to create maps", "learn the Geodesign process for land use" and "learn what was shared here and share it with the community." In regards to creating a land use plan they expected "to work together for a better Dilkon Chapter" and "see the future of Dilkon on a bright path, bring family and income into Dilkon (and) find balance of ranching and farming." This 'bright' path for many participants tied directly to their vision for Dilkon Chapter which included the promotion of a healthy rangeland, new economic opportunities, the exploration of renewable energy, and prioritizing long term planning with cultural preservation. Local input was the predominant theme received from respondents in regards to what they hoped to contribute to the land use plan, with minor themes including translating for elders, and protection of local cultural and natural resources. Specific examples of local input included the desire "contribute ideas that can improve the Dilkon community for community members" in particular "offer ideas and insight on items for projects that have been overlooked." Many of these comments fit within the indigenous themes of planning for the future to provide for future generations economically and culturally and that local knowledge in plan making is critical for identifying true needs within the community and for preserving the community (Jojola, 2013).

The second and third survey asked the same Likert-scale and open-ended questions. This was done in order to capture perceptions of community participants who could only attend one day of the workshop. The end of day 1 and the day 2 surveys had 15 and 14 respondents respectively. There were two open ended questions included in these surveys:

1. How were you able to contribute in the Geodesign Process?
2. How were disagreements resolved?

An important indigenous value in planning is that local knowledge be it traditional stories, personal experience, or native knowledge of the land are important decision support factors in the planning process. Throughout the Geodesign workshop many of the participants were surprised to the degree in which their ideas and knowledge were incorporated into the planning process. Dilkon community members indicated that they were able to facilitate discussion, provide personal knowledge and wisdom in the planning process, and make decisions for the betterment of their community. This is shown when one member stated, “I was able to decide where the locations and proposed housing and business sites would be” and another expressed excitement, “Wow! I was able to have input in the planning” and I was able to “help a lot more than I expected” and really “impact the design.” Others felt that they were able to “break down the concepts to my table and using consensus building to make map decisions,” and another said that they “took notes, listen(ed) to the group ideas. Added to it, branched ideas from their ideas." An additional participant indicated that "I plan on informing friends, family, and neighbors, and tell them to get more involved and ask if they have any ideas." Most importantly the general consensus among participants was that their "idea(s) were implemented as benefiting the entire community collectively." This is critical in many ways as one major issue in the Navajo Nation is that people often feel that plans are typically not implementable because of a lack of community input, or that it is perceived as not benefitting the entire community (Gardner & Pijawka, 2013).

We argue that Geodesign can be a platform to not only incorporate indigenous values within the planning framework but to also incorporate a synthesis of multiple, potentially conflicting visions for the future of the community to create a consensus and community-based land use plan. The second open-ended question, related to the ability to resolving disagreements. Several indigenous themes manifested in their responses including the importance of local knowledge in informing decision making. One participant indicated that "talking things out, according to fundamental principles rooted to traditional values of respect for one another. Dine (Navajo) fundamental law is based on cultural respect. Words are sacred and should never be taken lightly." The majority of participants agreed that "talking things out" and using the maps to "come to common ground" resolved many of the issues. The ability to discuss their ideas and show their ideas in its geographic extent greatly assisted in building consensus.

Likert Scale Results

Table 3.1: Likert scale results from end of workshop survey.

DAY 2	**Do you feel that your voice was heard in the Geodesign Process?**				
SCALE	Strongly Disagree **(1)**	Disagree **(2)**	Neutral **(3)**	Agree **(4)**	Strongly Agree **(5)**
RESPONSES	0	0	1	3	10
PERCENTAGE	0	0	6.2	21.4	71.4
AVERAGE	4.64 (Total Respondents 14)				
DAY 2	**Do you believe that the Plan Developed Today can be implemented in the Future?**				
SCALE	Strongly Disagree **(1)**	Disagree **(2)**	Neutral **(3)**	Agree **(4)**	Strongly Agree **(5)**
RESPONSES	0	0	0	6	8
PERCENTAGE	0	0	0	42.8	57.2
AVERAGE	4.57 (Total Respondents 14)				
DAY 2	**Do you believe that the Geodesign Plan developed today honors and reflects your culture and respects your traditions / values?**				
SCALE	Strongly Disagree **(1)**	Disagree **(2)**	Neutral **(3)**	Agree **(4)**	Strongly Agree **(5)**
RESPONSES	0	0	2	5	7
PERCENTAGE	0	0	13.33	46.67	40
AVERAGE	4.267 (Total Respondents 14)				
DAY 2	**Would you recommend Geodesign as a Planning Method to Other American Indian Communities?**				
SCALE	Strongly Disagree **(1)**	Disagree **(2)**	Neutral **(3)**	Agree **(4)**	Strongly Agree **(5)**
RESPONSES	0	0	1	3	10
PERCENTAGE	0	0	6.2	21.4	71.4
AVERAGE	4.64 (Total Respondents 14)				

At the conclusion of the Geodesign workshop Dilkon Chapter community members were asked the following four Likert-scale questions:

1. Would you recommend Geodesign as a planning method to other tribes?
2. Do you feel that your voice was heard in the Geodesign process?
3. Do you believe that the plan developed today can be implemented in the future?
4. Do you believe that the Geodesign plan honors and reflects your culture and respects your traditions and values?

When asked immediately after the workshop if they would recommend Geodesign as a planning method for other indigenous communities 92.8% of participants strongly agreed (71.4%) or agreed (21.4%) with the statement. At the end of the workshop one community member remarked in his survey that "this would be a great workshop for most (Navajo) Chapters… the service being provided is easily adaptable for community use." The ability to promote local decision making in the planning process places the planning power firmly within the local American Indian community. Many indigenous communities have felt left behind or excluded from traditional western planning processes and these strong responses indicate that Geodesign has been able to incorporate the community traditions and values within the planning process. In regards to whether or not the community members felt that their voice was heard, 92.8% participants either strongly agreed (71.4%) or agreed (21.4%) that their voice was heard. This is largely due to the focus on local decision making within the workshop and that the plans were designed by community members with the aid of professional planners. This is opposite of planning experiences where community members are informed of the planning efforts but ultimately expected to sign off on what the outside professionals have planned. All of the participants agreed (42.8%) or strongly agreed (57.2%) that the plan developed in the workshop would be implemented as the community land use plan in the future. The planning study completed by Gardner et al (2013) found that there was little optimism about implementation, but with this Geodesign approach there is. Finally, when asked if the Geodesign plan honors and reflects their culture and respects community values and traditions 86.67% of the participants strongly agreed (40)% or agreed (46.67%) with the statement. Cultural and traditional values were incorporated in the planning process by including local community decision making traditions and the participation of Navajo Nation experts both within Dilkon Chapter and the Navajo Nation government in the planning process.

Key Informant Interviews

The interviews conducted three months after the conclusion of the Geodesign workshop included two key informants, the Chapter Manager of Dilkon and a Land Use Planning Committee member, both of whom had participated both days of the Geodesign workshop and had received informal community feedback from both community members who participated in the Geodesign workshop and non-participants. The interviews asked:

1. Were community values and ideas incorporated into the land use plan?
2. How were disagreements resolved in the Geodesign process?
3. What is the current community support of the land use plan?

The interviewees argued that the participants in the Geodesign workshop took their roles seriously as representatives of the community, who would make decisions on behalf of their friends, family, and for future generations. They stated that the participants indicated that they “had the vision in mind, because the majority of the participants there were basing their decisions on the visioning that came up (in the earlier visioning workshops). So when we got to the workshop they were trying to include all of visions in there.” There were disagreements within the land use plan, but the key informants agreed that “talking things out” and being “able to see things on the map” helped resolve many disagreements. They also mentioned that “the whole process was really effective in terms of bringing out (ideas), pulling us more into … focus of what can and could be the reality of our environment. When you put it up (on screen) the peoples ideas, you were challenged, you wanted to jump in, you wanted to act, you wanted to be involved and to help and build this.” The excitement felt within the Geodesign workshop and the enthusiastic support persisted well after the workshop. Many community members inquired about the status of the land use plan and were curious about the Geodesign process. The interviews reported that they “received a lot of positive responses. Everyone was excited. Word got around and we had people that told us that I wish that I would have gone.”

3.5 Discussion

According to Gardner and Pijawka (2013), a central issue in Navajo Nation planning has been that community voices are often not heard or incorporated in the planning process in contrast to the objectives of indigenous planning. The Geodesign framework not only allowed participants voices to be heard; it also empowered them to utilize traditional indigenous approaches to reach consensus in regard to planning scenarios. All participants in the Likert-scale survey agreed or strongly agreed that the plan will be implemented. This indicates that the participants view this process as more than an exercise, but a means for producing an implementable plan that is trustworthy and community-driven with stakeholder interests, issues, concerns, and ideas taken into consideration. Since it engaged a diverse, representative set of community members in the planning process and is informed by community visioning sessions, the plan is expected to be readily supported by the broader community and because an official updated plan is part of the legislated Local Governance Act which specifies the criteria for acceptable land use plans. The plan-making model at the Navajo Chapter level was not for producing a 'comprehensive' plan but for developing a specific 'community-based' plan. In this way, this definition of planning corresponds to a bottom-up participatory decision-making approach that was through the Geodesign process.

We found that the Geodesign framework fostered openness and trust in the planning process and decision-making due to its community-based planning approach that firmly established control and ownership of the plan by the community. Success is reflected in the use of new land use designations for the community that met evolving needs within the Chapter such as recreation, conservation, and renewable energy development, the use of land suitability analysis, deliberate engagement of a broad range of stakeholders, and discussions and successful compromise between groups. The use of GIS mapping as both an educational medium and a way to visualize plans permitted creative and effective compromises. This embraced indigenous planning traditions of knowledge sharing and promoted sustainability while satisfying the Navajo Nation Local Governance Act (LGA) requirements (Kovach, 2015).

This case study also demonstrates that Geodesign can overcome identified barriers to plan-making in Indian country such as lack of community input and consensus identified by Gardner and Pijawka (2013) as well as providing opportunities for sharing community traditions with the next generation. For example, a group of elders from Dilkon Chapter identified areas traditionally important to the community and now a map exists that preserves this community knowledge at the Chapter for future generations. During the workshop, community members actively engaged with others to discuss future possibilities, ask questions, and contribute insight for potential land uses. These informal interactions are critical for compromise and acceptance, and are strong examples of indigenous decision-making through community-based local knowledge and the importance of relationships in the decision making process (Kapyrka & Dockstator, 2012; Wheeler et al., 2016).

The original land use plan was limited to existing land uses and designating land for a future hospital and new housing. The new Geodesign-based plan tapped into community knowledge to identify potential projects and more diverse land uses, including economic development, conservation, public services, recreation, energy development, and infrastructure improvements as well as clustered housing by far expanding the idea of planning to consider improving the quality of life for members within the community, especially the concept of designating a park for recreation and community gatherings. This expansion permitted Chapter members to consider future needs such as cultural resiliency traditions and conservation, a significant aspect of Navajo and indigenous planning (Cardinal, 2001; Kelley, 1986). Importantly, the community now has a digital plan and GIS-based maps that can serve as the basis for future planning efforts and adaptation.

The land use plan identified these 'conservation areas that would have been neglected through conventional planning approaches. Here the involvement of the elderly provided local knowledge that was utilized to protect traditional and spiritual landscapes needed as 'cultural resilience'.

This study has demonstrated that, as a community-based planning method, Geodesign promotes self-sufficiency for the Dilkon Chapter and sovereignty within the Navajo Nation, and effectively gives voice to Navajo community members to plan their own future. The notion of sovereignty to govern themselves and to have the inherent right to make decisions for their community and their land for themselves is an important goal and objective, and Geodesign as a planning tool pushed the concept of sovereignty and local ownership of land use decisions. The use of surveys to collect attitudinal and perception data to determine planning success was seen as useful methods to measure various success factors.

3.6 Conclusion

Geodesign shows great promise as a planning process that can empower indigenous communities and incorporate cultural and traditional values along with western planning methodologies. The four primary indigenous values identified at the start of this paper are local sovereignty, sacredness of the land, relatedness, and local oral and experiential knowledge where all present and incorporated within the Geodesign planning framework. In relation to local sovereignty, a common sentiment from the surveys was "I know my community and had fun making decisions on where and what should go there" and "I was able to decide where the locations and proposed housing and business sites would be."

This theme of local knowledge informing decisions and supporting local sovereignty was reiterated in the key informant interviews that took place three months after the workshop. The group reported that they were able to use the land use plan and suitability analysis to locate a proposed hospital housing site. The site was moved to one of the housing areas designated in the workshop, as the land analysis demonstrated the flood risks at the original site. The Geodesign framework allowed the community to identify and approve a more suitable area for this housing. A plan built upon consensus and supported by geospatial data empowered Dilkon Chapter to guide development in their community.

The Geodesign workshop also provided participants the opportunity to incorporate the indigenous values of sacredness of the land and the importance of community and experiential knowledge into the land use plan. In referencing the elders who participated in the workshop, one community member remarked, "with respect to conservation and cultural preservation, I think it is very important to involve community elders in this type of workshop, so to provide a wealth of cultural and historical narrative to designation or establishing a conservation area."

There was a consistent theme of preserving the land and the culture for the future while improving the overall quality of life and providing opportunities for youth throughout the workshop. For example, a community member commented, "I brought up a cultural center and a community/native garden, and the group liked the idea. Then when we heard that another group had a multi-purpose center, we added our cultural center and garden to the multi-purpose center." The need for a community building that allowed for both recreation and learning about the land and culture was prioritized by the community.

Using Geodesign enabled Dilkon Chapter stakeholders to demonstrate to the Navajo Nation and federal government that they have a plan for their community that is both scientifically rigorous and grounded in community values and traditions. Workshop participants consistently discussed the importance of planning for the future and their plan reflects this. The community identified economic development opportunities and sustainability initiatives that fit within their community culture and support jobs for young people so that they can stay in the community and support themselves. Knowledge sharing is at the forefront indigenous planning process. In the visioning sessions prior to the workshop and at the Geodesign workshop itself, community members were able to identify their goals for the community and contribute their local knowledge of the community, to determine a future direction. Of course, a concerted effort in developing suitability analysis mapping, housing analysis and other assessments, pre workshop visioning, and workshop computer management was all necessary for success.

CHAPTER 4

RESILIENCY-BASED COMMUNITY PLANNING IN DATA SCARCE AREAS: FLOOD RISK ASSESSMENT USING GEODESIGN IN THE TOHONO O'ODHAM NATION

4.1 Introduction

Communities have become increasingly vulnerable to flood risk as severe weather and flood events become more frequent and their impacts more severe. Many areas around the globe, however, lack the necessary data to assess vulnerability and to adapt and prepare for these increasing flood risks (Gupta, 2007). Data scarcity is primarily due to regions not having the technological and economic assets to collect information about their environment (Openshaw & Goddard, 1987; Thakur & Sharma, 2009; Williams et al., 2014). The lack of available data on the magnitude of these hazards often results in inadequate improvements in infrastructure and resiliency plans. This limitation in planning to attenuate future risk makes these areas less resilient to future disasters and reduces their ability to recover (McEwen & Jones, 2012). Prescient land use planning to reduce flood risk can minimize the consequences of these events which can be serious, extensive, and costly (Burby Raymond J. et al., 2000; King et al., 2016). Much of the flood risk research in resiliency planning and geographical sciences is focused on urban areas often around coastal cities, island nations, or on major inland waterbodies (Brody et al., 2009; Gupta, 2007; Lhomme et al., 2013; Maheu, 2012; McEwen & Jones, 2012). Research for strategies for land use plans to reduce risks of flash floods are rarer but typically target vulnerable urban areas (Bodoque et al., 2016) over rural locations (Boon, 2014). Rural areas require different resiliency strategies than urban areas and can become more resilient through careful development strategies (Kapucu et al., 2013). This research evaluates Geodesign as a planning framework that can be utilized to empower a data scarce American Indian community to utilize local knowledge to validate and improve remotely sensed predictive flood models to create a flood-resilient community-based land use plan.

Actions taken to reduce the vulnerability of places from extreme weather events and lessen impacts are known as climate resiliency. Climate resilience refers to the ability of a community - and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales – to maintain or rapidly return to desired functions in the face of a disturbance, to adapt, to change, and to quickly transform systems that limit current or future adaptive capacity (Meerow et al., 2016). Resiliency emphasizes implementing strategies and structures that strengthen the community to resist adverse events or circumstances and quickly return to the desired state of the community (MacKinnon & Derickson, 2012).

The four foundations of community resiliency are economic capital, social capital, environmental capital, and adaptive governance (Buckman & Rakhimova, 2015). These foundations of resilience directly correlate to how well a community can prepare, reduce the impacts, and recover from adverse events. Recently, the literature suggests an approach to resiliency planning through community participation. Economic capital in resiliency refers to the diversity of the economy and how well a community can withstand losses in markets or shocks to its economy. A community that has strong economic capital has numerous income revenues that can keep the community financially healthy in the event that one industry is adversely affected and the capital to invest in resiliency infrastructure. Also, this concept refers to economic resources available to rapidly rebuild infrastructure and other resources in the event of a disaster (Sherrieb et al., 2010). Social capital refers to citizen engagement and cohesion, the strength of the bonds between community residents, and the links to other communities and organizations for support. A community with strong social capital will have strong community bonds and active social organizations that will aide community members affected by adverse events, and make connections within and outside of the community (Magis, 2010; Putnam, 2001). Environmental capital is the ability of the surrounding environment to support the community. This means that environmental processes that historically have made communities more resilient to natural disasters are strengthened and preserved (Buckman & Rakhimova, 2015). Finally adaptive governance is the ability of the governing structures to adapt to ecological, economic, political, and social changes in a meaningful way that can accommodate and plan for both long and short term disruptions (Olsson et al., 2004; Quay, 2010).

Many rural areas in the United States, such as American Indian communities in the Western United States, lack accurate flood risk data and some are without federally-based risk maps. Unlike the vast majority of the United States, many American Indian communities do not have flood zones identified within their boundaries because of non-participation in the National Flood Insurance Program. This makes it difficult and or expensive to create land use plans that consider flood risk (NAIHC, 2017). Planning for these communities is further complicated by a lack of geospatial data readily available for general planning purposes (Walker et al., 2013).

This research explores a participatory land use planning approach through Geodesign to reduce flood risk and impacts in an American Indian community that has limited spatial data resources and planning experience. We evaluate Geodesign as an adaptive planning approach that can empower an American Indian community in the Southwestern United States to develop a land use plan that incorporates community flood risk resiliency, utilizes community knowledge in land use planning decision support, engages community members to utilize science and spatial analysis for land use decisions, and be guided by community values and traditions. It exemplifies the ability of a marginalized and data scarce community to utilize a combination of community-based resources to develop resiliency options.

4.2 Related Work

The following section provides key context for the research in relation to addressing data scarcity to build resiliency against natural hazards for land use planning efforts. This includes background on public participation, hazard perceptions, hazard mitigation, local knowledge, and data scarcity. The benefits of participatory GIS through Geodesign in merging geospatial analysis and resiliency planning are also outlined including past applications of Geodesign. Geodesign is reliant on abundant and accurate geospatial data to be effective in planning approaches and local knowledge can strengthen data quality for data scarce areas in Geodesign applications.

Public Participation

Since the 1970's planning theorists have argued that local communities, particularly those that are a minority or historically marginalized should be informed and consulted in planning and policy efforts and have the opportunities to express their values and interests in government decisions (Burke, 1979; Fagence, 1977; Slotterback & Lauria, 2019). Many local governments in the United States and Canada require community engagement in the urban planning process (Arnstein, 1969; Day, 1997; S. Fainstein & Fainstein, 1985). In the belief that engaging the local community builds goodwill and trust in the process and develop a sense of local ownership of the plan and trust in the decisions (Fagence, 1977; Oulahen & Doberstein, 2012). The public values expressed through citizen participation provide public sentiment on proposed policies and local knowledge about the area that otherwise would not be available for decision making (Blue et al., 2019; Day, 1997; Rich, 1986). In addition to these benefits, greater public involvement can generate unique solutions for local problems, build local capacity, enable local engagement with decision makers, and develop social capital (Berry et al., 1993; Laurian & Shaw, 2008; C. W. Thomas, 1998). Natural hazard mitigation plans have historically had limited community involvement and only recently has local engagement been promoted in these planning efforts (Allen, 2006).

Hazard Perceptions

Local residents experience flooding events and are aware of the extent and damage that can be done to their community and are therefore able to identify local threats (Azevêdo et al., 2020). Community perception of hazards, both technological and natural, will determine how a community will respond to hazard events (Kasperson & Pijawka, 1985). Communities that perceive natural hazards as threats that can be mitigated are more likely to adapt and become more resilient to these events than those that view hazards as out of their control (Kasperson & Dow, 1993; Ross, 2016). Communities that believe that natural hazards can be mitigated will invest in infrastructure, educate their communities, and create public policies that reduce their vulnerability to these events.

Hazard Mitigation

Disaster Risk Reduction plans and Climate Change Adaptation plans seek to reduce the vulnerability of communities to natural and manmade hazards and adapt through infrastructure development, education, and public policy decisions (Allen, 2006; Gero et al., 2011). Adaptation allows communities to identify risk (frequency of an adverse act and consequences), make decisions to reduce risk, implement those decisions, and evaluate the efficacy of those decisions (Dynes, 1998). Disaster management has historically been a top down approach, typically completed by the Federal government, that has only pushed for citizen participation over the past 30 years (Allen, 2006). Recruiting local participation for hazard planning events has been difficult because communities assume that government sufficiently address hazard risk, that they do not possess specialized knowledge for effective decision making in hazard mitigation, and that most local involvement in planning efforts relate to discouraging unwanted development and not building resiliency against hazards (Godschalk et al., 2003; Oulahen & Doberstein, 2012). The primary mechanism that local communities have increased their resiliency against natural disasters is through the development of local knowledge through increased education about natural hazards, how to responding to hazard events, and local strategies for reducing future hazards (Begum et al., 2014; Forino et al., 2016; Gero et al., 2011; Norton et al., 2019). Developing land use plans that accommodate for natural hazards is an important strategy for reducing community vulnerability and promoting resiliency but on the basis of geospatial risk data (Burby, 1998; Burby et al., 1999; Burby Raymond J. et al., 2000; Godschalk et al., 2003; King et al., 2016; Stevens, 2010). This prescient land use planning becomes a challenge when data concerning environmental hazards are scarce or unreliable.

Data Scarcity

Reliable and robust data are essential for modelling environmental risks and for assessing environmental hazards. Data scarcity reduces the reliability of predictive models and inaccurate assessments can be environmentally and financially costly (Ritzema et al., 2010). To overcome data scarcity communities have used citizen science to create more robust data sets (Buytaert et al., 2014; Buytaert Wouter et al., 2016), participatory GIS to utilize local knowledge of an area (Maheu, 2012; Singh, 2014; White et al., 2010), connecting environmental principles to known biophysical data to infer environmental information (Townsend et al., 2014), rapid reconnaissance of an area (Ritzema et al., 2010), and triangulating simulation models (Ireson et al., 2006). Many of these methods rely on community involvement and local participation to supplement existing data.

Local Knowledge

Local knowledge has become increasingly important in validating scientific analysis risk and in explaining discrepancies in hazard modeling (McEwen & Jones, 2012). This local knowledge can take the form of 'knowing' local information where community members can identify obstructions or deficiencies in the infrastructure, traditional knowledge which is cultural knowledge and traditional practices related to the environment, and historical knowledge of past hazard events (Dalton et al., 2018; Kates, 1976; McEwen & Jones, 2012). This information can be used to validate spatial data developed through spatial analysis (Dalton et al., 2018; Gero et al., 2011; McEwen & Jones, 2012; Tran et al., 2009).

Participatory GIS

Participatory GISystems seek to increase access and use of geospatial technologies to empower marginalized groups and enable these groups to create, edit, and analyze their knowledge of the environment as spatial data (Dunn, 2007; Elwood, 2006; Tran et al., 2009). In order to ameliorate the uneven access and use of geospatial technologies to marginalized groups, participatory GISystems provides opportunities to contribute knowledge electronically, verbally, and through paper form which can then be converted into spatial data (Chambers, 2006). This spatialization of local knowledge can transform the way these communities can perceive and govern their environment (Darvill & Lindo, 2015; Kyem & Saku, 2009). There has been considerable success in using participatory GISystems in engaging indigenous communities in generating community based data to promote natural resource management (McCall & Minang, 2005; Ramirez-

Gomez et al., 2015; Tripathi & Bhattarya, 2004), conservation (Darvill & Lindo, 2015; Ramirez-Gomez et al., 2013) and identify areas at risk for flooding (Kienberger, 2014; Kyem & Saku, 2009; Maheu, 2012; Pearce & Louis, 2008; Singh, 2014; Tripathi & Bhattarya, 2004; White et al., 2010) and is easily integrated into Geodesign approaches to create a flood resilient land use plan.

Geodesign

The Geodesign planning approach originates from the Landscape architecture field and seeks to merge the strengths of scientific analysis, particularly from geography and GIScience with the creativity inculcated within the design professions to design communities through an interdisciplinary and collaborative approach that conforms to the unique character of the local-natural environment (Foster, 2016; McHarg, 1995; Steinitz, 2012). Geodesign has been increasingly recognized as an interdisciplinary planning approach that merges multiple specialty fields and perspectives through the use of computer information systems, geospatial analysis, planning expertise, and local knowledge and community values to guide the planning process (Foster, 2016; Tulloch, 2017). Expanded application of Geodesign planning approaches are largely because of its ability to facilitate a collaborative environment between scientists, planners, and community stakeholders to create, edit, and simulate scenarios of potential designs and evaluate its impacts on a study area (G. Huang & Zhou, 2016; M. W. Wilson, 2015). This collaboration is done in person and over the internet which allows participants to share designs/plans, review suitability analysis, study impacts, and make land use decisions in real time (Li & Milburn, 2016; Steinitz, 2012, 2016). The reasoning behind planning decisions in a Geodesign approach can be triangulated through professional expertise, scientific analysis, and community knowledge and support (Borges et al., 2015; Eikelboom & Janssen, 2015).

Participatory GIS can be used in Geodesign approaches to visualize local knowledge, conceptualizing ideas and develop planning scenario options that can incorporate community derived spatial data. It enables participants to see how a proposed design element or scenario might impact existing systems and explore decisions around competing scenarios (L. A. McElvaney & Foster, 2014; S. McElvaney, 2012; Steinitz, 2012). The Geodesign processes emphasize interaction and rapid design feedback to enable stakeholders to effectively create, evaluate, edit, and share their ideas together and take immediate advantage of expert knowledge to produce a plan.

Some applications of Geodesign approaches have been observed in developing infrastructure and energy including the allocation of biomass supply changes (Hu et al., 2017), electric line placement (Moreno Marimbaldo et al., 2018), hydrogen fuel station siting (Kuby et al., 2018), green infrastructure (Cerreta et al., 2016), and to reduce energy emissions (Kambo et al., 2016). Several conservation projects have also utilized Geodesign to preserve biologically significant areas (Perkl, 2016), national scenic areas (G. Huang & Zhou, 2016), culturally important areas (Bartuszevige et al., 2016), and in natural resource management (McCall & Minang, 2005; Nyerges et al., 2016; Torrieri & Batà, 2017). Geodesign has also been used in accounting for flood risk in urban areas (Eikelboom & Janssen, 2017), particularly for flood resilient infrastructure (Zandvoort & van der Vlist, 2014), flood management policy (Torrieri et al., 2018), and in areas targeted for development adjacent to urban areas (Wu & Chiang, 2018). All of the flood risk case studies listed above use spatial analysis or national data sources to quantify flood risk in their study areas and its impact on other systems, but do not use a community-based approaches to validate assessments as was done in this case study.

4.3 Case Study: Sif-Oidak District of the Tohono O'odham Nation

Sif Oidak District of the Tohono O'odham Nation, located within the Arizona's Sonoran Desert, frequently experiences severe flash flood events that destroy homes, displace communities, and washout roads. This District sought to create their first land use plan through Geodesign to allocate land for new community development outside of flood areas and increase economic development opportunities. Land use planning has not been done in the past because of a lack of data for suitability analysis, limited GIS and planning experience.

The Tohono O'odahm Nation (TON) is comprised of three reservations located in central and southern Arizona. There are nearly 34,000 enrolled members[3] with just over 13,000 living within the jurisdiction of the Nation. The Tohono O'odham Nation is the second largest reservation in Arizona in both population and geographical size with approximately 2.85 million acres or roughly 4,460 square miles, almost double the size of Delaware. The main reservation sits firmly within the center of the northeastern extent of the Sonoran Desert. The northernmost portion of this reservation ends just south of Casa Grande, Arizona with the southern extent residing on the Mexico border. Much of the reservation is open desert space interspersed with rugged mountains.

[3] Persons with tribal membership to the Tohono O'odham Nation.

The Tohono O'odham Nation (TON) is divided politically into 11 districts (Figure 1). TON has two levels of government -- the National TON government and District governments. The National TON government consists of three branches and makes decisions on behalf of the entire Tohono O'odham Nation. The second level of government are at the District level. Each District has a legislative council that represent the communities within the Districts and elect a chairperson and vice-chairperson to lead District operations and govern locally.

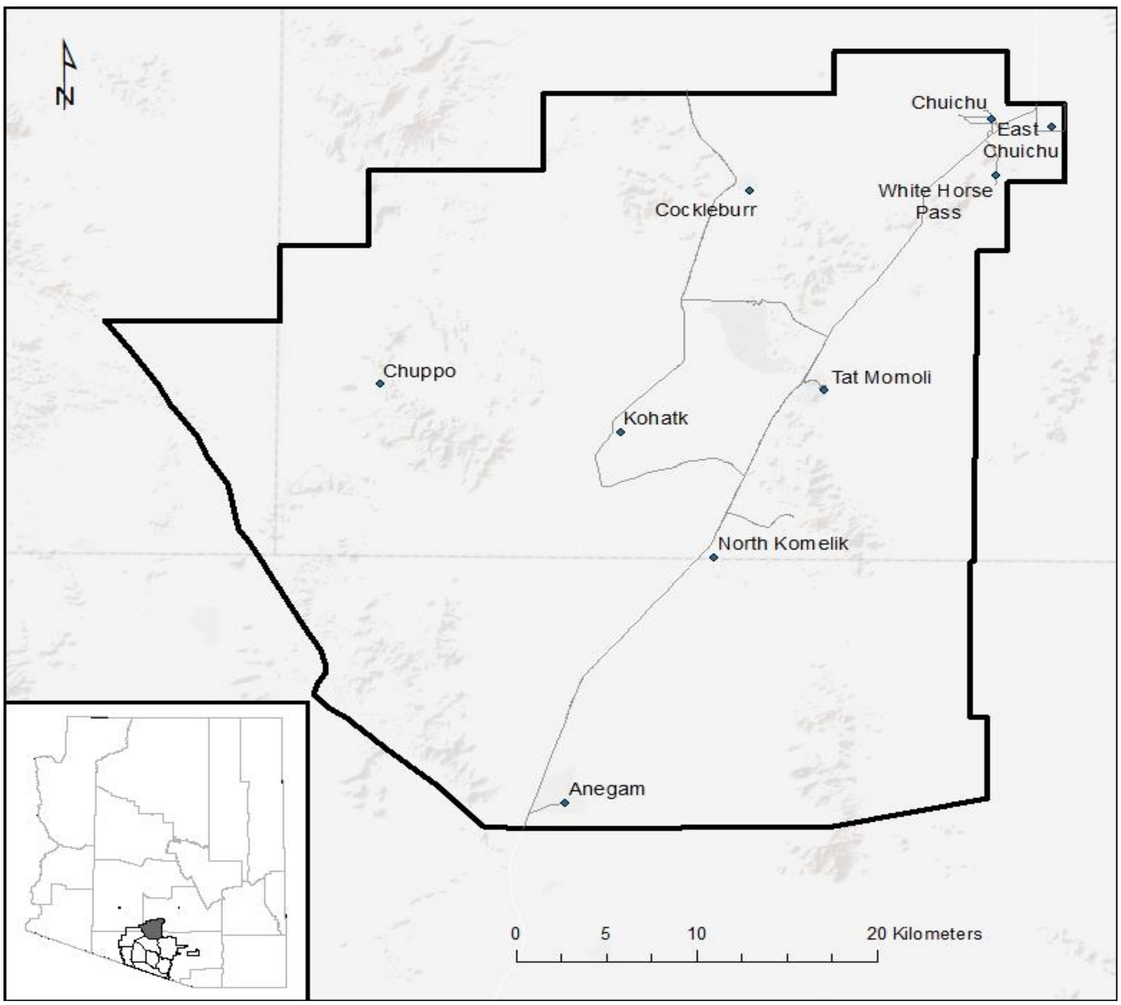

Figure 4.1: The Sif-Oidak District Boundary with the 9 communities identified on topographic imagery. Sif-Oidak District and Tohono O'odham Nation boundaries are

provided by United States Bureau of Land Management and the topographic background is provided by ESRI.

The Sif-Oidak District, which means “bitter field” is the northern-most district of the main Tohono O’odham Reservation. It is located south of the city of Casa Grande, AZ. This District has nine communities within its more than 650 square mile land base which include: Chuichu, East Chuichu, White Horse Pass, Cockleburr, Tat Momoli, Kohatk, Anegam, North Komelik, and Chuppo (Figure 1). The Sif-Oidak District has not developed an official land use plan prior to this study. The current land uses within the district are primarily ranching, agriculture, and community areas with a public service area in the centrally located North Komelik community. The majority of the land within the District would be considered open space and consists of vegetation natural to the Sonoran Desert. All housing is contained within the nine communities and they each possess a recreation field and a community cemetery. There are several important facilities within the District that include a large District-run farm and a large mining site that is currently in Environmental Protection Agency ‘care and maintenance’ status.

In the visioning session conducted in the spring of 2018 by the District, all nine communities identified flooding as a significant threat to the District that at times made roads impassable, flooded communities, and made it very difficult to expand the housing stock for community members wishing to live within the District and develop economic opportunities. Most municipalities and communities within the United States rely on flood risk maps created by the Federal Emergency Management Agency (FEMA) to identify areas that are at risk for flooding. However, FEMA has not done a flood risk assessment for most of the Tohono O’odham Nation and this includes Sif-Oidak District.

The Sif-Oidak District does not receive large amounts of rain annually (less than 10 inches) but some areas are subject to flash flooding. Arizona receives the majority of its precipitation in two separate seasons within the winter and summer. The greatest risk for flooding within the Arizona Sonoran Desert is during the summer from the large amounts of rain received during the North American Monsoon season (Arizona Cooperative Extension, 2006).

Due to infrequent rainfall within the Sonoran Desert, the ground is typically hard and dry and the infiltration rate of the ground is slow during heavy rainfall. The hard ground quickly transfers water downhill resulting in flashfloods that can cause extreme damage to persons and buildings in their path. The combination of shallow soils, sparse vegetation, heavy rainfall, drastic differences in elevation and traditional settlement patterns of the Tohono O'odham people near water create ample opportunity for devastating flash floods (Collins et al., 2018; Phillips & Comus, 2000).

Sif-Oidak District is particularly susceptible to these flash floods. The District geography primarily consists of steep mountains and large valleys consisting of alluvial fans. This makes flash floods very likely during heavy rainfall with the exact location of the flood at times difficult to determine. Many of the communities within Sif-Oidak District are astride or near woody washes that were traditionally important as water and food sources, but now have homes that are vulnerable to flooding. Many of these areas have been fortified by berms over time, however, many are now old, broken, and have declined in their strength and often break releasing flood water from theses washes (Duarte & Knott, 2018).

Nearly every year during monsoon season, district roads are inundated and become impassable and or dangerous to drive upon and many community members are trapped in their homes for days at a time with many children unable to attend school or adults work during flooding events. There have been several major flood events over the past fifty years that have forced the displacement of entire communities from their homes for months and years at a time during the rebuild. In the 1970's, the Chuppo community had such a severe flood event that they have been forced to permanently relocate. As recently as October 2018, many of the communities had the roads around their community washed out with one community, Kohatk, having half of its homes flooded and residents forced to relocate to Casa Grande, AZ for more than half a year. The risk for flash floods was a critical consideration within the land use planning efforts conducted by Sif-Oidak District through the Geodesign process.

4.4 Research Design

The application section will include a brief description of how community perception data was obtained through surveys prior to the start of the Geodesign workshop, how a flood risk map was developed for Sif-Oidak District prior to the workshop, and how flood risk was validated and used by community members within the Geodesign workshop to develop a land use plan. The survey makes known the community attitudes towards flood risk, specifically the perceived threat of flooding, whether or not it can be mitigated, and their personal experience with flood events. The results should indicate if the participants believe flood risk can be reduced, that they have personal experience with flooding in their community, and if they believe local knowledge is valuable in determining new land use designations. These same participants contribute community known high flood risk areas and validate the remote sensing assessment. The second section describes the evaluation methods. This includes using mixed qualitative and quantitative methods used for collecting evaluation data and evaluation analysis. These data will be used to evaluate Geodesign in overcoming data scarcity challenges in building resiliency against flood risk through community-based land use planning.

4.4.1 Determining Flood Risk

The study area did not have any flood maps from FEMA or county data that identified flood zones or flood risk. As stated previously, the study area is on tribal land in the Sonoran Desert, and primarily consists of rugged mountains and alluvial fans. According to FEMA there is no one reliable method for determining flood risk for alluvial fans because of inconsistent flood patterns in alluvial fans and the unique geographic conditions of these fans. FEMA, therefore recommended a flexible approach that needed to be customized for the study area (FEMA, 2012). FEMA guidelines offer five potential approaches to identifying flood risk in areas with an alluvial fan 1) FAN Program, 2) Sheetflow analysis, 3) Hydraulic Analytical Methods, 4) Geomorphic Data, post flood hazard verification, and historic information, and 5) composite methods (FEMA, 2012). This study utilizes the fourth method which recommends completing a flood risk analysis using geomorphic data and combining that with historical flood information and post-flood hazard verification. This application is the method recommended for alluvial fans with little or no urbanization (FEMA, 2016). In order to meet the FEMA recommendation and provide flood risk information to the community for decision support in their planning efforts flood risk was identified using:

1. Surveys given to community members that could share their recollection of past flooding events and perceptions of flood risk
2. A spatial analysis using remote sensing data.
3. Community members participating in the Geodesign workshop were able to create geospatial data mapping of community known flood areas from the most recent flood event and historical flood events.

Community Involvement

The Sif-Oidak District council is made up of 18 community members, two from each of Sif-Oidak District's nine communities, and a chairperson and a vice chairperson that lead the Sif-Oidak District. The primary participants in both the visioning session and the Geodesign workshop was this District council with select community members in attendance who could provide cultural or professional expertise to the planning exercise, major land users within the District as well as representatives from the Tohono O'odham Nations planning department. As such, the surveys given to understand the community perspectives on flood risk and the evaluation of the planning process are provided by these select community members. This means that the community information and the evaluation results are not a random sampling of the community, but a non-probability sampling method that is both a purposive and convenience sampling (Etikan et al., 2016; Field et al., 2006; Uprichard, 2013).

Public engagement in the planning process and in collecting community knowledge for flood risk was done in two parts. The first was in a visioning session and the second in the Geodesign workshop. The visioning session identified both the long term and short term goals for the community as well as the threats to accomplishing these goals. The primary threat identified in this workshop was flooding. To obtain more information about flood risk and how it has historically impacted the District, participants completed a survey that sought to understand the occurrence and location of flood events within the community, the severity of the damage, whether or not community members are regularly displaced, solutions for mitigating flood risk within their community, and their perceptions of flood risk for their community and the District.

Spatial Analysis of Flood Risk

The flood risk analysis within the Sif-Oidak District used the method outlined in Kabenge et. al (2017) *Characterizing flood hazard risk in data-scarce areas, using remote sensing and GIS-based flood hazard index.* The flood factors used in this analysis include slope, flow accumulation, distance from drainage network, drainage network density, land use cover, geology, and rainfall intensity (Kabenge et al., 2017). The Sif-Oidak District falls within the Santa Cruz river basin. A 10-meter digital elevation model (DEM) for this region in the State of Arizona was acquired from Arizona State University's GIS data repository. This elevation data was used to calculate the slope, flow accumulation, and drainage network within the basin. Rainfall data for the Santa Cruz River Basin was obtained from the National Oceanic and Atmospheric Administration (NOAA). The land use cover and the soils information was obtained from the United States Geological Survey (USGS) and the USDA Natural Resource Conservation Service, respectively. These data were processed using Kabenge et. al's (2017) flood hazard index and uses a weighted overlay analysis to assign the final flood risk value (Ağaçsapan & Çabuk, 2019; Malczewski, 2004). The final flood risk for the Santa Cruz River Basin is then separated into five classes using Jenks natural breaks into very low, low, moderate, high, and very high flood risk (Jenks, 1967).

Table 4.1: This flood risk factor table is based on Kabenge (2017) flood hazard index assessment. The weight is based on a 10 scale.

Flood Factor	Flood Hazard Index Weight
Slope	2.02
Flow Accumulation	2.03
Distance from drainage network	3.35
Drainage network density	.30
Land Use Cover	.84
Geology	1.09
Rainfall intensity	.37

Community Knowledge of Flood Risk

Spatial knowledge of flood risk was obtained both prior to and during the Geodesign workshop. Participants unable to provide local flood knowledge prior to the workshop were able to contribute their knowledge of flood risk within the Geodesign workshop where they identified flood risk areas using interactive maps with high resolution satellite imagery (Chingombe et al., 2015; Eilola et al., 2019; Kienberger, 2014; Tran et al., 2009; White et al., 2010). A single community member may not know flood risk for the entire community but an aggregate of local knowledge from many communities provided a high risk flood map for local known areas within the District (McEwen & Jones, 2012). All of the community-based planning and community flood risk data were completed on Geodesignhub or on google earth.

4.4.2 Evaluation Methods

The first evaluation survey was given at the beginning of the Geodesign workshop and was intended to capture community perceptions of flood risks for their community. This survey consisted of Likert scale questions that primarily used a 10 point scale where 10 representing significant, 5 representing moderate, and 1 representing not significant. The questions using this scale included:

1. How concerned are you about flood risk?
2. How would you rate the threat of floods as a hazard for the Sif-Oidak District?
3. How would you rate the threat of floods as a hazard for the Tohono O’odham Nation?

This survey also utilized a four-point Likert-scale of perceptions for flood damage. The four-point scale ranged from 4 being severe, 3 moderate, 2 little, and 1 no. Questions that utilized this scale include:

1. How much damage has been done to your own property due to flooding?
2. How much damage has been done to your community due to flooding?

3. What impact has flooding had on employment within the Sif-Oidak District?
4. What impact has flooding had on housing conditions within the Sif-Oidak District?

The end of workshop survey was given to evaluate the effectiveness of the Geodesign workshop in empowering this community to create flood-resilient community-based land use plan. This survey also used Likert scale questions on a five point scale with 1 representing strongly disagree and 5 representing strongly agree to evaluate participant agreement with the following statements:

1. Do you feel that your voice was heard in the Geodesign process?
2. Do you believe that the Geodesign plan honors and reflects your culture and respects your traditions and values?
3. Do you believe that the land use plan supports the community vision for the land use plan?
4. Do you feel that the plan developed today will reduce risk of flooding in your community and District?

The District council represented their communities in decision making efforts because they were elected to do so and had direct access to local knowledge of the community through their own experiences and from the people who belonged to their communities. Using Sif-Oidak District Council members to provide flood risk information, participate in the Geodesign workshop, and to evaluate the planning process insured that all of the communities were represented in the planning effort and that local knowledge from across the community could be shared. In addition to the Sif-Oidak

District Council fifteen community members from the District and three planners from the Tohono O'odham Nation Planning Department also participated in the Geodesign workshop. The participants within this workshop were chosen because of their decision making authority, influence within the community, local expert knowledge, and that they represented diverse interests within the District. The surveys are representative of this population within Sif-Oidak District and they provide both the flood perception, local flood risk knowledge, and Geodesign evaluation data.

4.4 Results

Spatial Analysis of Flood Risk

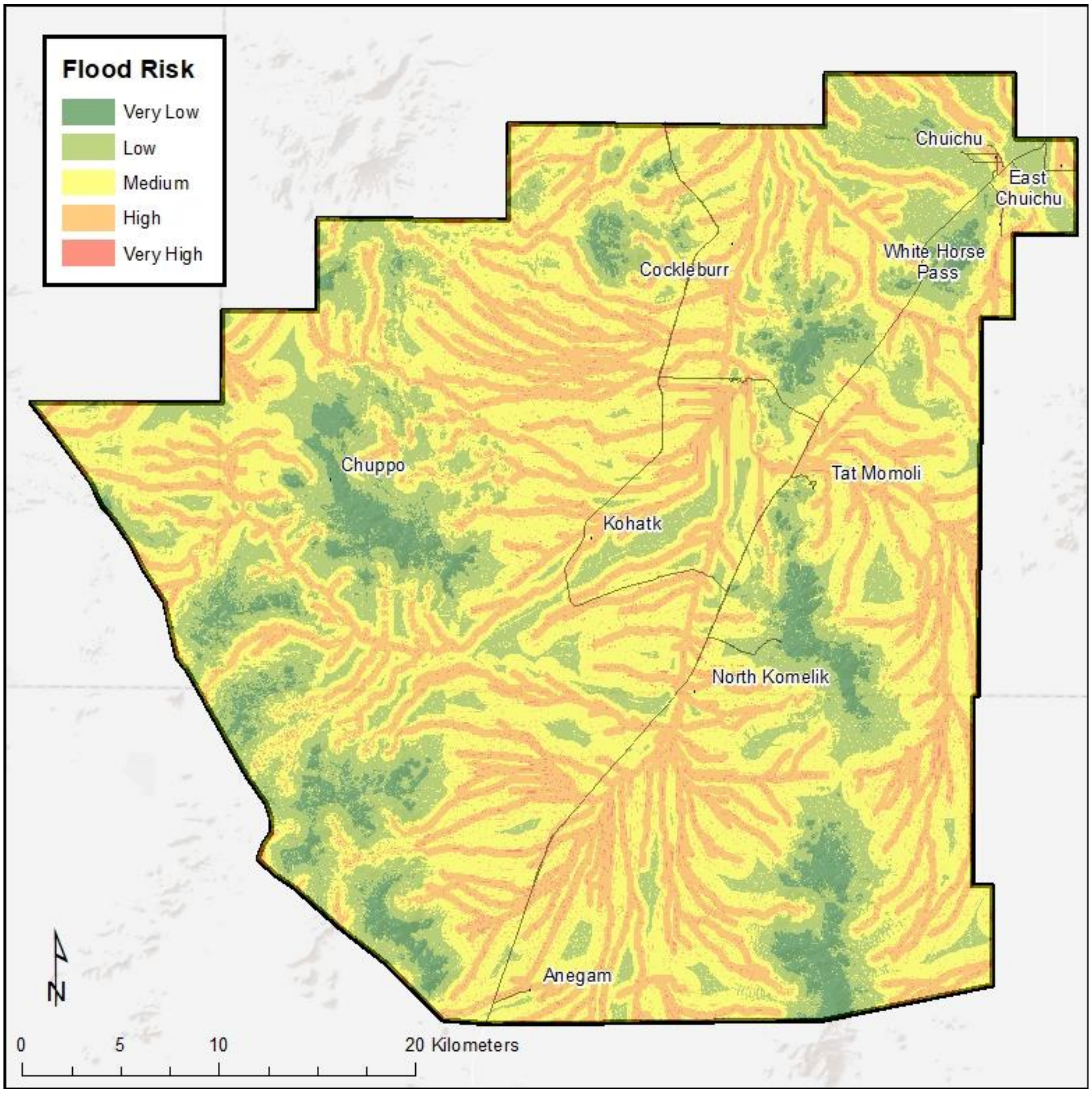

Figure 4.2: Flood risk map created using Kabenge et. al 2017 flood risk methodologies on Sif-Oidak District of the Tohono O'odham Nation. Very high flood risk is typically centered in drainage network and difficult to see at this scale.

As seen in figure 4.2, Sif-Oidak District contains many areas that have high to medium flood risk, in particular near or encompassing many of the existing communities and along the main roads. According to the flood risk assessment 28.3 percent of the District's land area was classified as high flood risk with just over 41.9 percent considered medium risk. Areas considered to be low or very low flood risk accounted for 22.3 and 5.9 percent respectively. The vast majority of the very low risk flood risk areas are found in the mountains within the District.

Flood Risk Perceptions

Table 4.2: Likert scale results from flood perception survey (n=40).

How would you rate the floods as a hazard for Sif Oidak District?										
Scale	**Not Significant (1)**	**(2)**	**(3)**	(4)	**Moderate (5)**	**(6)**	**(7)**	**(8)**	**(9)**	**Significant Threat (10)**
Responses	**0**	0	0	0	4	4	7	9	3	13
Percentage	0	0	0	0	10	10	17.5	22.5	7.5	32.5
Average	8.05 (Total Respondents 40)									
Significant (8,9,10)				**62.50%**						
How would you rate the floods as a hazard for the Tohono O'odham Nation?										
Scale	**Not Significant (1)**	**(2)**	**(3)**	(4)	**Moderate (5)**	**(6)**	**(7)**	**(8)**	**(9)**	**Significant Threat (10)**
Responses	**0**	0	0	1	3	3	8	5	6	14
Percentage	0	0	0	2.5	7.5	7.5	20	12.5	15	35
Average	8.175 (Total Respondents 40)									
Significant (8,9,10)				**62.50 %**						
How concerned are you about flood risk?										
Scale	**Not Significant (1)**	**(2)**	**(3)**	(4)	**Moderate (5)**	**(6)**	**(7)**	**(8)**	**(9)**	**Significant Threat (10)**
Responses	**0**	0	0	1	1	0	0	6	10	21
Percentage	0	0	0	2.56	2.56	0	0	15.38	25.64	53.85
Average	9.15 (Total Respondents 39)									
Significant (8,9,10)				**94.87 %**						

Prior to the start of the Geodesign workshop, the Sif-Oidak District Councilmembers, Sif-Oidak District chairpersons, and select community members were given a survey to document the perceptions of flood risk at the District and in their communities (n=40). Overall, the flood risk perception survey found that the risk of flash flood is a significant concern in the community / District and has impacted the entire

District in terms of repeated relocations of people, increased home and road damage, employment and education, and temporary and permanent relocations of communities. When asked if the flood risk is a significant hazard to the community on a scale of 1 to 10 where 1 represents not a hazard and 10 a significant hazard, 62.5 percent of responses indicated a rating of 8, 9, and 10 demonstrating a large number perceiving the flood hazard in the District as significant. A similar percentage believe that the threat of floods is significant to the Tohono O’odham Nation as well. Are flood hazards a concern, yes, by 94.9 percent of responses. Of the responses taken prior to the start of the Geodesign workshop, 72.5 percent of attendees from Sif-Oidak District had experienced a flooding event in the last 10 years. During the last decade out of 26 responses, 13 responses experience floods once, 4 every year, 6 twice, one occasionally, and two had not experienced floods. This indicates that even for community members that have not experienced flood events they are a considerable concern.

Were families impacted by these flood events? Significant impacts were experienced by 5-10 percent but moderate impacts were experienced by almost 40 percent. Over half of the survey takers indicated moderate to significant adverse impacts to families. In fact, 35 percent of families according to the survey had to relocate because of flood impacts. Was individual property damaged? According to the survey 37.8 percent of responses indicated moderate damages to properties and 16.2 percent indicated severe property damage with no damages by 43.2 percent however, were there damages to the community? Responses to this question showed moderate and severe impacts reported by around 83 percent of survey responses. Responses showed moderate and high impacts on employment by 51 percent of those answering.

Importantly, the survey validated the large and extensive impacts of floods on housing, transit, roads, and economic development. Responses showed that 48.7 percent indicated ‘moderate’ impacts and 40.5 percent indicating ‘severe’ impacts on housing conditions. An interesting point is that flood hazards have been continual over the last decade, have been continuing with little mitigation. Among 69 percent of survey responses also show that floods have become more severe over the last decade.

Participatory GIS

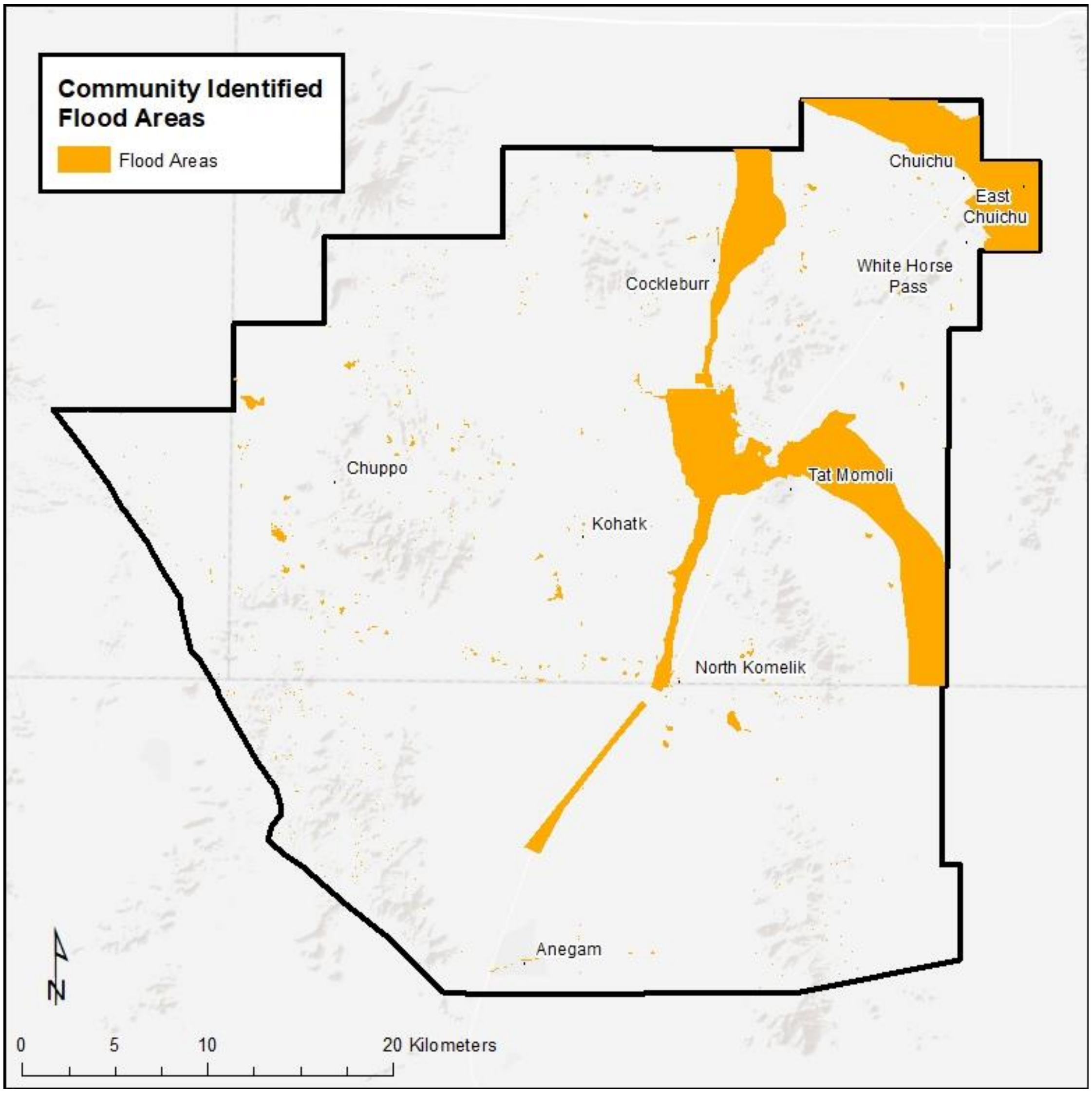

Figure 4.3: This map shows flood risk areas identified as historical flood risk areas or as known flood risk areas by Sif-Oidak District community members.

There were over 30,300 acres identified as high risk historical flood areas by Sif-Oidak District community members that were integrated in to the flood risk analysis used in the Geodesign workshop (figure 4.3). Within the Geodesign workshop community members relied on contributed data and the scientific analysis on flood risk when designating areas for commercial development, new housing, and new public service areas. Community members also identified land use designations for agriculture, conservation, ecotourism, ranching, and open space within the flood risk areas. As part of the process for flood risk resiliency participants supported the development of a flood risk map, validated its analysis with local knowledge, indicated flood damage areas, and areas in need of resiliency infrastructure and new locations for communities outside of flood risk areas.

Mixed Methods Flood Risk Map

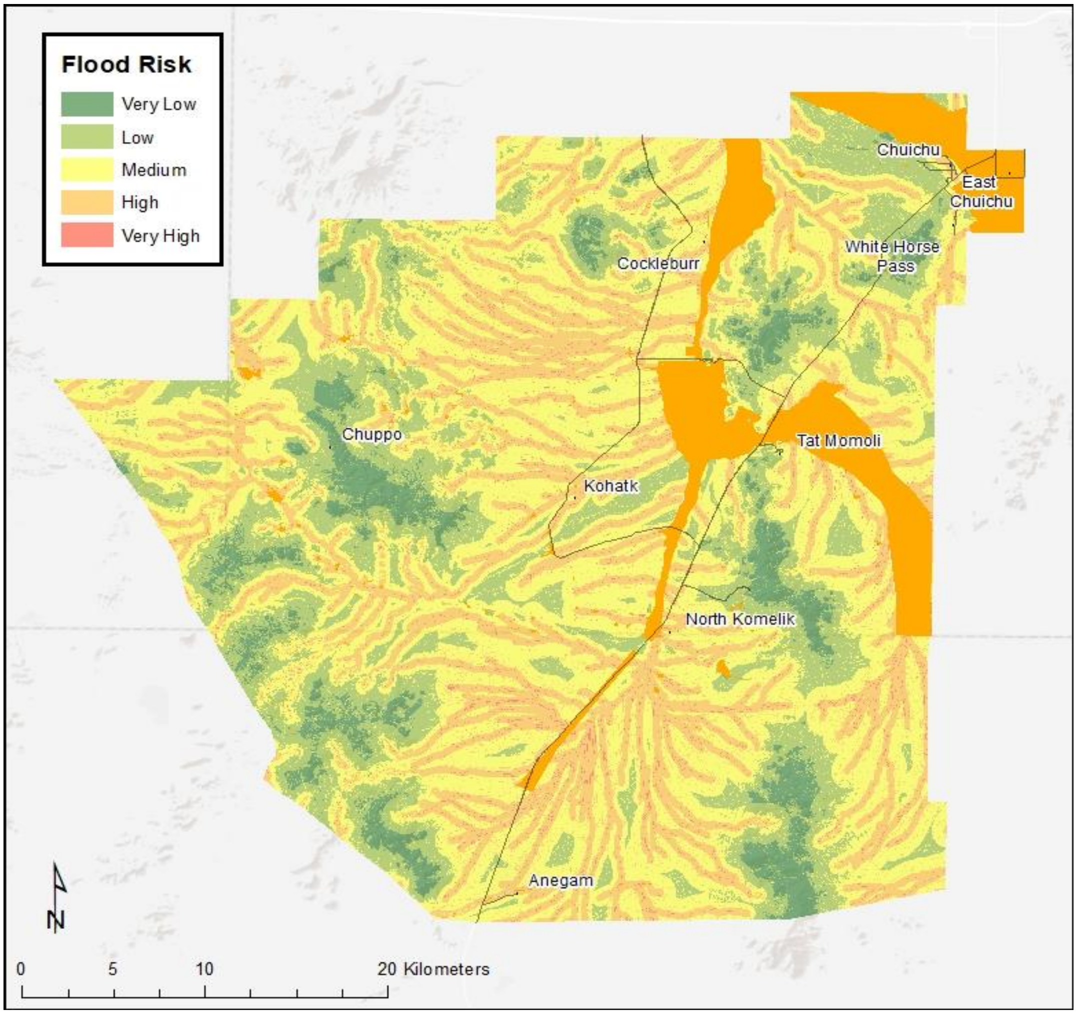

Figure 4.4: This map shows the mixed methods flood risk map used in the Sif-Oidak Geodesign workshop to develop a community-based land use plan.

The map in figure 4.4 was utilized by Sif-Oidak District community members in making land use decisions. The local flood knowledge and the remote sensing analysis provided critical information on how development needed to be approached in these areas based on risk. The community identified flood areas were considered 'high' flood risk regions. This increased the proportion of high flood risk areas in Sif-Oidak District from

28.3% to 32.6% (table 4.3). This adjustment did reduce the available area to develop that did not require flood reducing infrastructure by nearly 29 square kilometers, however, it allowed for additional open space, conservation, agriculture, or ecotourism designations.

Table 4.3: This table shows the assessment results for the flood risk remote sensing analysis, the community contributed flood data, and the area for the modified flood risk map. * This column denotes where the high flood risk areas identified by the community fell within remotely sensed flood risk data categories.

Flood Risk Remote Sensing Analysis			Community Identified Flood Zones		Modified Flood Risk Area	
Flood Risk	Area km	Area %	Area km*	Area %	Area km	Area %
Very Low	102.03	5.9	0.06	0.04	101.97	5.9
Low	384.26	22.3	17.26	12.71	367	21.3
Medium	722.05	41.9	51.5	37.94	670.55	38.9
High	487.96	28.3	62.54	46.07	561.7	32.6
Very High	27.31	1.6	4.39	3.23	22.92	1.3

Land Use Plan

Development initiatives within this community have been stymied because of flood risk. Using community knowledge and remote sensing analysis the Sif-Oidak District successfully created their first land use plan using Geodesign approaches to create opportunities for new housing within the community, identify economic development areas, and conservation zones. Throughout this resiliency flood planning effort and in the Geodesign workshop Sif-Oidak District confirmed and designated 10 different land uses within the District that included open space, agriculture, commercial economic development, conservation, ecological tourism, grazing, housing, industrial economic development, commercial solar, and recreation (Figure 4.5). The District followed three basic strategies in using the flood risk assessment map 1) designate land uses for high flood risk areas that would not be impacted by flooding such as conservation, open space, ecotourism, or grazing; 2) housing, industry, public service, or economic development areas that were designated in flood risk areas are required to install flood mitigation infrastructure; 3) designate new community housing, economic development, and public services outside of high flood risk areas. Through the use of the community and scientific based flood assessments the Sif-Oidak District could strategically plan for future development against flood risk within its communities.

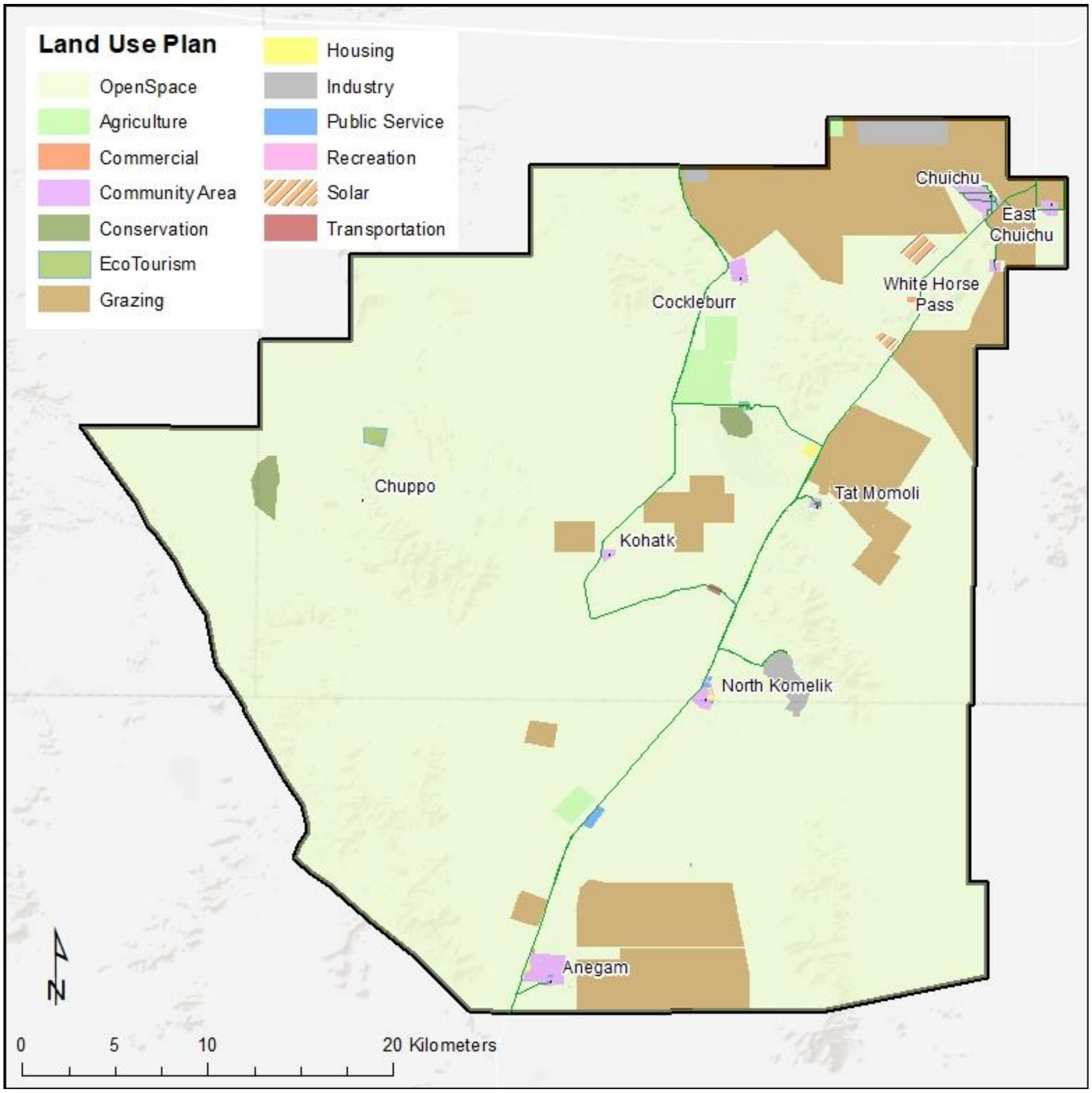

Figure 4.5: Sif-Oidak District Community-Based Land Use Plan using Geodesign approaches.

Evaluation of Geodesign and Community Flood Risk Engagement

Table 4.4: Sif-Oidak District responses to end of workshop survey.

Do you feel that your voice was heard in the Geodesign process?					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree (4)**	**Strongly Agree (5)**
Responses	0	0	2	16	7
Percentage	0	0	8	64	28
Average	4.2 (Total Respondents 25)				
Agree or Strongly Agree			**92 %**		

Do you believe that the land use plan supports the community vision for the land use plan?					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree (4)**	**Strongly Agree (5)**
Responses	0	0	3	12	8
Percentage	0	0	13.04	52.17	34.78
Average	4.2 (Total Respondents 23)				
Agree or Strongly Agree			**86.96 %**		

Do you believe that the Geodesign plan honors and reflects your culture and respects your traditions and values?					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree (4)**	**Strongly Agree (5)**
Responses	0	1	2	13	7
Percentage	0	4.35	8.7	56.52	30.43
Average	4.13 (Total Respondents 23)				
Agree or Strongly Agree			**86.96 %**		

Do you feel that the plan you developed today will reduce the risks of flooding in your community and District?					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree (4)**	**Strongly Agree (5)**
Responses	1	1	6	12	3
Percentage					
Average	3.65 (Total Respondents 23)				
Agree or Strongly Agree			**65.22 %**		

At the conclusion of the Geodesign workshop the Sif-Oidak District community members were asked in a survey if the plan developed in the Geodesign workshop will reduce the risk of flooding in their community and District. The majority (65.2%) either strongly agreed or agreed that the plan would increase resiliency to flood risk for the district with 26.8% being neutral to the possibility of reduced flood risk in the community. When asked to comment on these questions the community members felt that much of the existing housing and public service would continue to be at risk for flooding, but that new development determined in the land use planning effort would be less vulnerable to flooding due to location. Many participants felt that strengthening of the protective berms, better drainage networks within the community, and increased vegetation on berms and drainage networks among other flood mitigation strategies would be necessary to help the current at-risk communities.

Community members did the following to incorporate local knowledge to create a land use plan that was resilient towards flood risk: 1) they were able to validate the risk data created using spatial analysis, 2) identify areas of high flood risk, in particular locations that greatly impacted the community such as roads and community areas, 3) identify new areas for housing that were at low risk for flooding validated by risk map, 4) document flood infrastructure that was vulnerable for failure or that had failed, 5) describe the severe impact that flooding has had on transportation, economic development, and housing within the District.

Kohatk, a community within the Sif-Oidak District, was forced to relocate more than half of its members outside of the District for more than six months because of a flood event in fall 2018. The Geodesign workshop was held 3 months after this flood event and representatives from Kohatk community were able to identify flood infrastructure (berms) that failed during the flood event and needed to be strengthened, roads that were vulnerable to flooding during monsoon season, a segment of road that will require a bridge to prevent communities being trapped during flood events, the extent of the flood within the community, and new land uses for new home development that were outside of flood risk areas and would be more resilient against flood events (see figure 4.6).

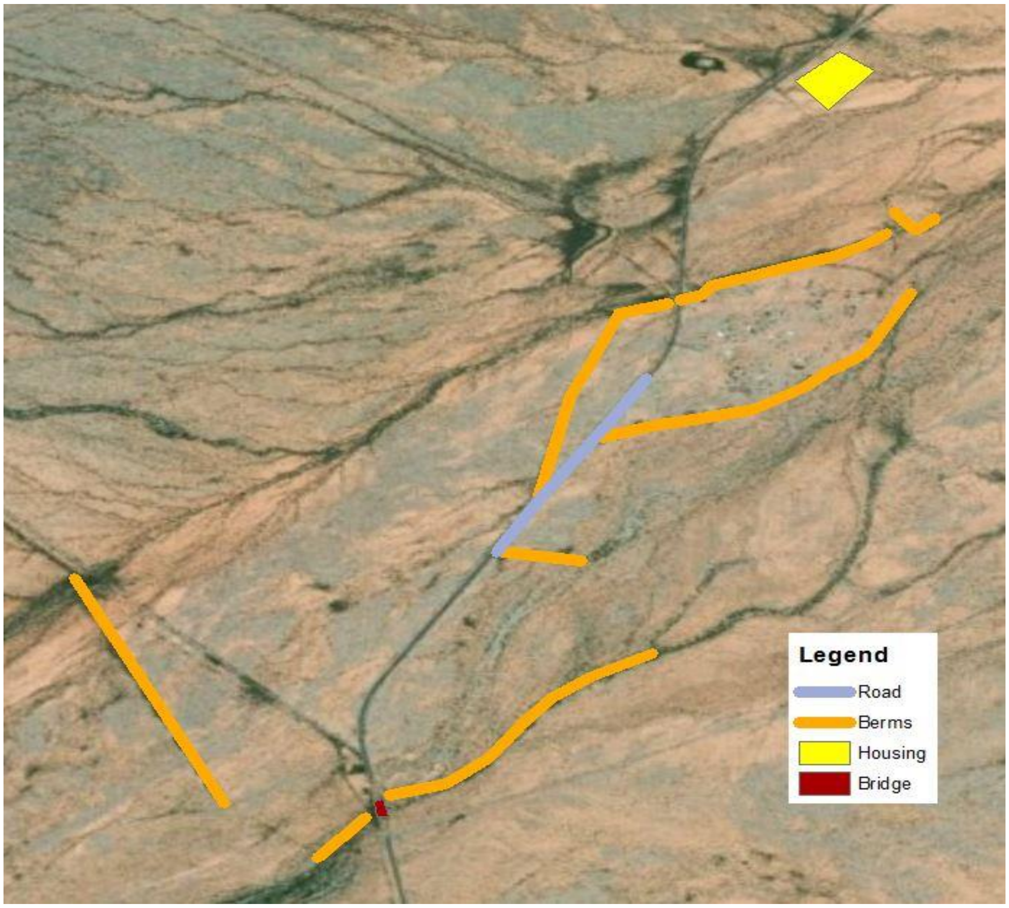

Figure 4.6: This is a satellite image of Kohatk community in Sif-Oidak District of the Tohono O'odham Nation. The orange represents berms in need of repair or failed during the October 2018 flood event. The road section highlighted in grey flooded in October 2014. The yellow land designation represents new housing outside of flood current flood zones. The red in bottom left designates a section of the road in need of a bridge.

4.5 Discussion

We found that the Geodesign approaches engages community members in contributing local knowledge of natural hazards in the planning process and participants to interact and contribute assessment data to create resiliency based land use plans. This land use plan is the first of its kind within the District and only the second District within the Tohono O'odham Nation to develop a land use plan. The risk of flooding has long hindered planning efforts and development within Sif-Oidak District and many new housing initiatives have been curtailed because of flood risk. According to the 2000 census and community data, the population within Sif-Oidak has migrated out of the reservation to nearby communities because of the lack of new housing and limited economic opportunities within the district directly due to flooding vulnerability. This community-based participatory planning effort was found to be critical in providing a path for increasing resiliency against flood risk while providing increased economic development and increased quality of life opportunities for those living in the District and those who wish to return. This case shows the role of Geodesign in providing a validated framework for developing land use resiliency from a community-based participatory geoscience approach. How is the plan a resilient plan?

The land use plan developed in the Geodesign workshop has the potential to strengthen the economic capital within the District. Currently, the only employment opportunities in the District are at the District office, at the District farm, or as a rancher. Most other economic opportunities for community members are within nearby towns outside the reservation or with the Tohono O’odham National government. The visioning session assisted the community in outlining long and short-term economic development goals for the community and to identify the opportunities for economic development. In the Geodesign workshop the Sif-Oidak District council and community stakeholders were able to identify areas for economic development in low risk flood areas to minimize flood hazard vulnerabilities and economic opportunities in areas that were resilient to flooding. This included identifying multiple areas for tourism, industrial development (mining and heavy industry), and commercial development. These new economic development areas could provide both much needed commercial services to the District, keeping money within the community, and provide diverse economic employment opportunities within the District with minimal risk to future development. The Geodesign approach permitted community plans that would reduce/minimize future risk to places of employment and berms. The land use plan utilized risk mapping as a vulnerability reduction tool with local input.

The Sif-Oidak District has demonstrated strong social capital in the face of natural disasters related to flooding. With many community members being displaced from their homes after major flooding events, sister communities within Sif-Oidak and the Tohono O'odham Nation at large have housed displaced District members for extended periods of time and the Sif-Oidak District government is quick to mobilize and aid its communities in times of disaster. This workshop strengthened social capital within the community by providing additional linkages between Sif-Oidak District and the Tohono O'odham Nation government through the assistance of TON planners in the Geodesign workshop and the involvement of county, and local university personnel. Areas for opportunity for increasing social capital would be in increasing the links between Sif-Oidak District, adjacent Districts, the TON national government, and cities within close proximity to Sif-Oidak as well as linkages to Federal agencies like FEMA. Many community members identified failing berms as the cause for flooding within some of the communities within Sif-Oidak District in the last major flood event, but indicated that weaknesses in flood management systems in other Districts caused excess water to flow into Sif-Oidak District overwhelming existing flood resistant infrastructure. A truly flood resilient Sif-

Oidak District will require careful coordination between neighboring Districts to insure that flood infrastructure is maintained.

Local knowledge was recognized as critical for Sif-Oidak District in particular because it is a data scarce area for both environmental and demographic data. Many community members are knowledgeable of areas that have historically been at risk for flash floods and have provided that knowledge. Furthermore, widespread community involvement in the planning process can identify areas within the flood infrastructure that need improvement and identify areas for development that can take advantage of unique resources within the District. As shown in the surveys, residents of the District felt that local knowledge greatly informed land use decisions.

As stated earlier in the paper, adaptive governance is the ability of the governing structures to adapt to ecological, economic, political, and social changes in a meaningful way that can accommodate and plan for both long and short term disruptions. Sif-Oidak District is increasing its ability to adapt to changing ecological and economic circumstances by engaging in land use planning efforts for the first time. The use of Geodesign by the Sif-Oidak District government to create a plan that is purposively resilient against flood risk demonstrates the District's desire to overcome traditional planning barriers and reverse the population trends within the community. As part of this process the community worked with a local university, TON resources, and local community knowledge to create a flood risk map. They utilized this flood risk map to strategically designate land uses for new development and could determine the level of infrastructure needed to make the new developments flood resistant. The land use plan also boosted overall resiliency of the community by utilizing local knowledge of the existing infrastructure to identify areas that needed to be repaired to fortify the existing infrastructure.

4.6 Conclusion

Data scarcity is a significant planning barrier for regions hoping to develop resilient communities against increasingly frequent natural hazards. This study demonstrated that the Geodesign approach can organize and incorporate local knowledge to supplement and validate geospatial analysis for flood risk in data scarce areas. This study has three mean findings. First, that communities within data scarce areas can use local knowledge to supplement geospatial analysis. In this case study local participants were able to verify and correct assessments for areas that they had considerable on the ground knowledge. Second, communities trusted scientific assessments in which they were able to contribute and validate and use these assessments to strategically develop a flood resilient land use plan. Third, utilizing community involvement in overcoming data scarcity and decision making empowers data scarce communities to reduce flood risk at multiple resiliency scales.

This approach did have some limitations. First, that this area was a data scarce community and most of the geospatial analysis relied on remotely sensed data with little ability to truth assessments outside of local knowledge. The spatial resolution of the remotely sensed data varied between 10m and 30m which is a medium to high resolution. Even with this resolution there leaves considerable uncertainty in flood risk. Also, this case study took place within three months of a major flooding event. Hazard perceptions and accuracy of community knowledge of flood data may change the greater time distance between these events.

Geodesign used public participation to increase resiliency against flood risk areas by engaging the community to contribute local knowledge of flood risk that was not available (McEwen & Jones, 2012), empowering the community to actively participate and confront flood risk (van den Berg & Keenan, 2019), make decisions for implementing resiliency strategies for future community and infrastructure development by linking resiliency planning with other planning efforts (Smit & Wandel, 2006), establish clear goals to reduce flood risk (Woodruff & Stults, 2016), and address flood risk through multiple strategies (Meerow & Woodruff, 2019). This process was able to merge community knowledge with scientific analysis to address data scarcity challenges for an American Indian community in order to develop their first land use plan.

CHAPTER 5

EVALUATING GEODESIGN FOR COMMUNITY-BASED TRIBAL PLANNING: THE ROLE OF PLANNERS IN MARGINALIZED COMMUNITIES

5.1 Introduction

Prioritizing public participation in planning has become a guiding principle to engage marginalized communities for many urban and rural planning efforts (Brabham, 2009; Cornell & Kalt, 1998; Norton et al., 2019). Despite this emphasis on public participation and the extensive theoretical frameworks within the planning and design fields that prioritize community engagement, seldom do these frameworks when transformed into formal planning processes rise above 'tokenism' even when required by law (Arnstein, 1969; Brody et al., 2003). This has been especially true for American Indian (AI) communities where a history of marginalization from local land use decisions has resulted in a shortage of planning experience and capacity for many (Gardner & Pijawka, 2013; M. Hibbard, 2006). Differences in western planning approaches and non-western land management practices have also hindered planning efforts and attempts to exert local sovereignty and reclaim rights to historically inhabited land (Fixico, 1998; Walker et al., 2013). The goal of this research is to assess the effectiveness of the Geodesign framework for community-engaged and culturally-aware land use planning for American Indian communities.

Geodesign is a portmanteau of geography and design and originates from the landscape architecture field (Li & Milburn, 2016). The Geodesign approach is a technology-enabled and data driven leveraging tool that combines the strengths of geographic information science (GIS), with the creativity of the urban design fields to empower communities and planners to develop plans that are aligned with the unique character, the local culture, and the natural environment of the community (Foster, 2016; McHarg, 1995; Steinitz, 2012). A guiding principle within Geodesign is that modern planning efforts require interdisciplinary approaches and collaboration involving GIS experts, planning professionals, and community stakeholders (Chiquito et al., 2018; Orland, 2016). As a technology and data driven approach Geodesign simultaneously encourages planning that maximizes the interaction and contributions from scientists, stakeholders, and planners and relies on rapid plan simulations and evaluation of alternative futures (Chakraborty & McMillan, 2015; M.-C. Lee, 2016; Norton et al., 2019). It also is based on stakeholder engagement and community visioning providing for a participatory process in decision making that enables decision makers to both engage in scientific decision making processes while incorporating stakeholder values (Borges et al., 2015; Hulse et al., 2016).

To assess the effectiveness of the Geodesign framework for community-engaged and culturally-aware land use planning in American Indian communities, we aim to make two contributions. The first is an evaluation of Geodesign as a public participation planning approach that empowers historically marginalized communities in creating land use plans guided by community values, historical traditions, and geospatial analysis. Second, it explores the role of the planner in implementing a community-based Geodesign approach. To do this, we utilized Geodesign for land use planning in two American Indian communities in the Navajo Nation as case studies. The remainder of this paper provides the background literature on public participation, recent applications of

Geodesign, and a review of tribal planning. We then present descriptions of the case studies, the approach for implementing Geodesign land use plan, evaluation methodologies used in this study, results from the evaluation methodology, a discussion, and concluding remarks.

5.2 Background Literature

Over the past fifty years, planning theorists have argued that the communities affected by planning decisions, particularly those that are a minority viewpoint or historically marginalized should be informed and consulted in planning efforts and should have the opportunity to express their values in government decisions (Burke, 1979; Fagence, 1977; Slotterback & Lauria, 2019). This communication model between planning departments and the community should be an inclusive dialogue that formulates public interest through continuous discussion on decisions that affect the local community (Dryzek, 1990; Healey, 1996; Innes & Booher, 1999; I.M. Young, 1995). Many local governments in the United States and Canada require community engagement to democratize the planning process and redistribute planning power to citizens (Arnstein, 1969; Day, 1997; S. Fainstein & Fainstein, 1985). Scholars argue that engaging the local community in planning efforts can build goodwill and trust in the process and develop a sense of local ownership of the plan (Fagence, 1977; Oulahen & Doberstein, 2012). The values expressed through citizen participation provide planners with more accurate public opinion on proposed policies and local information about a community that may not be readily available to the planner (Blue et al., 2019; Day, 1997; Rich, 1986). In addition to these benefits, greater public participation can identify unique solutions for planning problems, build planning capacity within a community, empower a community to engage within local decision making, create trust between planners and the local community, and develop social capital (Berry et al., 1993; Laurian & Shaw, 2008; C. W. Thomas, 1998). Tribal communities have historically been marginalized in the planning process and had limited input in planning decisions (M. Hibbard, 2006; Ward, 1992; Zaferatos, 1998). Through greater public involvement in planning efforts and decision making tribal communities can plan their communities in alignment with their values and traditions.

Indigenous scholars contend that their communities need to reconnect with historical traditions to plan for their future (Fawcett et al., 2015; Fixico, 1998; Walker et al., 2013). North America's indigenous people planned for their communities in accordance with their cultural and social traditions, prior to first contact with Europeans. These communities utilized their traditional knowledge of local geographies and community values to make environmental decisions and allocate resources (Jojola, 2013).

Tribal Nations retain sovereign powers of self-government within their land in addition to the "trust" relationship with the federal government. Included within these powers of self-government is the authority to plan for future community development as well as managing both natural and cultural resources (Cornell & Kalt, 1998; Robinson, Maclean, Hill, Bock, & Rist, 2016;Zaferatos, 1996, 1998). Despite this sovereignty, many challenges remain in exercising this planning authority. Some of these challenges include incompatible priorities for land under tribal jurisdiction between state, federal, and tribal governments, historical efforts by the federal government to limit or undermine tribal authority in local decision making; limited planning experience within tribal communities in meeting planning regulations imposed by funding sources (Galbraith, 2014; M. Hibbard, 2006; Matunga, 2013; Miller, 2013). Many of these challenges demonstrate the need for a planning process that can integrate both indigenous approaches and western planning, including Geodesign.

In general terms a design project that utilizes Geodesign utilizes geographic knowledge, experience, data, and information to guide the planning process. Thus, Geodesign is not a new concept and has essentially been practiced in a rudimentary form by landscape architects and planners since the mid-19th century (Li & Milburn, 2016). It is with McHarg's (1969) development of overlay analysis that allowed for planners to begin systematically investigating and evaluating ecological and environmental processes to inform planning efforts for land utilization. Gradual advances in geospatial science, information technology, and greater access, quantity, and ability to analyze data have provided new opportunities for social and environmental knowledge to guide formal planning processes (M. W. Wilson, 2015).

A more modern conception of Geodesign is to leverage geospatial technologies for analyzing, quantifying, and visualizing environmental processes scientifically and in real time through the internet that permits real time feedback and analysis on design decisions from an interdisciplinary group of experts and diverse decision makers. It is not simply a GIS tool but provides opportunities to create both science and value-based designs through interdisciplinary collaboration through technology (Wissen Hayek et al., 2016). This interdisciplinary approach potentially improves the quality and efficiency of designs and plans, while maximizing social benefits and minimizing social costs (S. McElvaney, 2012).

The use of Steinitz Geodesign framework has increased over the past five years, particularly in the development of energy and infrastructure where it has been utilized to design green infrastructure (Cerreta et al., 2016), identify locations for alternative fuel stations (Kuby et al., 2018), transmission line placement (Moreno Marimbaldo et al., 2018), and biomass supply chains (Hu et al., 2017). Applications also include developing mitigation strategies for climate change and natural disasters (Kim, 2017), conservation planning (G. Huang, 2017; G. Huang & Zhou, 2016; Perkl, 2016), and natural resource management (Nyerges et al., 2016). This great diversity of planning applications from a Geodesign approach reflects the flexibility of the framework. The design approaches range from a Geodesign expert team that creates optimized plans to divergent stakeholders working with experts to create a collaborative plan. The Geodesign approaches, principles, and methods are not uniformly applied in practice because they need to be able to flexibly address projects that vary in size, scale, culture, content, and timeframe (Steinitz, 2014).

Researchers have placed Geodesign within the context of other design approaches, but have not placed the framework in the context of planning theories, rather labeling it as a planning tool (Batty, 2013; Foster, 2016; Li & Milburn, 2016). Geodesign as a planning approach has been used to support positivist planning and is a powerful tool for rational planning efforts. Within the Geodesign framework clear goals are set throughout the planning process, scenarios are developed to account for competing priorities, powerful quantitative analysis is used for decision support and decision making, and at the end of the planning process an implementable plan is developed with costs calculated (Hudson et al., 1979). The majority of Geodesign planning projects are guided by quantitative deterministic, probabilistic, and/or judgement approaches that are completed through a systems analysis viewpoint. A shortcoming of rationalist planning theory is that it does generally ignore marginalized communities in the planning process and has rightly been criticized for its reductionist tendencies towards goal setting, social values, quantification of environmental process, and ignoring of pluralist interests of a community by centralizing the planning process thus becoming susceptible to powerful special interests amongst other critiques (Allmendinger, 2002; S. S. Fainstein, 2014; Friedmann et al., 1973; Grabow & Heskin, 1973; Irving, 1993). There are opportunities afforded by Geodesign's flexibility, however, to incorporate strengths from other planning theories such as incremental and transactional theories, within formal planning process in Geodesign applications. For example, Geodesign planning facilitators can utilize stakeholders with diverse objectives to collaboratively plan and to seek out local values through volunteered geographic information, which has been done in Geodesign classroom exercises (Borges et al., 2015; Kalvelage et al., 2018).

Planning theories that challenge traditional rational planning prioritize confronting centralized power dynamics in planning, diversifying voices heard in the planning process, understanding the experiences of persons living in the planned area, and through social activism (Arnstein, 1969; Fischer, 2016; Iris M. Young, 2000). Fainstein (2014) argues that any planning effort that excludes people affected by planning decisions is unfair. Nevertheless, even with the advances in technology for processing and analyzing big data and the interconnectedness through social media it remains changeling to involve all potentially affected communities. To promote equity in planning and spread the benefit of planning equally to all communities planners have recommended diversifying the planning field with planners that do not belong to the dominant social group (J. M. Thomas, 2008), educate planners to prioritize equity over efficiency (Marcuse, 2012), and engage in planning efforts that recognize the plurality of objectives in diverse cities and communities (Campbell, 1996; Healey, 2010; Iris M. Young, 2000). These efforts largely stem from Lefebvre (1968) idea of the 'right to the city' which contends that the city should be a co-created space prioritizing common good over individual rights. Planning movements that are pertinent to this research, have resulted from these efforts which include new urbanism, which prioritizes human scaled development (Ellis, 2002), environmental equity, which calls for the dispersion of environmental risk equally across the population (Zimmerman, 1993), collaborative planning that engages diverse stakeholders in making planning decisions (P. A. Fisher & Ball, 2003), and community based planning that uses local knowledge as the guiding vision for planning decisions (Elwood & Leitner, 1998; Grengs, 2002). Successful development on tribal lands have given the community decision making authority in the planning process and this effort builds on these successes (Biles, 2000; P. A. Fisher & Ball, 2003; Miller, 2013). We contend that Geodesign approaches can promote greater equity in the planning process for marginalized communities through greater participation and through the incorporation of local knowledge and values.

5.3 Research Design

The research design is based on the implementation and testing of two case studies. Case study research demands the assimilation of real-world events with data collection requirements. The case study is not typically conducted in a lab nor in the library but with real people in real time observing events as they unfold (Byrne & Ragin, 2009; Yin, 2015). The case study here involves both qualitative and quantitative data were collected through surveys and a focus group to evaluate the Geodesign planning process and its success and effectiveness as implemented within these two Navajo Nation communities. This was done in order to provide insight into the planners' role in the Geodesign process and if the approach empowered participants historically marginalized from the planning initiatives to engage in the planning process. The remainder of this section describes the basis for the case studies including the motivation for the Geodesign study, a description of the study areas, and additional background on tribal governance and sovereignty.

Geodesign Motivation

The motivation for land use planning generally and the specific approach using Geodesign arose when in the winter of 2013, US Route 89 collapsed removing the most direct route between Flagstaff and Page Arizona. In response, Navajo Route 20 (N20) was paved to be a temporary bypass while US Route 89 was repaired. The newly paved road offered the communities of LeChee and Coppermine to develop new land use plans that could take advantage of the greater access that this route provided. In 2018, LeChee Chapter and Coppermine Chapter each participated in a Geodesign workshop to update their land use plans and identify land designations that were now possible with the newly paved road (figure 1). In the end, the goal of the Geodesign study for both communities was to develop community-based land use plans that aligned with community values and priorities for economic, new housing, and public service development.

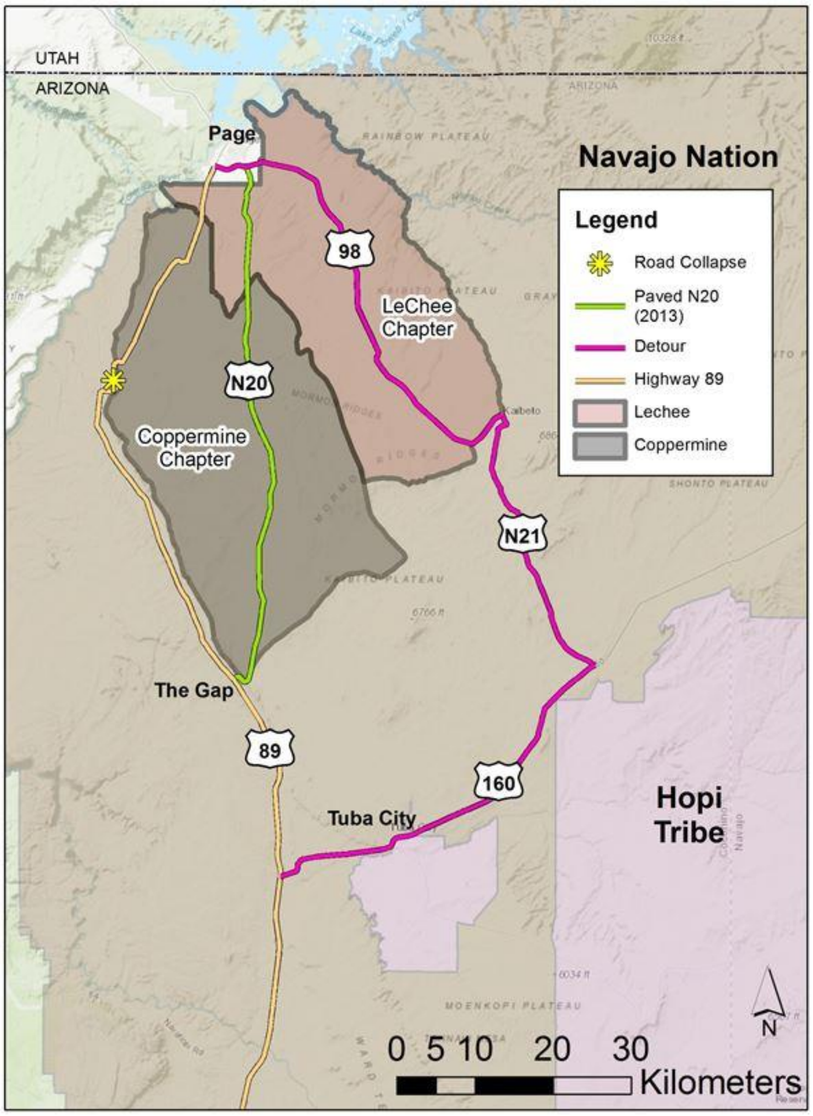

Figure 5.1: This figure shows a map of the Northwest corner of the Navajo Nation. Yellow Starburst is where the road collapsed on US 89 in route to Page, AZ. Magenta road is the detour to the city of Page prior to the paving of the 89T and the green road is the 89T which later became the N20.

5.3.1 Study Areas

This research presents two applications of Geodesign planning approaches for developing land use plans for tribal communities based on Navajo lands near Page, Arizona. These two communities are Coppermine and LeChee Chapter (figure 5.1). Coppermine chapter is located in Northeastern Arizona near the westernmost border of the Navajo Nation just outside of the city of Page, AZ. Its 375 square miles sit upon the Kaibeto plateau and has a high desert climate with sandy soils where copper was extracted throughout the 19th and 20th century (Yurth, 2013a). The Chapter has a relatively low population with less than 500 people currently residing within the Chapter boundaries. The current land designations within the Chapter are wholly scattered housing / grazing with no commercial, economic development initiatives along the N20 (which is also known as Coppermine road). The last land use plan for Coppermine chapter was completed in 2004 and only identified locations within the chapter for clustered housing and as of 2018 none of those clustered housing areas have been developed.

LeChee Chapter is also located in Northeastern Arizona on the Northwestern border of the Navajo Nation. LeChee shares nearly its entire southern border with Coppermine Chapter. LeChee surrounds the City of Page, AZ and is home to roughly 1,500 Native Americans. Along with bordering Page, LeChee also borders Horseshoe Bend and contains Antelope Point, and the world famous upper and lower Antelope Canyons. In addition to these popular tourist attractions LeChee chapter contains the controversial Navajo Generating Station. The majority of the American Indian population in LeChee Chapter lives within the LeChee community, which sits just outside of Page, AZ bordering the city limits. The remaining population lives in a scattered housing habitation pattern along Routes 89, 98, and N20. The LeChee community seeks to become a sister city to Page, however, no economic development plans have been completed along the N20. Much of the population within LeChee either works in Page or at the Navajo Generating Station. The generating station is set to close soon and closure of the generating plant may result in the loss of hundreds of direct and indirect jobs within the Navajo Nation. Developing N20 for job creation focused on tourism is a critical development opportunity. The last time that LeChee had updated their land use plan was in 2012, one year before the N20 was completely paved and fenced.

Land Use along Navajo Route 20

As described above, both Coppermine and LeChee Chapters have not created any economic development along the N20 corridor. Currently the LeChee community straddles the N20 and has a clustered housing settlement on the N20 just outside of Page, AZ. This settlement contains the Chapter House, a small dental clinic, and a pair of water treatment lagoons as its public services. The remaining 7.5 miles of N20 within LeChee consist of scattered housing and grazing land uses. Just on the other side of the border of the LeChee community in Page, AZ, the N20 contains many industrial and marine businesses, including auto repair shops, scrap metal services, and boat storage. As the N20 intersects the US 98 and moves into Page there is a general store trading post, gas stations, campgrounds, and a Navajo Village heritage center that serve the residents and tourists of Page and Lake Powell. Coppermine Road (N20) in Page even contains the city's Police Station and Fire Station. The only economic development along the N20 within the Navajo Nation is at the intersection of Highway 89 at N20 at The Gap community where there is a gas station and auto repair shop, including The Gap trading post. There is an elementary school in Coppermine Chapter near its boundaries of Bodaway Gap and Tuba City along N20. The Coppermine Chapter house and administrative building are just off the N20 as well. These administrative buildings are located 25 miles north of The Gap and 20 miles south of LeChee community and Page's city limits. With a well paved road that connects and increases access between The Gap, Coppermine, and LeChee communities there is opportunity for development in what is now some of the most rural areas in America, and importantly for recovery in the northernmost extent of the Bennett Freeze area[4], reclaiming a region marginalized by injustice.

Navajo Local Governance Act

Located in Arizona, Utah, and New Mexico, the Navajo Nation possesses the physically largest land base and the second highest tribal population of any American Indian community in the United States. The Navajo Nation has consistently strived to become more self-sufficient as a tribal nation providing many services at the local level to its members. As part of its goals to promote self-sufficiency and local sovereignty the Nation developed the Navajo Nation Local Governance Act of 1998 (LGA). Because of

[4] The Bennett Freeze was a development ban by the Federal government on over 1.5 million acres of land claimed by both Navajo Nation and Hopi Tribe. During this freeze houses could not be built or repaired, no new infrastructure such as water or gas lines could be constructed, and road repairs and road construction was forbidden in the area. The ban lasted over forty years beginning in 1966 and only being lifted in 2009. The southern third of Coppermine Chapter falls within the former Bennett Freeze area.

its size and population, the Navajo Nation has sought to provide avenues for decentralized governance at the local level. The LGA outlined the separation of powers within the Navajo Nation and allowed for local government at the Chapter level, that provided greater local authority and decision-making powers to these local governments. Part of the powers delegated by the LGA included land use planning. However, in order for a Chapter to retain local government authority one of the requirements was to keep an updated land use plan that demonstrated that the Chapter had accounted for natural, cultural, and community resources which include infrastructure and land carrying capacity. Another requirement of the land use plan is that it needs to demonstrate that the guiding principles of the land use plan were derived by the local community and these plans are considered as community-based plans (Navajo Nation Local Governance Act, 1998).

After the LGA was passed 96 out of the 110 chapters had developed land use plans. However, a requirement of the LGA included a 5-year update requirement. Fifteen years after the initial passage of the LGA less than 10 of the Chapters had completed the update and few were implemented (Gardner & Pijawka, 2013). Gardner et al. argue that the updates did not take place because many of the plans did not have public participation involvement, had limited use of land suitability analysis and Geographic Information Systems (GIS), and much of the planning was largely completed by entities who were not part of the community. We argue that Geodesign can be an empowering planning tool/approach for traditionally marginalized communities to contribute local knowledge and engage in the planning process. Our argument is that Geodesign can provide all of the requirements missing from earlier attempts at plan-making in the Navajo Nation at the local level.

5.4 Methods

The methods for this research are divided into application and evaluation methods. The first section application, will include a brief description of the Geodesign workflow as implemented in both LeChee and Coppermine Chapters. The second section will describe the qualitative and quantitative methods used to collect and evaluate information gathered during the Geodesign planning process to assess the level of success of the Geodesign process as a planning approach and particularly as it relates to its effectiveness in empowering marginalized communities and exploring the planner's role in this process.

5.4.1 The Geodesign Planning Approach

The goal of this section is to provide the details on how the Geodesign study method is applied to the case studies on the Navajo Nation. Here we describe the Geodesign workflow, the process for identifying workshop participants, and the execution of the Geodesign workshop. In each section, we describe the general approach and provide the specific methods used in the case study.

Geodesign Workflow

The formal framework for Geodesign goes through three design iterations to : 1) "understand the study area", 2) "Specify Methods", and 3) "perform the study," as shown in figure 2 (Steinitz, 2012). This design structure fits well with traditional design structures that promote a fluid iterative approach without sacrificing a strong organizing structure (Foster, 2016; Kumar, 2012). The first iteration is dedicated to understanding the study area which includes identifying its geographic extent as well as understanding how environmental, political, and cultural processes currently operate. This first iteration identifies the priorities of the planning project and discovers the competing constraints and limitations within the study area while ascertaining the desired outcomes (T. Brown & Katz, 2011). The second iteration identifies the methods in which principle factors within the study area can be quantified and assessed in order to evaluate if the design area and its systems can meet the objectives for the area. It is essentially in this stage that the 'how' to perform planning effort or the design of the design which is implemented in the final stage. The spatial data collection and geospatial analysis needed for decision making is also completed in the second iteration. The final iteration is creating the land use design/plans/scenarios and presenting them to the stakeholders for acceptance and prioritization. This begins a cycle of optimization, revision, and an option for implementation as new information is obtained from the stakeholders and participants (Nyerges et al., 2016; Steinitz, 2012, 2014).

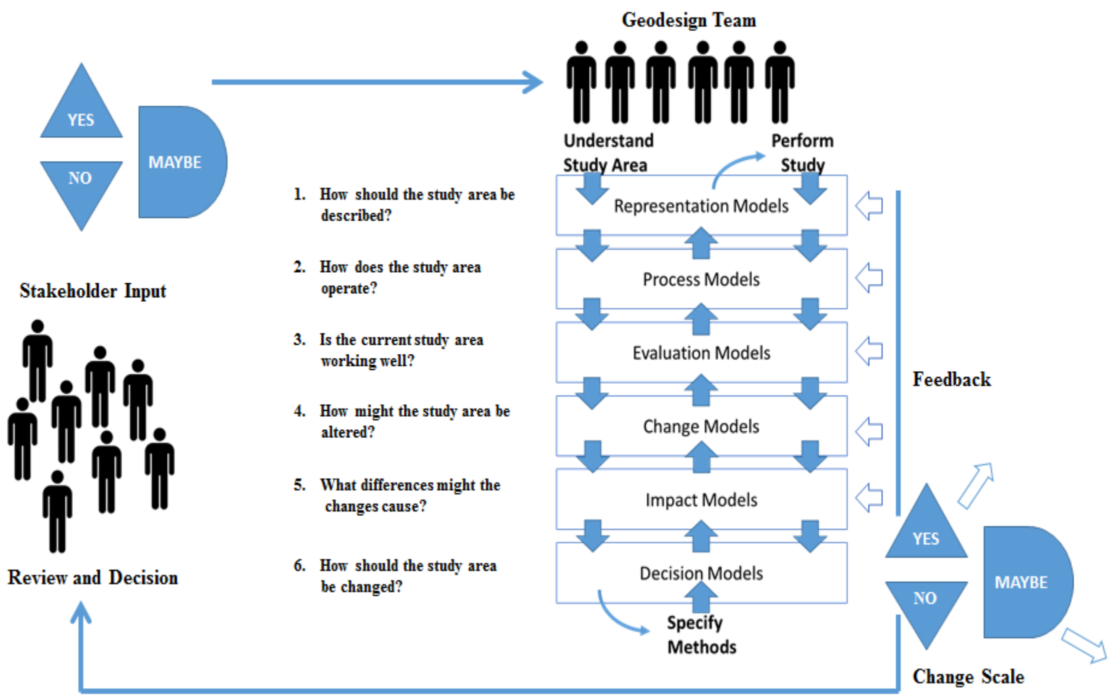

Figure 5.2: This diagram is created from the Geodesign Framework proposed by Carl Steinitz (2012).

Each iteration within this Geodesign application was vital for connecting community values and goals to the planning process and decisions, and enables the practitioners to collect assessment data capable to support the vision and accurately assess the planning area. Each step supports and builds upon the previous step and can be an iterative process as needed. In these case studies the planners knew that the end product was going to be a land use plan, however, the form of the land use plan required systematic input from the community to be a community-based land use plan. To identify these values and inform the assessments needed for the Geodesign workshop, the planner worked with the community to identify the local resources that would be available for the planning process. These resources included community experts and government officials that provided the planning team with past planning documents and assessments that have been completed in the community. This gave the planning team a glimpse into the current planning processes of the community. Following the identification and cataloguing of these resources visioning session(s) were held to identify the needs and goals of the community from the bottom up and a SWOT analysis was conducted to identify local perceptions of the strengths, weaknesses, opportunities, and threats to the community as well as the desired future direction of the community. At the conclusion of the visioning session(s) the planner has a clearer idea of the current social processes operating within the community as well as the desired future state of the community. From this information a visioning report is developed that clearly outlines the goals, objectives, and the results of the SWOT analysis for the community to review and validate. From this visioning report the planner created a list of required geospatial data and assessments both demographic and environmental in order to conduct needed land suitability analysis. The planner met with the community to identify any additional local sources then reached out to non-local sources for data that was not housed locally within the community. Any assessment or geospatial data not available from these sources needed to be collected or created by community experts, community volunteers, or a member of the planning team. Once all of the required assessment and geospatial data was collected the planners worked with GIS specialists both with local and non-local sources to conduct a land suitability analysis and create an impact assessment chart. This was validated by the community. Upon completion of the land suitability analysis a Geodesign workshop was scheduled and workshop participants invited to participate (see figure 5.3).

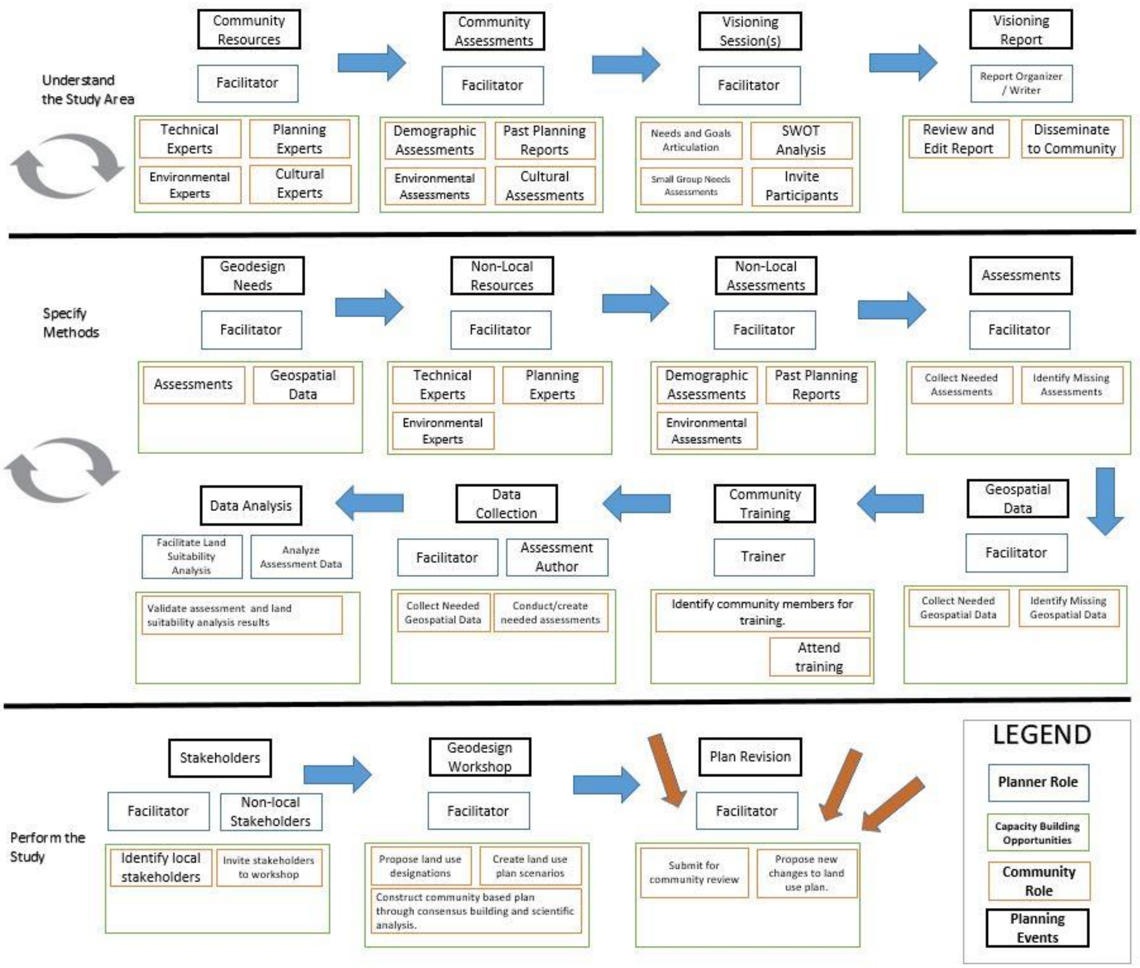

Figure 5.3: The Geodesign planning framework as applied in these case studies. The role of the planner, community, and planning events are described. Opportunities for building planning capacity within the community. ** The step by step approach for facilitating a Geodesign workshop is in figure 5.4.

Identifying Workshop Participants

A critique of previous land use plans developed under the LGA requirements is that they had limited community involvement, which resulted in a limited capacity to implement any land use plans. Carefully selecting community participants addresses this shortcoming. Geodesign workshop participants should both be stakeholders who have power to make decisions on behalf of their community, and represent multiple viewpoints within the community. This participant strategy recognizes the diverse priorities within the community and provides opportunities for compromise and negotiation, whereas previous planning efforts were stymied due to excluding key stakeholders and land users (Gardner & Pijawka, 2013). The participants need to be prepared to share their local knowledge and goals to inform decision making and be willing to negotiate and compromise with the other stakeholders. For the workshop and the visioning session, the Geodesign facilitator should work with community leaders and provide suggestions on selecting representative participants for a workshop and should include stakeholders, interested community members, and community experts. Participants should be selected with the purpose of the planning effort in mind as well as development issues and community goals (Steinitz, 2012). The LeChee chapter vice-chairperson and the Coppermine land use planning committee identified and invited community members to participate in their respective workshops. Invitees in both workshops included key representatives of the communities such as Chapter officials, grazing managers, major land users, local residents, and community professionals. At both workshops there were three planners and a GIS specialist from the Navajo Nation in addition to GIS and planning experts from outside the Navajo Nation. There are planning professionals within the Navajo Nation, however, there is significant turnover in the planning department and many chapters are unaware of the resources that the Navajo Nation has available for chapters to use in the planning efforts (Gardner & Pijawka, 2013). The planning team connected the local communities to these resources.

The Geodesign Workshop

Within the Geodesign workshop, the process followed the Steinitz (2012) participatory model. This included five stages (Figure 5.4). In the first stage the planning team and a community leader explained to the participants the purpose of the workshop, the results of the visioning sessions, especially including goals and objectives/needs, and an introduction to the Geodesign software that would be used in the workshop (this software being Geodesignhub). Geodesignhub is a software specifically designed to conduct a workshop that allows for participants to interact and draw on land suitability analysis maps with satellite imagery, share designs, negotiate plans, and determine rough estimates of the cost for implementing new land use designation. The second stage required the planner and the community manager to assign each participant to a team which would generate land designation ideas for a single land use be it economic development, conservation, public service, housing, amongst others. These focused land use designation groups served as an 'expert group' where both community experts, non-local experts, and interested community members generated potential land uses. Ideally, there should be a planner at each expert group to provide expertise and discuss ideas. The third stage required the planner to work with a community leader to separate these groups into stakeholder groups who could represent the various interests and visions present within the communities. These groups would generate the first round of land use plans. In this case both LeChee and Coppermine Chapters broke up into four initial stakeholder groups to generate their land use plans. When creating this first round of land use plans each particpant can utilize the land use designations that are already created or create their own. Each stakeholder group had a planner available to them to provide recommendations, discuss ideas, and facillitate discussion and compromise within the group. Upon completing the first round of land use plans the groups elect a spokesman to present their land use plan to the workshop at large. After these presentations are complete the planning team facilliates an exercise where the groups identify groups through which they believe compromise can be achieved and combines these groups. These four land use stakeholder groups were merged into two stakeholder groups and the process was repeated. The final stage of the Geodesign process included the two stakeholder groups merging their land use plan into one through compromise and negotiation facilliated by the planning team.

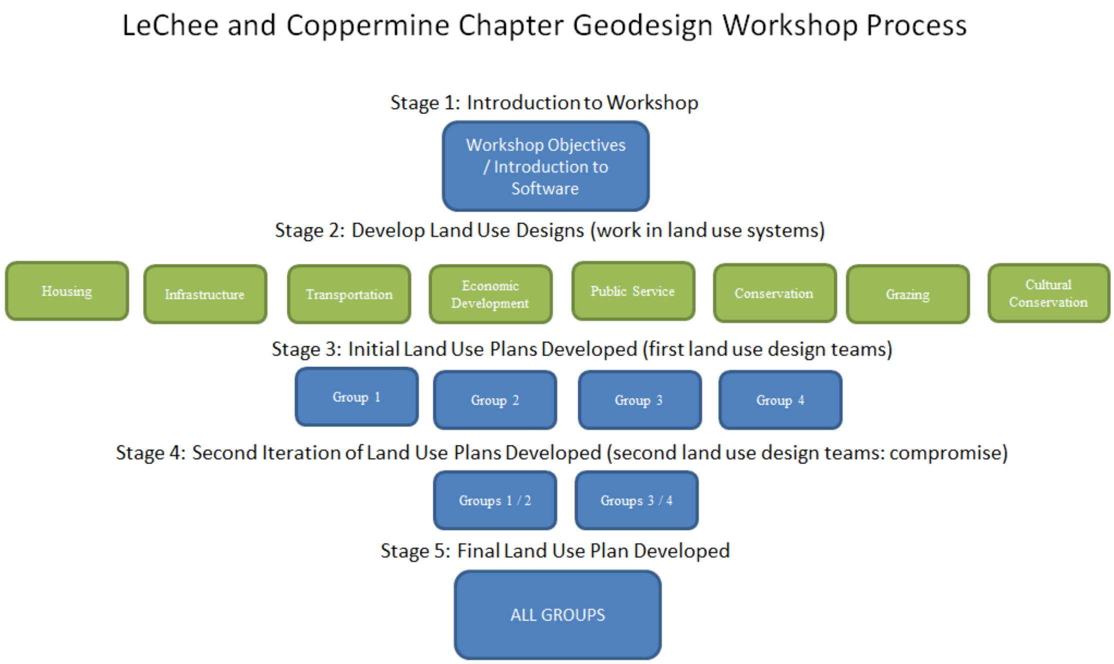

Figure 5.4: Geodesign workshop format used by Coppermine and LeChee Chapters.

5.4.2 Evaluation Methodology

Workshop Participants

All community members from these chapters were encouraged to attend and participate in the Geodesign workshop and were notified through chapter meetings and posted announcements. However, there were targeted invites to the workshop that were considered key stakeholders in that they were either major land users, family representatives, local government officials, or community professionals. Over 30 stakeholders from Coppermine Chapter were invited to participate in the Geodesign workshop, with 23 who participated in at least one day of the 2-day workshop. There were three planners and one GIS professional from the Navajo Nation as well as a two planners and a GIS specialist from outside the Navajo Nation engaged in the workshop to assist workshop participants. LeChee Chapter also invited 30 stakeholders from their community with 18 attending at least one day of the 2-day workshop. Three planners, a GIS specialist, and tribal utility authority expert, and an environmental/recreation manager from the Navajo Nation also actively participated in the workshop. These participants were identified through the guidance of the planning team. Both chapters included key stakeholders and representatives of the community to participate in the Geodesign workshop including Chapter officials, community development professionals, major land users, local residents (from across the age spectrum), the land use planning committee, and ranchers. Major land users in the Navajo Nation have blocked planning implementation in the past when not consulted in the planning effort, but when included in the process can see the benefit of the planning effort for the community at large are more amenable to new land uses. All qualitative data in the evaluation methodology is from the experiences reported by these participants.

Participant Surveys

Surveys were given by the researchers at the end of the Geodesign workshop to evaluate participant experiences, perceptions, and attitudes. for elements within the Geodesign process that are intended to promote and support public participation and community engagement (J. Patton, 1999). The surveys used Likert-scale questions of strongly disagree (1) to strongly agree (5), with the purpose to evaluate participant degree of agreement. These Likert-scale questions provide statistical insight on participant perceptions of Geodesign as a planning approach that effectively incorporates multiple perspectives, community values, and community engagement (Carifio & Perla, 2008). The questions included 1) Do you feel that your voice was heard in the Geodesign process 2) Do you believe that the plan developed today can be implemented in the future 3) Do you believe that the Geodesign plan developed today honors and reflects your culture and respects traditions / values 4) Would you recommend Geodesign as a planning method to other American Indian communities?

Focus Groups

The focus group consisted of six members of the Coppermine Chapter Land Use Planning Committee (CLUPC), two Coppermine Chapter Community members not affiliated with the land use planning committee and who did not participate in the Geodesign workshop, and the Coppermine Chapter Vice President. The CLUPC consists of major land users, business owners, and former and current government officials. We included a focus group as part of the study to gain an understanding of a larger population under study (Cochran et al., 2008; Leech & Onwuegbuzie, 2007; M. Q. Patton, 1999).

The hour-long focus group was conducted by the facilitator of the Geodesign workshop whose recorded audio was later transcribed. The focus group was semi-structured with the overall purpose to identify opportunities for improvement in conducting Geodesign workshops in American Indian Communities, the role of the planner in Geodesign planning approaches, evaluate degree of support of the land use plan from the community, and to compare and contrast the Geodesign approach to previous planning efforts within the Chapter using Arnstein's ladder of participation (Arnstein, 1969).

Arnstein's ladder of participation measures the community control over planning efforts. This measurement is an eight-point scale divided into three groups: no participation, degrees of tokenism (symbolic participation), and degrees of citizen power (real participation). The no participation group consists of 1) manipulation and 2) therapy. This grouping has no opportunities for feedback from the public and the plan is promoted as the best option. The degrees of tokenism group consists of 3) informing, 4) consultation, and 5) placation. This group begins the process of community involvement but is limited in that at best the public is informed of the planning process and public input is requested through surveys but no decision making power is outside of community. The degree of power group or real participation includes 6) partnership, 7) delegated power, and 8) citizen control. This grouping gives decision making authority to communities and ranges from negotiated citizen control through partnership to complete citizen control.

The evaluation of planning participation using Arnstein's ladder of participation asks what has public involvement been in past planning project, what was public involvement in this planning project, and what public involvement in planning should be (Bailey et al., 2011). The participants in the workshop were given a concise description and visual depiction of Arnstein's ladder as to which they referred to when answering and discussing the above questions. Utilizing the qualitative data generated from this focus group the Geodesign facilitator completed a thematic analysis using quotes from focus group participant responses. The themes were identified from these responses and reviewed by four university researchers who specialize in transportation planning, environmental/risk analysis planning, geospatial analysis, and community engagement with one researcher being an enrolled tribal member of the Navajo Nation (J. Patton, 1999; Teufel-Shone & Williams, 2010).

5.5 Results

The end product of a Geodesign planning process in this study is a finalized community-based land use plan for two areas. The land use plan for the Coppermine Chapter prioritized increasing public services and economic opportunities within the community that largely did not rely on tourism, although it did include some areas designated for camping and recreation. LeChee Chapter's land use plan prioritized identifying new land use designations within 1.5 miles of the town of LeChee. Economic development designations consisted of replicating tourism opportunities found within

Page. All of these land use designations were identified, mapped, and approved by Coppermine and LeChee community members who participated in their respective Geodesign workshops. Coppermine Chapter developed their first land use plan through this process (figure 5.6).

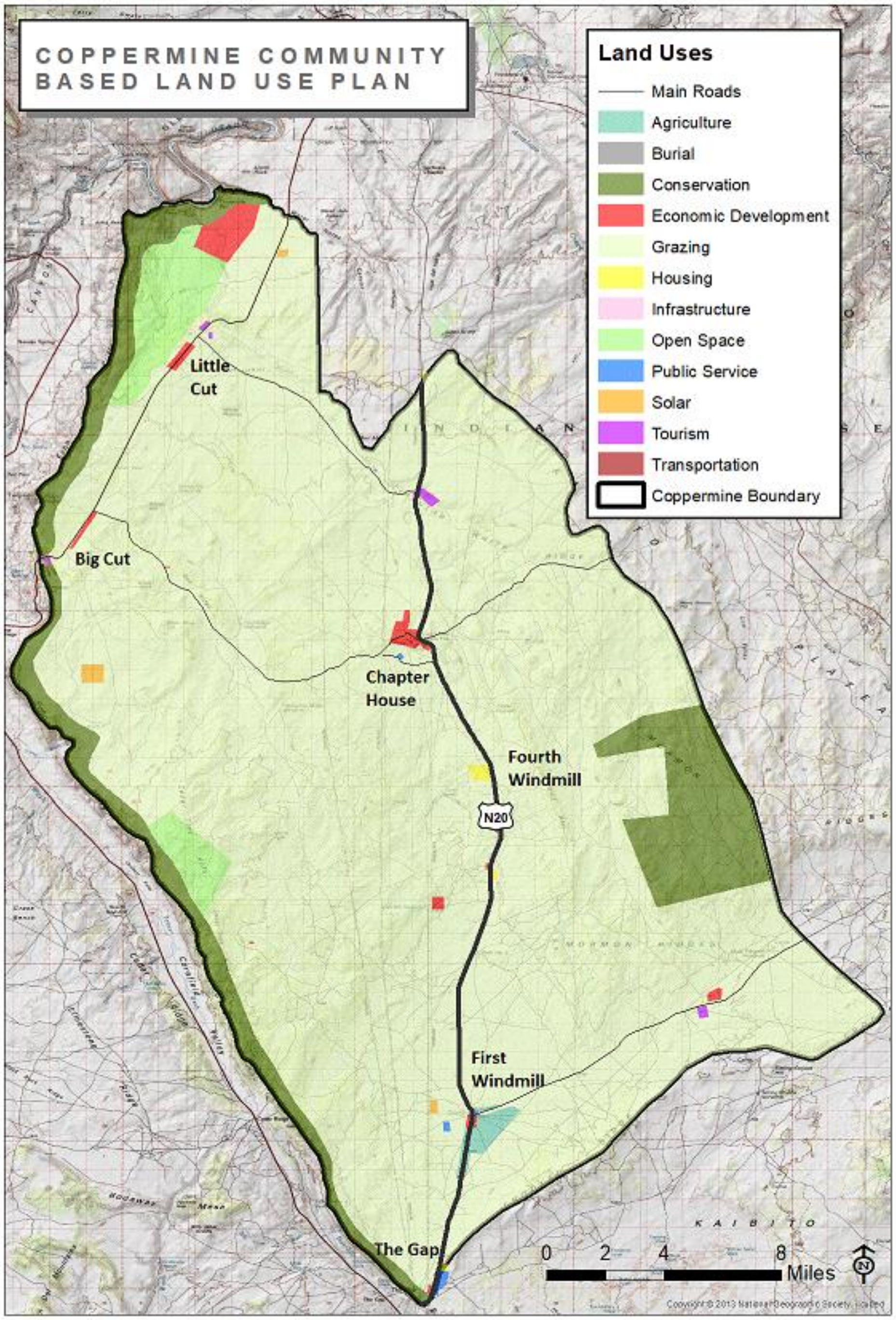

Figure 5.6: Coppermine Chapter Land Use Plan along the N20.

Survey Results

At the conclusion of the Geodesign workshop both LeChee and Coppermine Chapter participants were asked four Likert-scale questions to evaluate participant perceptions of the Geodesign approach (figure 5.1). When asked immediately after the workshop if they would recommend Geodesign as a planning method for other indigenous communities, all of the participants from Coppermine either strongly agreed (60%) or agreed (40%) with this statement and 92.3% of participants from LeChee chapter strongly agreed (84.6%) or agreed (7.7%) with the statement. As the literature section showed indigenous communities have felt left behind or excluded from traditional western planning processes and these strong supportive responses indicate that Geodesign has been able to incorporate the community traditions and values within the planning process. In regards to whether or not the community members felt that their voice was heard, all of the participants in Coppermine either agreed (60%) or strongly agreed (40%) that that their opinions or knowledge were considered in the Geodesign process and the plan and in LeChee all participants either strongly agreed (53.8%) or agreed (46.2%) that their voice was heard. This response is largely due to the focus on local decision-making within the workshop and that the plans were largely designed by community. This is opposite of traditional planning experience in their community where they were informed of the planning efforts and were expected to sign off on what the outside professionals have planned. In addition, all of the participants from Coppermine chapter agreed (61.5%) or strongly agreed (38.5%) that the plan developed in the Geodesign workshop would be implemented as the community land use plan in the future, this is similar to

LeChee Chapter in which 92.3% of participants either strongly agreed (61.5%) or agreed (30.8%). The planning study completed by Gardner et al (2013) found that there was little optimism about plan implementation tribal communities, but with this approach demonstrated strong optimism about implementation.

When asked if the Geodesign plan honors and reflects their culture and respects community values and traditions all of the participants from Coppermine Chapter strongly agreed (38.5%) or agreed (61.5%) with the statement and 92.3% of LeChee Chapter participants strongly agreed (53.8%) or agreed (38.5%) with the statement on the likert-scale. These results indicate that Geodesign engages these communities as active decision makers in the planning process and that they are able to use both scientific decision making mechanisms and community values to develop a consensus based land use plan. This community control and utilization of both science and non-traditional knowledge for decision making is important in marginalized and indigenous planning efforts (Jojola, 2013; Matunga, 2013; Zaferatos, 1996).

Table 5.1: Likert results from end of workshop survey for LeChee and Coppermine Chapter.

Question: **Would you recommend Geodesign as a Planning Method to other Tribes?**					
COPPERMINE CHAPTER					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree** (4)	**Strongly Agree (5)**
Responses	0	0	0	6	9
Percentage	0	0	0	40	60
Average	4.6 (Total Respondents 15)				
Agree or Strongly Agree				**100%**	
LECHEE CHAPTER					

Scale	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
Responses	0	1	0	1	11
Percentage	0	7.7	0	7.7	84.6
Average	4.7 (Total Respondents 13)				
Agree or Strongly Agree				**92.3%**	

Question: **Do you feel that your voice was heard in the Geodesign Process?**					
COPPERMINE CHAPTER					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree** (4)	**Strongly Agree (5)**
Responses	0	0	0	9	6
Percentage	0	0	0	60	40
Average	4.4 (Total Respondents 15)				
Agree or Strongly Agree				**100%**	
LECHEE CHAPTER					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree** (4)	**Strongly Agree (5)**
Responses	**0**	**0**	**0**	**6**	**7**
Percentage	**0**	**0**	**0**	**46.2**	**53.8**
Average	**4.53 (Total Respondents 13)**				
Agree or Strongly Agree				**100%**	

Question: **Do you believe that the plan developed today can be implemented in the future?**					
COPPERMINE CHAPTER					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree** (4)	**Strongly Agree (5)**
Responses	0	0	0	8	5
Percentage	0	0	0	61.5	38.5
Average	4.4 (Total Respondents 13)				
Agree or Strongly Agree				**100%**	
LECHEE CHAPTER					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree** (4)	**Strongly Agree (5)**
Responses	**0**	**1**	**0**	**4**	**8**
Percentage	**0**	**7.7**	**0**	**30.8**	**61.5**
Average	**4.46 (Total Respondents 13)**				
Agree or Strongly Agree				**92.3%**	

Question: **Do you believe that the Geodesign plan honors and reflects your culture and respects your traditions and values?**					
COPPERMINE CHAPTER					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree** (4)	**Strongly Agree (5)**
Responses	0	0	0	8	5
Percentage	0	0	0	61.5	38.5
Average	4.38 (Total Respondents 15)				
Agree or Strongly Agree				**100%**	
LECHEE CHAPTER					
Scale	**Strongly Disagree (1)**	**Disagree (2)**	**Neutral (3)**	**Agree** (4)	**Strongly Agree (5)**
Responses	**0**	**0**	**1**	**5**	**7**
Percentage	**0**	**0**	**0**	**38.5**	**53.8**
Average	**4.46 (Total Respondents 13)**				
Agree or Strongly Agree				**92.3%**	

Arnstein's Ladder of Participation

The focus group revealed that there exists a 'gap' in the expectations for community participation and control and in community participation for past planning efforts (Arnstein, 1969; Bailey et al., 2011). The focus group indicated that public participation for past planning efforts spanned from manipulation to placation with the majority of participants indicating informing, with an average response of 3.5 or between informing and consultation. Perceptions for participation in past planning efforts largely related to where they lived within the Chapter. Those that lived in the Former Bennett Freeze area were prevented from development and even prevented from repairing their homes as long as the land dispute remained in place, several recalled requesting the development of the N 20 many years before its actual construction and being told that it was not feasible or needed until the catastrophic failure of the US 89. When transmission lines were installed in the chapter community members were surveyed and informed of the placement of infrastructure but community sentiment was largely ignored. One focus group participant relayed this experience having "gone to a planning meeting when I was a lot younger and the community was invited but it seemed like we weren't being heard that we were being looked over."

Focus group participants initially indicated that public participation should be delegated power and citizen control, but after a lively discussion the focus group participants determined that public participation should be delegated power and a partnership between the governing officials of the chapter, the community members within the chapter, and the government officials in the Navajo Nation and the Federal government. One remained committed to citizen control because they felt even elected local officials did not always represent all community interests. This resulted in an average public participation score of 7 revealing a gap of 3.5 between participation in past planning efforts and what the role of public participation should be.

Finally, the focus group was asked where the Geodesign approach fell within Arnstein's ladder and they identified that the planning framework was a partnership. They indicated that the stakeholders from Coppermine Chapter were representative of community vision and community members were able to convey their ideas not only to Coppermine government officials but with planning experts and stakeholders from both within and outside the Navajo Nation. They felt that the support they received and expert guidance and feedback on their ideas was very beneficial and felt confident that what was produced would be approved and funded by the Navajo Government. The focus group identified a 'gap' in their expectations for public participation in planning efforts within Coppermine Chapter and what they have experienced in past, but found that the Geodesign approach came much closer to meeting these expectations with only a gap of 1.

Table 5.2: Focus group results from participant perception of participation for past, current, and future planning efforts.

Question: From your experience, how would you rate public participation efforts for your community in past planning efforts using Arnstein's Ladder?								
Scale	**Manipulation (1)**	**Therapy (2)**	**Informing (3)**	**Consultation (4)**	**Placation (5)**	**Partnership (6)**	**Delegated Power (7)**	**Citizen Control (8)**
Responses	1	0	3	2	2	0	0	0
Percentage	12.5	0	37.5	25	25	0	0	0
Average	3.5							
Question: What should community participation be in planning efforts for your chapter using this ladder?								
Scale	**Manipulation (1)**	**Therapy (2)**	**Informing (3)**	**Consultation (4)**	**Placation (5)**	**Partnership (6)**	**Delegated Power (7)**	**Citizen Control (8)**
Responses	0	0	0	0	0	3	4	1
Percentage	0	0	0	0	0	37.5	50	12.5
Average	7			**Gap**	3.5			
Question: How would you rate the degree of participation in the Geodesign planning approach to develop your most recent land use plan?								
Scale	**Manipulation (1)**	**Therapy (2)**	**Informing (3)**	**Consultation (4)**	**Placation (5)**	**Partnership (6)**	**Delegated Power (7)**	**Citizen Control (8)**
Responses	0	0	0	0	0	8	0	0
Percentage	0	0	0	0	0	100	0	0
Average	6			**Gap**	1			

5.6 Discussion

The three roles of the planner in a community-based Geodesign approach are 1) a facilitator, 2) planning expert resource, and 3) community capacity builder. Many of these communities are data scarce or are not aware of the data that is available for their community. Basic spatial data and GIS maps needed for plan making were often lacking in Chapters, so the initial objectives are to find these at various and different governmental agencies, inside and outside of the specific Nation especially State Government agencies especially for transportation and natural resources. The planners preparing for the Geodesign workshop often need to facilitate the development of a series of GIS - based maps in order to develop the feasibility and suitability assessment for each land use under consideration. This process may take considerable time and commitment, and may require the planner to train community members in programs such as google earth to obtain community data, but it is a pre-condition for a successful workshop. We see that the planners not only work with the Chapter or local community leadership but most likely must coordinate data sharing on behalf of the community with state agencies, county governments, and government agencies within the Indian nation. “We put in a lot of work gathering data, but we needed the technical assistance with mapping because it was something that we did not know how to do.” In addition to facilitating mapping efforts planners also need to be able to facilitate assessment for demographic and housing issues as census data from these community may be inaccurate or unavailable.

The key role of the planner in addition to providing expertise on technical processes and evaluating data needs is as facilitator. This effort is significantly more than running a citizen participation process on a site decision, a design, or a NEPA – related problem. The planners are distributed among stakeholders at the workshop and they help with the process, specify issues, provide examples, and discuss possible impacts. Planners are invaluable in facilitating conflict resolution and assisting in the development of compromise scenarios. A community member indicated that it is very “beneficial from someone outside the community to assist in leading discussions because it reduces conflict in decision making." As such, the facilitator-planner needs to be flexible to discuss and provide needed information that cuts across disciplines and must seek to be very familiar with the local community culture, economy, and housing. As stakeholders discuss the needs for new homes and where to place them, the involved planner needs to understand or seek knowledge as to home size, spatial distribution of homes based on traditional culture, and overall size for that land use type. Most difficult for planners without experience with the tribe, is a fundamental knowledge of local traditions and culture as this is not often provided. The facilitator-planner has to be viewed as a planner educator to rapidly answer questions on feasibility, interactions, and land use regulations for transportation, development, and other factors as well as assist the community in connecting community vision to land use designations.

We have also learned that once the land use designations have been made by the workshop participants, the plan is a draft and often needs to go back to the designated Chapter leadership / planning committee for clarification and expertise from other stakeholders that were not present at the workshop. How that feedback process is structured is critical to the success and completion of the plan. The role of the planner often requires sensitivity to local knowledge in contrast to technical knowledge but the planner in this case requires the ability to discover local knowledge and see its importance in land use decisions. The planner facilitates the exchange of ideas, leads participation, reduces conflict of ideas, yet ultimately needs to educate the participants at the same time on planning methods and decision- making and concepts. Local knowledge is one of the most critical variables and the question becomes how a planner can be effective in discovering local knowledge, its importance, and how it can be used almost simultaneously.

What we learned in these community-based exercises is that Geodesign can work with communities that have little experience in planning, are data-poor, may not be fully engaged with GIS technology, have been distanced from making their own decisions as part of a legislative process. In these cases, the participants have been disenfranchised and have not often been able to make decisions such as designating places for shopping, employment, energy, infrastructure, and assuring health care among other factors. In previous planning efforts the community has felt that "specialists…put it together and all they did was sign our name to it." The Geodesign workshop can provide community involvement and engagement among diverse sectors of a community including those that have typically been left out such as the elderly. The community said that planners in the Geodesign workshop should be guides in the planning process, "You guys basically held our hand and guided us through the process and we were able to come up with the plan, the community did it, we did it." The communities found that this application of Geodesign fit within Arnstein's ladder as a planning framework that gave community members real decision making power in developing their land use plan.

A limitation of this research is that the success of the land use planning initiative is highly dependent on the motivation of the community, the ability of the participating planning professionals, and the trust relationship between the community and the participating planner. The planners and GIS professionals from outside of the Navajo Nation who facilitated these workshops have extensive experience working with Tribal communities and were known to the communities prior to this land use planning effort and were sought out by the communities for assistance. Both communities needed to complete a land use plan update and desired to take advantage of the expertise offered.

5.7 Conclusion

In previous planning efforts, these communities have historically been consulted and informed of planning developments within their communities, but actual decision making power has been limited. As shown in these two case studies, Geodesign planning approaches can be used by planners to empower marginalized communities to engage in the planning process and incorporate diverse perspectives and values in decision making. Using Arnstein's ladder of participation, the community conveyed that Geodesign gave the local community decision making authority on future development and land use designations. The Geodesign approach engaged historically marginalized populations within the planning process and empowered them to contribute their local knowledge of their land and form partnerships both within and outside their community to guide sustainable development. We found that the role of the planner in this process is as a capacity builder that facilitates planning efforts for the community, building skillsets to foster self-sufficiency within the community, and as education resource to guide planning efforts when called upon.

Chapter 6

6 Conclusion

This research began as an evaluation of a planning framework crafted to address planning barriers within the Navajo Nation associated with the Local Governance Act. The Navajo Nation Local Governance Act required that each Navajo Chapter government create community-based land uses plans that 1) demonstrate that the plan was guided by principles and vision as articulated by the community; 2) clear evidence that natural, cultural, human resources, and community infrastructure has be accounted for; 3) land carrying capacity is considered, and 4) land use designations anticipate and meet the future needs of the community. In addition to these requirements the communities were required to update their plans every five years. Gardner et. al. 2013 found that these LGA requirements were not being met in land use planning efforts because there was a lack of community based participation in decision making, limited use of geospatial technologies and land suitability analysis, few technical planning experts available within the community, and difficulties in reconciling conflicting priorities. It was believed that Geodesign planning approaches could both address the requirements of the LGA and reconcile the planning barriers identified in the 2013 report and should be tested.

Much of the research within indigenous planning focuses on the challenges in utilizing non-Western planning approaches, asserting sovereignty under Western governments, data scarcity, and limitations in local planning capacity. Specifically, indigenous planning scholars have called for planning approaches that offer indigenous communities the opportunity to utilize Western planning methods subservient to local community values and traditions. This gap led to a research question to evaluate how Geodesign approaches could integrate indigenous values, traditions, and priorities supported by western planning approaches.

Chapter 3 addresses this research question and evaluates the first application of a Geodesign planning approach in an American Indian community and its effectiveness in incorporating indigenous values of 1) the importance of local sovereignty, local decision making planning for community prosperity; 2) Knowledge is generated in many forms and that indigenous ways of knowing are legitimate ways of knowing; 3) that the land is sacred and should be preserved for future generations; 4) and that everything is intrinsically related, the people, the environment, and society. Dilkon Chapter developed a community based land use plan that is both scientifically rigorous and grounded in community values and traditions. Through the use of surveys, community participants indicated that community values guided the planning process and decisions were made by community stakeholders for the benefit of the community. Furthermore, the community related that their decisions prioritized preserving the land and the culture for future generations. This was done with the hope that planning development with cultural and environmental preservation will improve the overall quality of life for the community and create additional opportunities for their children and grandchildren. Dilkon Chapter found that Geodesign approaches supported community knowledge and values in local decision making and allowed for compromise through consensus building to make land use decisions that met LGA requirements.

The majority of Geodesign projects are completed in data rich areas that use national data sources to complete spatial analysis and to understand ecosystem processes in informing planning decisions. In addition, these projects are completed by a diverse group of planning professionals, scientists, and GIS experts with stakeholders approving final designs. This identified a gap to test Geodesign as a bottom up planning approach that uses local knowledge to overcome data scarcity challenges and inform decision making for land use designations. This led to a second research question to evaluate how Geodesign can enable data scarce communities to develop land use plans that are resilient against natural disasters. In Chapter 4, Sif-Oidak District of the Tohono O'odham Nation addresses this question by using the Geodesign process to create a flood risk assessment using remote sensing data that is validated through community knowledge of known flood risk areas. Through Geodesign approaches this community used local participation to increase resiliency against flood risk areas by contributing local knowledge of flood risk that was not previously available, make decisions for implementing resiliency strategies for future community and infrastructure development, establish clear goals to reduce flood risk, and address flood risk through multiple development and land use designation strategies. This case study demonstrated that Geodesign could merge community knowledge with scientific analysis to address data scarcity challenges in developing land use plans.

With many planning theorists emphasizing the importance of just cities there has been a rise in the importance of evaluating public participatory processes in planning efforts particular for marginalized communities that have historically been excluded from decision making processes. This led to a final research question that evaluates how Geodesign can be an empowering planning process that engages marginalized communities in decisions making and the role of planners in this process. This research questions is addressed in Chapter 6 through two case studies in the Navajo Nation that use Geodesign to update and create land use plans through bottom up community-based decision making processes. Through the use of surveys and focus groups these case studies revealed that representatives from these marginalized communities were able to contribute local values, and have a direct say in decision making for land use designations. Using Arnstein's ladder of participation as a metric for community power in decision making, Geodesign proved to be a marked improvement on past planning efforts closing the 'gap' between public participation in decision making for past planning efforts and where the community believes public participation should be.

Across all of these case studies Geodesign proved successful in empowering the people of the place to develop land use plans that carry the voice and vision of the local community. This approach greatly assisted communities with limited planning or technical experience to actively participate in the planning process and gain valuable experience for future planning efforts. The Geodesign approach was crucial to the success of the planning efforts in three important ways. 1) Community members were able contribute local knowledge that could be easily visualized and shared with the rest of the community; 2) The land suitability analysis maps and new land use designations facilitated discussions between competing viewpoints within the community and between experts participating in the workshop; 3) the stakeholders were able to understand the impacts of their decisions and able to compromise and build consensus in decision making in real time.

By involving diverse community perspectives and competing priorities for land uses at these workshops a greater number of community members gained valuable experience in the planning process and multiple viewpoints and values were considered in decision making. Because these plans were built on consensus there were more advocates to explain the purpose of new land use designations and how they would benefit the community. The increased participation by numerous representatives of the community greatly increased the likelihood of the acceptance and implementation of the plan. All of the plans in this dissertation are developed through community consensus and incorporate local knowledge and values in decision making. Nevertheless it is important to note that these decisions are also grounded in scientific analysis provided through the Geodesign process.

The objective of this dissertation was to demonstrate that Geodesign planning approaches can be used as an empowering planning alternative for American Indian communities that promote self-sufficiency, tribal sovereignty, and internal planning capacity and creates land use plans that are economically, socially, and environmentally resilient, culturally sensitive, and incorporate community values. This was shown through four case studies in the Navajo and Tohono O'odham Nation that resulted in three unique but interrelated research articles that fundamentally demonstrated that Geodesign could be used to integrate both scientific and community knowledge to address data scarcity and inform decision making towards land use planning, empower communities to actively participate and guide planning efforts, and to incorporate indigenous values as guiding principles for planning efforts. Through Geodesign two communities developed their first ever land use plans and two were able to update and improve upon their previous plans.

Contributions to Geography

Geography as a field explores the physical processes of the earth's surface and the human societies that live upon it as well as the interactions between people and their immediate environment (Bonnett, 2003). Geography seeks to understand where something is, why it is there, and how that thing develops and changes over time, and what else is there. Geodesign must answer these location based questions to thoughtfully design new land uses that fit within the social and environmental constraints of the study area. In this research Geodesign does this by utilizing methods and theoretical frameworks from Geographies primary subfields of cultural and physical geography. This research addresses these questions and contributes to the overall field of geography in four important ways.

This first is that this research demonstrates how the role of cultural geography, particularly attachment to place and historical/cultural values can be attached to a spatial location and be used to make placed based decisions. Within these case studies indigenous communities voluntarily mapped historically and culturally significant areas to the local community and used this community generated spatial data as constraints on land use designations and future development. These approaches can be used by any local or neighborhood entity to identify areas for preservation within their communities. Place attachment and place memory can be a valuable tool at any jurisdictions at any jurisdictional scale to map areas that need to be conserved and protected because of their cultural significance. Second, this research uses experiential knowledge of local communities to address gaps in spatial data related to natural hazards. We used flood hazard maps generated by remotely sensed data to generate rough maps of flood risk, but these maps were validated and improved upon by local knowledge of historical flood events and locally known flood areas. Third, that indigenous communities utilized Geodesign to adapt to natural hazards and become more resilient against flood risk. Geographic data may tell us about the magnitude of certain hazards and their location, but Geodesign processes validated where and how often these hazards have occurred and the level of damage and locations of occurrences that non community validity maps alone cannot provide. In this way we can more fully understand the vulnerability and social needs of the community for making effective adaptations. These communities recognized and documented the risk of natural hazards to their community and developed mitigation strategies against these risks through the use of prescient land use decisions bolstered by community knowledge and consensus decision making. Finally, this research demonstrates that Geodesign approaches merge diverse topics of economics, social/cultural factors, and the environment with topography that can engage stakeholders to recommend new land use designations grounded in scientific geographic assessments. Geography is used as a medium to connect assessments and local knowledge to known areas and educate people without professional skills to make informed land use decisions. All of these contributions are significant contributions to disaster resiliency work in geography using participatory approaches and local knowledge to reduce vulnerability to natural hazards.

Data scarcity is not a problem unique to indigenous communities. Many developing nations, rural regions, and rapidly developing peri-urban areas lack hazard data to mitigate risk from natural disasters. Geodesign can be used by these entities as an approach to quickly catalog and organize available geographic data for land use decision making to reduce vulnerability to natural hazards. Through this data collection process gaps within the data are identified and local knowledge of the area can be marshalled to reduce these gaps as was done in our case studies. This in turn can also produce assessments that show geographically the most vulnerable areas within a region to inform disaster mitigation decision strategies.

Our case study communities are less vulnerable to flood hazards by using the Geodesign process to scientifically analyze flood risk for their region that was in turn validated by local experience and local knowledge. This work demonstrates that Geodesign can support land use decision making at multiples scales while evaluating land use decision impacts on multiple systems. Local knowledge can be marshalled to provide unique insights into the geography of the land and in turn support and fine tune geographic assessment models of the area. As a regional approach Geodesign can collect both multiple intergovernmental and interdepartmental scientific assessment data and local experiential data sources and create a hybrid - comprehensive risk assessment. In addition to data development, Geodesign approaches can be used to discuss and make decisions about adaptations to risk as part of the strategic decision making process. These decisions can be spatially visualized, for example a priority to reduce flood risk to housing areas could manifest in a high flood risk area being designated as a conservation / recreation area instead of housing development.

Limitations and Future Work

The communities that participated in these case studies volunteered to be a part of this research so that they could overcome planning barriers unique to their community and develop community-based land use plans. Working with American Indian communities requires considerable effort to understand the culture and unique character of the communities. This is both an opportunity and a necessity to develop both personal and professional relationships based in trust. The success of Geodesign in empowering these communities to actively participate in the planning process is largely dependent on the trust relationship between the planner and the community as well as the motivation of the community to see the project through until the end. The collaborative design environment and powerful analysis methods offered through the Geodesign approach are irrelevant if trust cannot be established between the planner and the community. Thus the success of the Geodesign approach in American Indian communities relies on a planner’s cultural humility, interpersonal communication skills, and personal integrity as well as the technical and professional skillsets unique to the planning field.

Within the case studies for this dissertation, Geodesign has been successful in merging scientific analysis and local knowledge to inform decision making in developing community based land use plans. It has also assisted American Indian communities in the Navajo and Tohono O’odham Nation overcome challenges in planning capacity, data scarcity, and in increasing community participation in planning efforts. Future work should include efforts to utilize Geodesign as a land use planning approach at the regional level. This should include the collaboration between multiple American Indian Communities to optimize resource allocation and build social linkages, economic capital, and environmental capital with adjacent communities. Further, additional case studies are needed to test the flexibility of the Geodesign planning framework in American Indian communities for planning efforts outside of land use planning.

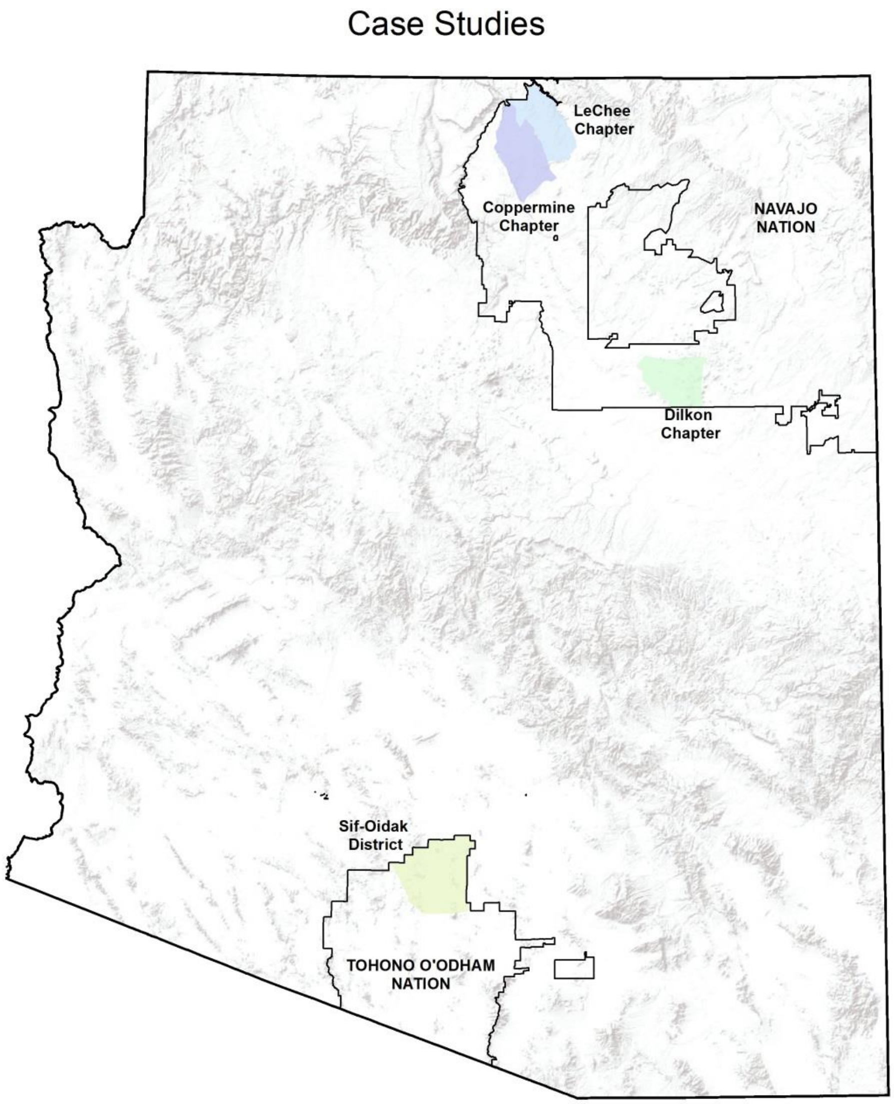

Figure 6.1 Map of case studies for dissertation.

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