GROUND TRUTHING GREENING THROUGH GIS: A MICROSTUDY OF SOIL AND WATER CONSERVATION IN BURKINA FASO

By

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TABLE OF CONTENTS

List of Figures

List of Tables

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CHAPTER 1

SAHELIAN GREENING AND RESEARCH QUESTIONS

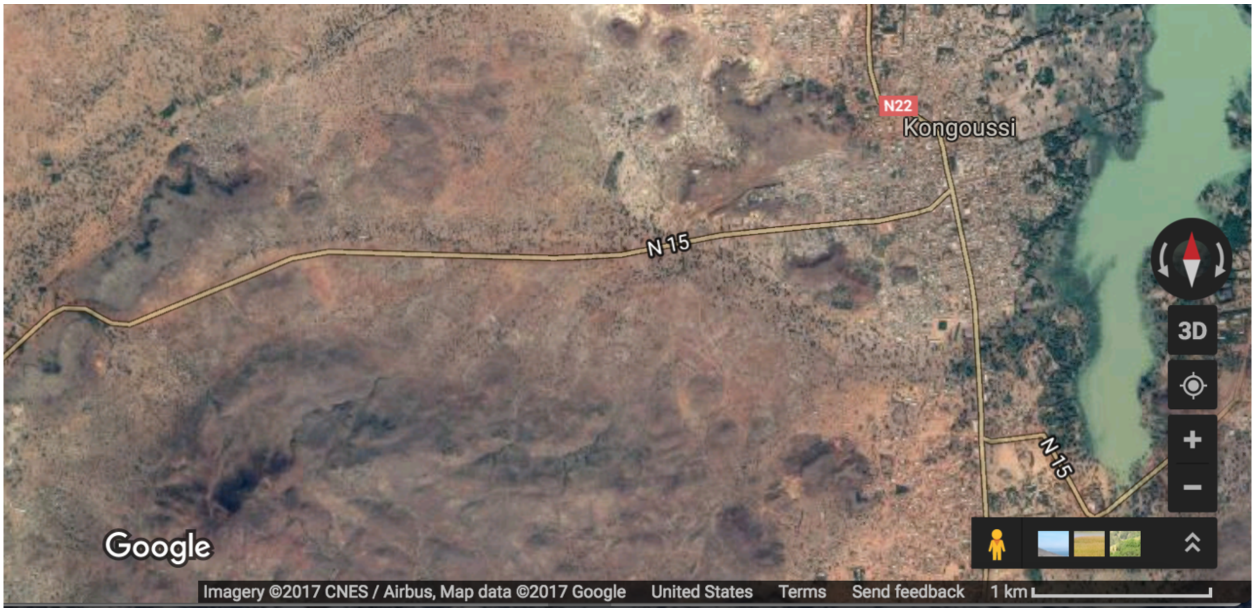

Figure 1. Satellite Image of the department of Kongoussi in Burkina Faso from Google Maps

Introduction

Figure 1 features a satellite view of the department Kongoussi within the West African country Burkina Faso via Google Maps. To the viewer, this rather rudimentary and coarse snapshot of a satellite image seen from Google Maps reveals nothing particularly noteworthy. The most easily observed features are a body of water, some trees, a nearby city, or mostly barren drylands. However, from this image, there is no evidence of local peoples' resilience to a fluctuating environment that presents complex challenges. In fact, in this area of the Sahel, Mossi farmers have employed Soil and Water Conservation (SWC) projects by means of semi-permeable damns and small stone bunds, or *diguettes*, to rehabilitate degraded lands. While such work by farmers may not be evident in Figure 1, what are the implications of using high-resolution satellite imagery for comprehensive spatial analysis at the ground level?

The Sahel

The Sahel region of Africa is a semi-arid climatic zone situated at the southern border of the Sahara Desert. In fact, “sahel” is derived from the Arabic word for ‘shore,’ as it is situated at the edge of the immense desert expanse. Frequent droughts are a natural phenomenon in the Sahel, often resulting in famine and distress migration (MA 2005). Fluctuating climatic and rainfall patterns also drove much of the regional land cover changes and vegetation reduction in the 1970s and 1980s. However, anthropogenic factors such as overgrazing, mono-cropping, and other unsustainable methods on the land have also played a role (MA 2005). Despite the ubiquitous challenges presented by the unpredictable Sahelian environment, the ecosystem exists dynamically, and changes constantly (Herrmann et al. 2005). The methods of analysis for studying anthropogenic and ecological responses to environmental degradation ultimately transform how the Sahelian landscape is understood and acted upon. While the regeneration of vegetation, or “greening,” of the Sahel has been well-documented, the underlying causal processes remain ambiguous.

Research Questions

The main objective of this thesis is to explore new methodologies through Geographic Information Systems (GIS) to gain insight into the processes affecting greening. Furthermore, the analysis seeks to highlight the relationship between local Soil and Water Conservation projects and tree cover, exploring the role of local SWC initiatives in greening. The mechanisms foundational to greening are poorly understood from the local-level, emphasizing the necessity of examination through high-resolution satellite imagery.

In order to understand the impact of local conservation efforts in the broader process of greening, I examine: what is the spatial relationship between tree cover and SWC in northern Burkina Faso in the villages Sakou, Loulouka, and Kouka? To begin investigating this question, I also ask: how is high-resolution satellite imagery effective in evaluating greening on a local scale? What are the advantages, as well as the shortcomings, of GIS methods in studying greening? How does the methodology utilized in this thesis inform future work surrounding greening in the Sahel and a broader understanding of the Sahelian environment?

Building upon a human ecology framework and the models laid out by Leach and Mearns (1996), the analysis recognizes that broad environmental processes such as greening must consider the role of smallholders. The management and adaptation techniques of subsistence farmers within this dynamic semi-arid ecosystem remain critical to understanding larger processes.

Methods

High-resolution satellite images of three different villages in Burkina Faso analyzed through Geographic Information System (GIS) software provided grounds for investigation of the relationship between SWC and tree cover. Utilizing panchromatic (black and white) rather than multispectral (color - R, G, B and NIR) imagery achieved a more clearly defined image, providing greater potential for a more thorough and comprehensive examination. The analysis involved georeferencing all of the images in order to produce a uniform projection on a singular map, as well as the utilization of polygon, polyline features, and buffers. Ultimately, the intersection of these feature classes provided data to test the hypothesis: tree cover will be greater among areas treated by Soil and Water Conservation projects. A more in-depth exploration into methodology concerning GIS and environmental studies of the Sahel region will be offered in the following section. Spatial analysis also included tables to examine frequency, in addition to graphs and tables that display the results.

Desertification of the Sahel

The Sahel region of Africa is frequently associated with environmental degradation, more specifically, *desertification* (West et al. 2017). The term gained traction following the 1975 study of the Sahel by J.G. Charney. Charney hypothesized that overgrazing in the Sahel region was degrading vegetation and land productivity, ultimately resulting in desertification (1975). According to this study, degradation led to a self-perpetuating process of increasing ground albedo and less solar radiation absorption, resulting in desertification (Charney 1975). Subsequently, the image of an exploited environment marked by widespread desertification manifested itself in public perception of the region. As a result, skewed perceptions inform the work done by non-governmental organizations (NGOs), those offering international aid, as well as broader policy decisions by regional governments (Leach and Mearns 1996). As defined by the U.N. Convention to Combat Desertification, desertification refers to "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities." (MA 2005:5) More generally, land degradation can be understood as any decrease in overall productivity of a dryland.

The dominant narrative of desertification initially emerged following the work of Hugh Lamprey and Fouad N. Ibrahim in the 1970s and 1980s (Swift 1996). Lamprey conducted a study based on ground and aerial observations of northern Sudan, in which he concluded that the Sahara Desert boundary was rapidly expanding southwards, threatening the productivity of the bordering land (Swift 1996). Ibrahim outlined similar assumptions through his geographical work in northern Darfur, concluding that desertification was largely human-induced through unsustainable practices (Ibrahim 1984:17). While drought was understood as a fairly common occurrence in the Sahel due to the highly variable patterns of rainfall, it was not acknowledged as the main source of desertification (Swift 1996). Prominent studies of the time understood the main impacts of desertification as human-induced, involving decreasing land productivity, deforestation, and expanding sand dunes (Swift 1996:79). These initial views became ingrained in the global community. Experts in the fields of geography and ecology and organizations interested in international development such as the UN used this analysis to inform their work. Ultimately, establishing a dominant narrative that set the foundation for future action in the region.

The consensus surrounding Lamprey and Ibrahim's work began to be reevaluated as more ecological studies were conducted following subsequent droughts in the 1990s, most notably by Tucker et. al in 1991. Through a satellite-derived vegetation index, fluctuations in vegetation and rainfall could be effectively mapped along the boundary of the Sahel and Sahara between 1980 and 1990 (Tucker et. al 1991). Despite evidence suggesting the possibility of desertification, Tucker et. al determined the evident inter-annual variations in the margin by which the desert boundary was shifting necessitated long-term studies. In order to accurately determine if prolonged desertification is occurring, studies require several decades of data.

Greening of the Sahel

Satellite imagery in which the Normalized Difference Vegetation Index (NDVI) was measured over the course of 1982 to 1999 implies that a reversal of desertification has been occurring in some parts of the Sahel (Olsson et. al 2005). The term *greening* commonly refers to the process of increased revegetation in the Sahel region. Comparing annual rainfall data with NDVI patterns indicated a correlation between the two variables; Olsson et. al recognized that an increase in rainfall could not alone account for the increases in vegetation (2005:563). A particular source of issue comes from the relatively coarse 8-km spatial resolution utilized for the measurements of NDVI. Coarse resolution presents a great challenge when trying to pinpoint an exact location to compare rainfall, especially considering the inconsistency of rainfall in a semi-arid environment (Olsson et. al 2005). In addition, changing practices in land use and management, as well as demographic and migratory shifts, may contribute to the fluctuations in land cover. Greening is a complex and dynamic process influencing a range of social and environmental factors. Thus, further studies which encompass a variety of perspectives and disciplines are necessary for a more complete understanding of the mechanisms behind greening (Olsson et. al 2005).

Challenging the Received Wisdom

In the 1996 edited volume *The Lie of the Land: Challenging Received Wisdom on the African Environment*, Melissa Leach and Robin Mearns document a range of cases challenging “received wisdom” of destructive environmental change and unsustainable human behaviors affecting the African landscape. The dominant modes of thinking frequently link broad concepts such as ‘carrying capacity,’ yet are informed by limited, short-term observation (Leach and

Mearns 1996:5). The prevailing international narrative essentially dismissed all accounts of the land by local people. However, the practices of the local people's response to environmental changes and role in resource management proved to be highly prudent. Despite the "received wisdom" often being taken for granted, through an interdisciplinary approach that considers a historical, ecological, and anthropological analysis, a re-imagination of the narrative attached to the African landscape becomes possible. In their seminal text focusing on deforestation, Fairhead and Leach (1996) look at the case study of Kissidougou, Guinea in West Africa. The study offered an alternative to the broadly accepted narrative that deforestation in the area ensued as a result of uncontrolled slash and burn agriculture by the local people. By utilizing a combination of aerial photographs (satellite imagery) and ethnographic ground-truthing (information gathered by direct observation and interviews, on location), Fairhead and Leach revealed the reality of the landscape. Patterns of central villages were in-fact surrounded by mosaics of forest, ultimately demonstrating reforestation. Their theoretical framework utilizing traditionally anthropological and ecological methodologies questioned the efficacy of traditional ways the African landscape has been analyzed. The human ecological framework laid out by Fairhead and Leach combines both the activities of local actors and satellite, setting the foundation for this thesis work.

Observable trends of increased vegetation and rainfall are understood as the main driving force affecting greening; however, there remains "outliers" in certain areas of the Sahel where local people institute major land rehabilitation initiatives (Rishmawi and Prince 2016). While these land rehabilitation efforts improved land productivity through means such as irrigation, shortened fallow, and erosion control, the scale of observation in conventional land productivity regressions does not illustrate a long-term effect on the productivity of vegetation (Rishmawi and Prince 2016). The debate regarding anthropogenic effects on the Sahelian environment thus remains unclear as it extends beyond the conventional desertification framework, warranting further study.

Burkina Faso

My thesis work was primarily focused in northern Burkina Faso, an environment that historically endured environmental degradation from exploitation of the central resources such as forests and fields (Sawadogo 2011). In order to combat the significant environmental stresses characteristic of the Sahel, local farmers within the region instituted a variety of initiatives involving Soil and Water Conservation. Through a series of long-term field studies involving rural participatory appraisal, or conversing with local farmers about perceived environmental changes, remote sensing of satellite images, and statistical data on crop yields, rainfall, etc., Reij et. al (2005) demonstrated the evolving role of SWC in the central plateau of Burkina Faso. Sawadogo (2011) too conducted a prominent study in which agronomic surveys of various villages demonstrated the impact that SWC projects present in northern Burkina Faso had in improving land productivity and local livelihoods (Sawadogo 2011:127).

One of the most prominent techniques of SWC used in conjunction with semi-permeable dams is contour stone bunds, known in French as *diguettes* (West et. al 2017). *Diguettes* are low and narrow rock barriers that are assembled between plots of agricultural land as a means to inhibit soil erosion (West et. al 2017) (Figure 2). Semi-permeable dams, as seen in Figure 3, are larger than *diguettes*, running perpendicular to gullies of washes, or areas of water drainage. The rock bunds and dams collect a range of organic deposits; an example is the entrapping of plant seeds that will eventually grow adjacent to the stone barriers (West et. al 2017, Reij et al. 2005). In a village with an agricultural-based livelihood, there often exists hundreds of diguettes spanning a 5-km radius from the center of the village (West et. al 2017). Soil and Water

Conservation projects overall have prompted revegetation of some 100,000 hectares with evidence of improved crop yields and soil quality (Reij et al. 2005:649, 651). While local farmers and households experience clear small-scale benefits, the effects of SWC on the larger Sahelian landscape remains poorly understood (West et. al 2017).

Figure 2. A *diguette*, or contour stone bund, in northern Burkina Faso. Photo courtesy of Colin Thor West

Figure 3. A semi-permeable dam in northern Burkina Faso. Photo courtesy of Colin Thor West

Overview of chapters

In the next section of my thesis, I explore the various methodologies that have been fundamental to analyzing desertification and greening, both traditionally and following the widespread incorporation of GIS and RS technologies. This will include outlining the conventional GIS/RS methods that are presently well-established in the fields of landscape ecology and environmental science. I also explain my own set of procedures for landscape analysis and the implications of such processes. Finally, in the final section I provide a series of tables and graphs produced as a result of my analysis, offering corresponding explanations of the results. I conclude with a discussion of the observed trends and relationships between SWC and tree cover in northern Burkina Faso, as well as final thoughts on the future expansion to this work as it pertains to the establishment of new methodologies in the study of greening within the Sahel.

CHAPTER 2

DISCUSSION OF METHODOLOGY

Review of Traditional Methods

The increasing prominence of remote sensing (RS) and geographic information science (GIS) prompted an emergence of new techniques in environmental research and studies of human-environment interaction. However, its advent presented various limitations that need be addressed. In order to establish a background of traditional GIS usage, a brief overview will be provided of the traditional methodology used to study the Sahelian environment. This leads into an overview of the shortcomings associated with GIS technology as articulated by Turner's 2003 study of grazing management in western Niger, a part of the Sahel bordering Burkina Faso. Finally, an alternative methodology is offered that recognizes the complex, dynamic relationship between humans and their environment. Such methodology seeks to curtail past shortcomings associated with GIS and conventional studies of the Sahelian landscape.

According to Turner (2003), there are three main issues arising from traditional environmental study of the Sahel. These issues can be understood as: spatially/temporally biased observations, isolated or singular visual descriptions, and failure to consider or attempt to understand local-level, rural production systems (Turner 2003:258). With regard to spatially and temporally biased observations prior to satellite usage, observation relied upon travel by individuals around the land. Consequently, observations were limited to the dry season, restricting the scope of the study. As a result, many far-reaching conclusions were drawn about the region based on a single locality (Turner 2003). Further pertaining to spatial bias, isolated evaluations of the environment often lacked dependable interpretations and failed to account for factors of rainfall, soil condition, and human activity, essentially ignoring the larger systems affecting change (Turner 2003).

Perhaps the most pertinent weakness of traditional studies of the Sahel remained the lack of understanding of rural production systems at the local-level. Within the Sahel, the relationship between farmers, agro-pastoralists, pastoralists, and land is dynamic, emphasizing the need for a holistic approach to analysis. In early approaches failing to consider such complexity, circular arguments attributed sparse vegetation interchangeably to environmental degradation and human activity, ignoring the role of climatic and geographical factors all together (Turner 2003:258). With a strong dependence on visual description of patterns, scientific interpretation remained more "flexible" in the conclusions that could be drawn. Thus, political and economic objectives of nation-states and international institutions, such as the United Nations, have shaped the body of findings regarding environmental change in the Sahel. The result manifested as a lack of understanding of the human contexts and ecological mechanisms and processes underlying such changes (Turner 2003:259).

Methodologies of environmental analysis in the Sahel evolved with the emergence of GIS technology. Causal interpretation by comprehensive pattern identification and overlay analysis certainly prompted significantly more complex explorations. However, these techniques still hold the potential to present similar issues reminiscent of past methods (Turner 2003:264). A particular issue stems from scale. It is common for GIS to be utilized for analysis of the subnational region, focusing on the entirety of West Africa (Turner 2003:264). The data often underlying such analyses is limited and low-resolution, in addition to being disconnected to any sort of work highlighting human-environmental interaction or processes. In a study by Laris (2005) of mosaic burning in southern Mali, the biases associated with coarse-resolution are evident, as the fine-scale spatiotemporal trends typical of burning in this area of the savanna were essentially undetected by the algorithm used. In fact, the coarse imagery led to miscalculation of burning by at least a factor of 10 (Laris 2005:419).

Consequently, the major implications of resolution biases on global analyses on land management and the study of environmental change must be addressed (Laris 2005:412). Thus, while GIS produces more complex quantitative inquiries, the predisposition of using land cover as the sole variable in assessing anthropogenic effects on land is misguided (Turner 2003:265). Approaches taking a human ecology-based perspective are ideal in this regard, where local land practices and land cover change are evaluated on the ground, at a local-scale. The integration of remote sensing and ethnographic methods facilitates exploration of the processes underlying environmental and cultural change, as well as perceptions of landscape itself (Jiang 2003). In a "mixed methods" case study of Inner Mongolia, Jiang shows how Remote Sensing (RS) provides additional insights regarding landscape change, which ethnography exclusively would not discern. An analysis of satellite imagery complements the qualitative data offered by accounts of local actors, enhancing understanding of human–environment relationships (Jiang 2003). However, the potential for GIS to support work within human ecology requires an increase in the resolution of the imagery used for analysis. High resolution imagery illustrates the actual dynamic of a locality in instances of land linked to specific activities and specific actors, presenting an invaluable opportunity for future GIS work (Turner 2003:265).

Feature digitization, understood as identifying and digitizing direct features or attributes of the land through high-resolution satellite imagery, is a rather novel methodology core to this analysis of SWC and tree cover. The approach described in the following subsection is an experimental endeavor in human ecology using GIS and high-resolution satellite imagery as a means for "bottom-up" analysis.

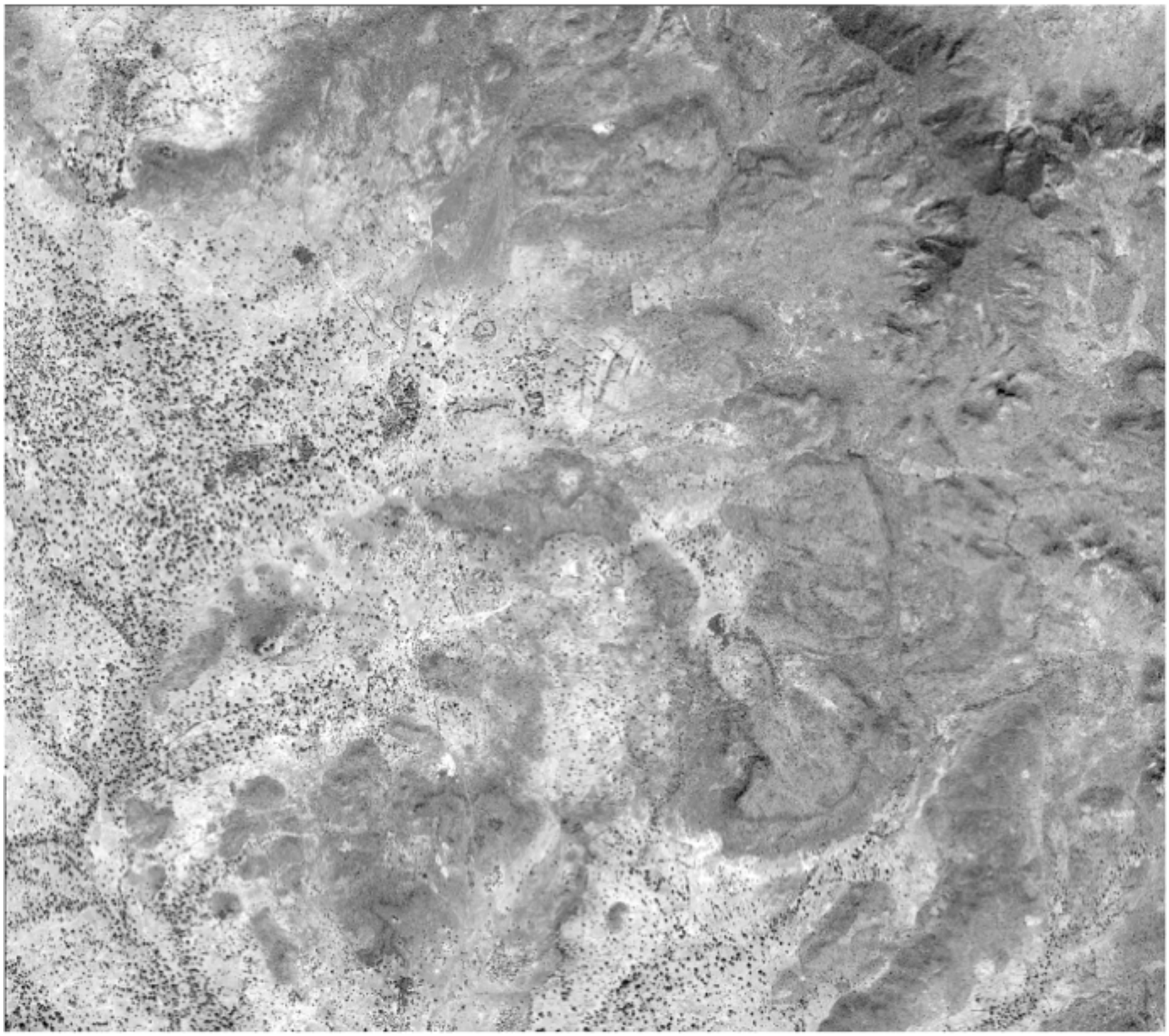

Figure 4. Raw panchromatic satellite image of Sakou

Figure 5. Raw panchromatic satellite image of Kouka

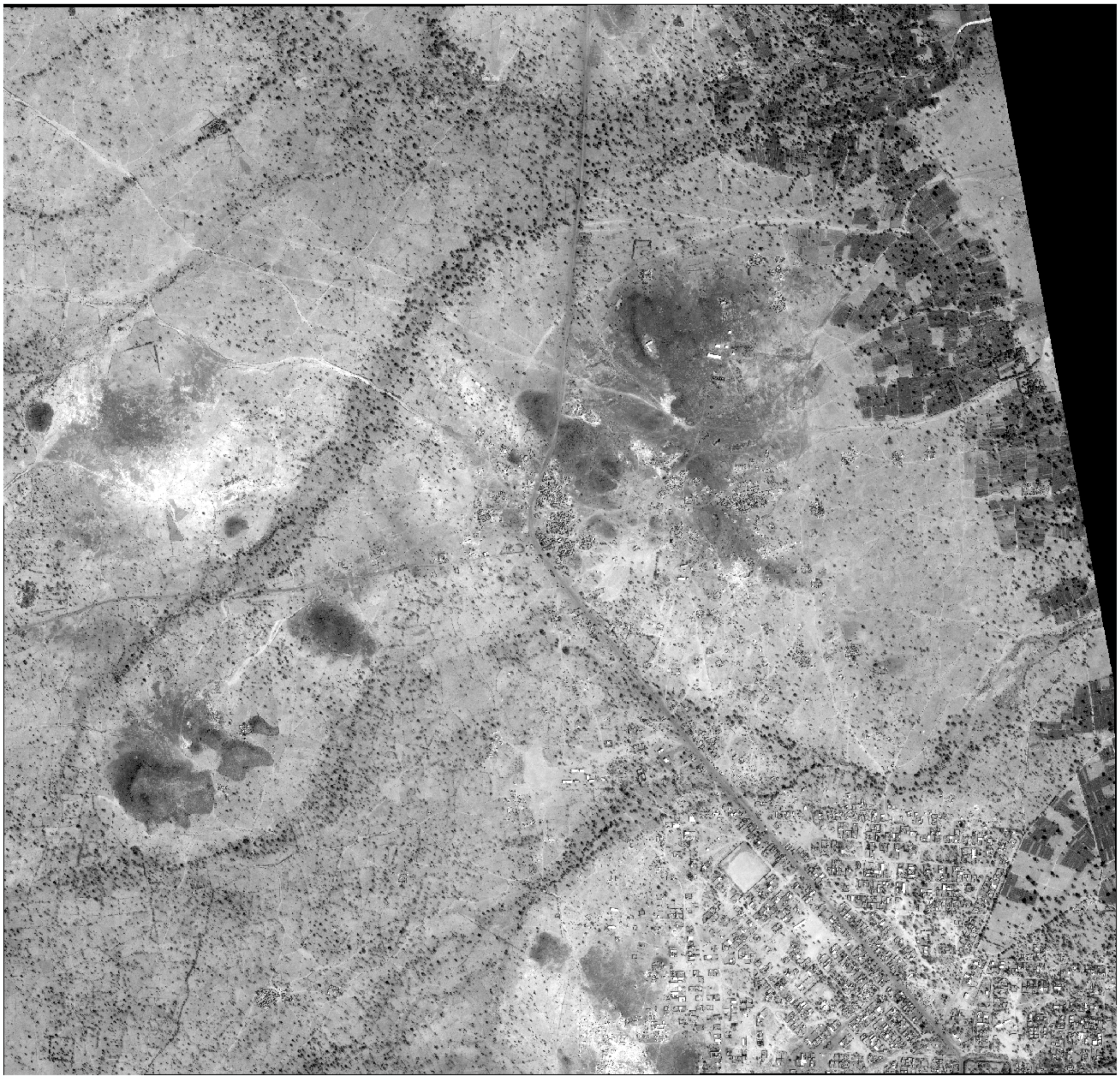

Figure 6. Raw panchromatic satellite image of Loulouka

Description of Methodology

The analysis used high-resolution GeoEye-1 multispectral satellite imagery, consisting of 4-band multispectral (red, green, blue and near infrared) images in conjunction with panchromatic images for the three villages Sakou, Kouka, and Loulouka. The images were produced by the GeoEye-1 satellite and were captured in 2014 prior to the beginning of the rainy season in Burkina Faso.

As shown in Figure 7, for each 25-km^2 (5-km X 5-km) sized image, a random sampling of grid sections was applied to the raw layer of the panchromatic images, ultimately covering approximately 32% of the image. Utilizing the fishnet tool on ArcGIS 10.4, 300 90-m by 90-m grid samples were initially added as a layer over the raw image, making 900 total grids across the three villages. The sampling was entirely arbitrary; there was no specific targeting of dry or wet appearing areas of each landscape or any further analysis of elevation and proximity to water sources.

In regards to image quality, each multispectral satellite image had a ground resolution that was approximately 2-m, while each accompanying panchromatic image's ground resolution was ~0.5-m. Referencing Figures 8 and 9, one can see the obvious blurring of features and details within the colored image. The panchromatic imagery's higher resolution permitted the identification of on-the-ground SWC projects, or semi-permeable rock dams.

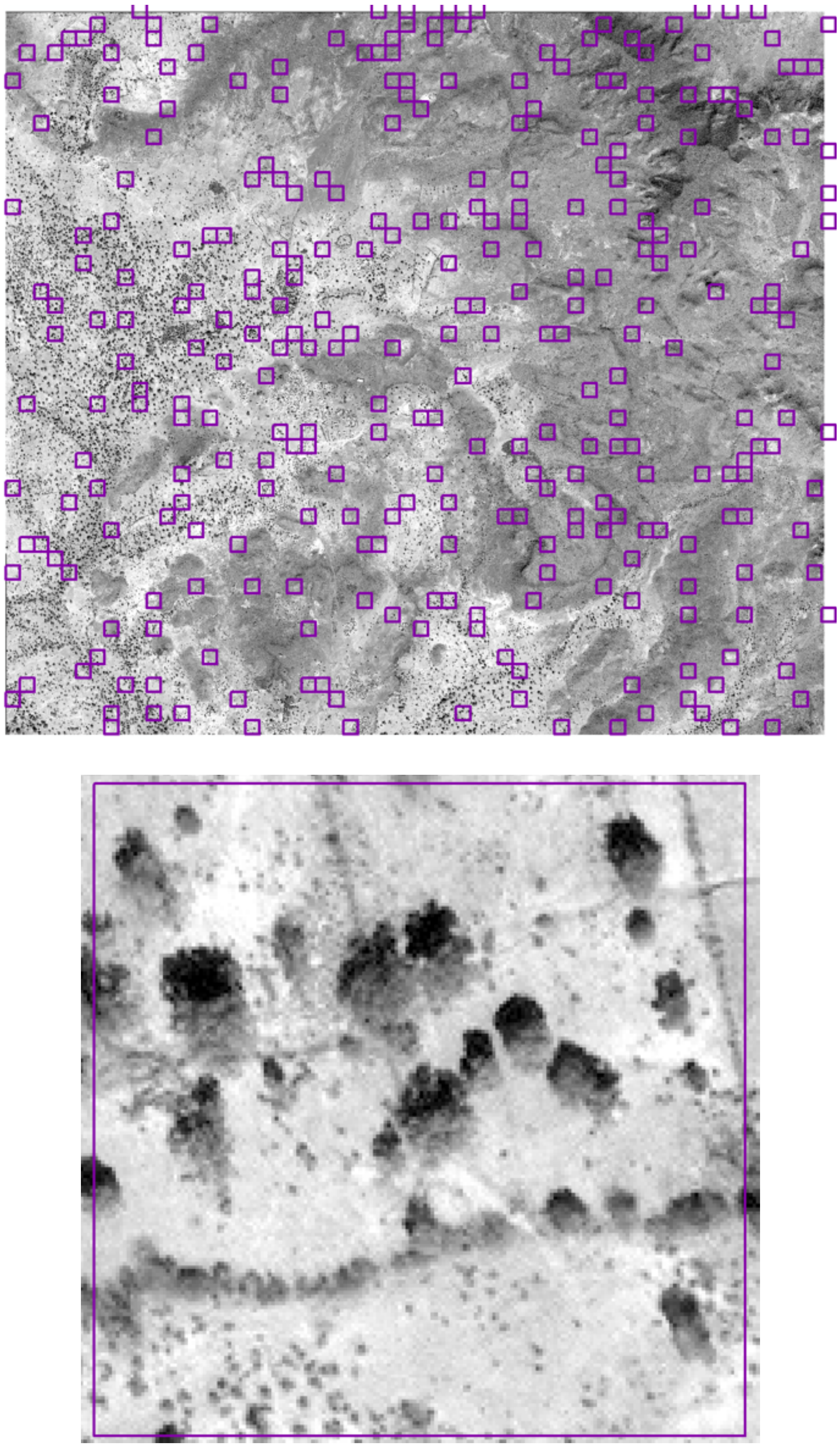

Figure 7. Randomized sampling of grids on satellite image of Sakou and zoomed-in view of grid cell.

Figure 8. GeoEye-1 multispectral satellite image

Figure 9. GeoEye-1 panchromatic satellite image

Within each of these 8100-m^2 grid cells, the objective was to first conduct spatial analysis, focusing on the presence of any trees. Based within the high-resolution image, as seen in the panchromatic of Figure 10, the canopy of each tree was digitized as a polygon, followed by an approximate measurement of canopy diameter. In order to focus on mature trees, discounting shrubs and other low-lying vegetation, a measurement tool embedded within the software allowed the diameter to be measured. A focus on more "established" trees also served as rationale for the 10-m or greater standard set as grounds for digitization of a tree. Each tree falling into the criterion of a diameter greater than 10-m and located within a grid was correspondingly digitized through creation of polygon features (Figure 10). All tree polygon features were aggregated into a singular feature class. Similarly, the dams present in each of these three villages were digitized as polyline features, having been identified through the appearance of straight lines, consisting of another feature class. In comparison to *diguettes,* dams are much more visible in the imagery; *diguettes* are small and low, and thus difficult to identify.

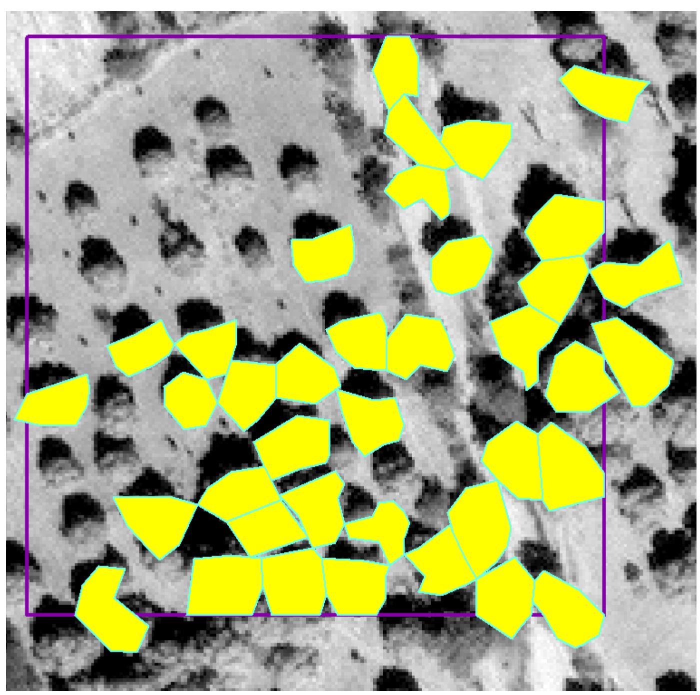

Figure 10. Digitized trees within a grid cell

To begin to examine the presence of any relationship between dams and trees, a rounded buffer was added to each dam, reflecting the range of land treated by SWC. The buffers were made 200-m in order to highlight the connection between dams; dams are intentionally constructed along washes to form a network, thus a buffer size large enough to encompass the linkages between dams needed to be selected. Rather than viewing dams in terms of isolated plots of land, the buffers were necessary to show the broader configuration and patterns of SWC at a village-scale. Additionally, *diguettes* surround the areas in between dams. Thus, the creation of a 200-m buffer accounted for the dams, and it approximated the surrounding *diguettes*. In Figure 11, the "network" produced from overlaying buffers is shown for Sakou, illustrating the contiguous, yet somewhat patchy distribution of SWC.

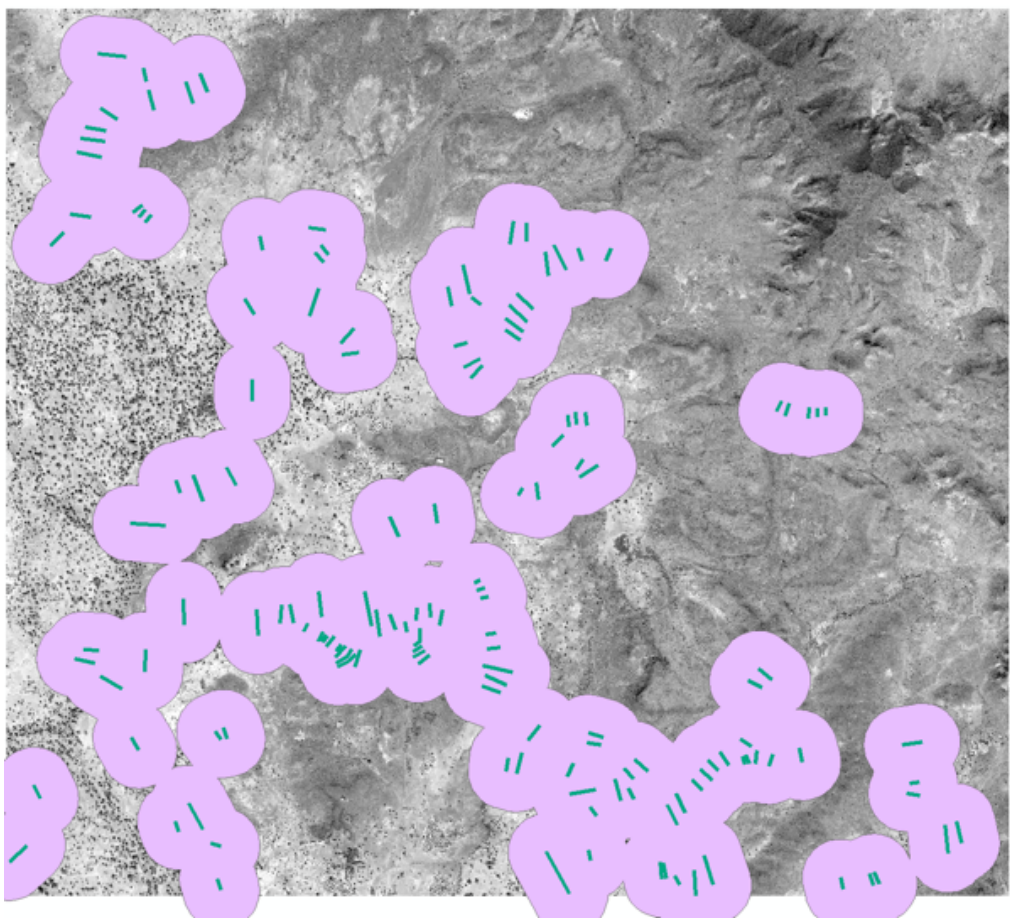

Figure 11. Network of SWC of dams and buffers

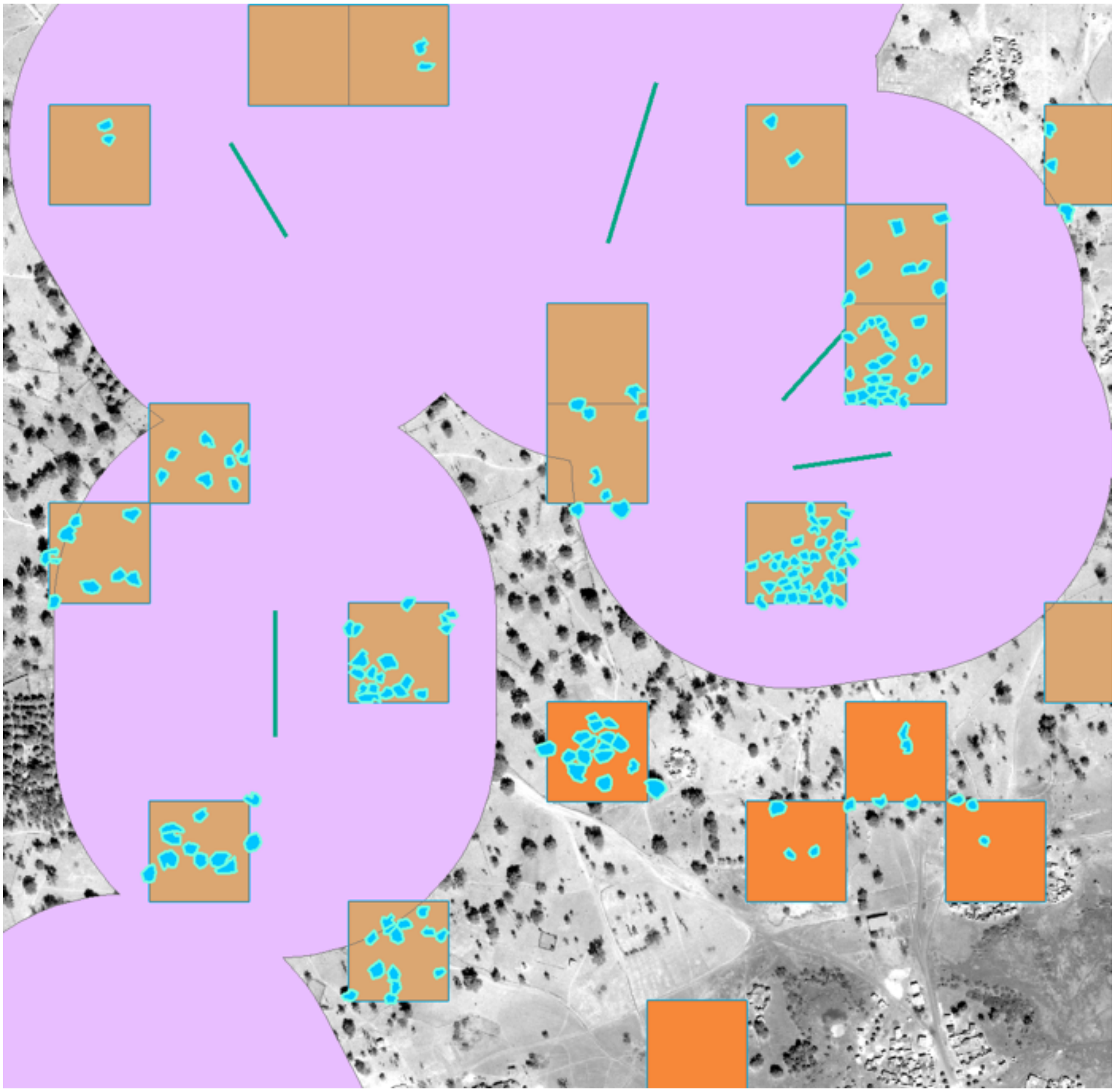

Figure 12. Intersection between grid cells, trees, and buffers

Using the Intersect geoprocessing tool, spatial referencing of all of layers can be analyzed simultaneously. The Intersect tool generates an analysis of all intersections in terms of geometric relationships between the features of all of the layers of the image. For example, all grid cells where tree polygons existed within a buffer would be grouped into one set of attributes. By referencing Figure 12, these intersections are more easily visualized: the brown grids are classified as within buffers, the orange grids as outside of buffers, and the blue polygons are all trees inside of grids. The result was a data set that could be used for the initial analysis of SWC and tree cover. Figure 12 ultimately shows the clear distinction of grids inside or touching the buffer versus those lying outside.

There were ultimately four categories possible within the data set: presence of both trees and SWC, absence of both trees and SWC, presence of trees and absence of SWC, and absence of trees and presence of SWC. A combination of Union and Intersect Geoprocessing tools ultimately combined feature classes into a single layer that produced a table with these corresponding categories, as shown by Table 1.

Table 1. Categorization of grid cells

		Trees	
		Yes	No
Buffer	Yes	?	?
	No	?	?

CHAPTER 3

DISCUSSION OF OBSERVED TRENDS IN SWC AND TREE COVER

Results and Analysis

Upon initial comparison, no obvious correlation between tree presence and SWC was apparent from the results shown in Table 2 and Figure 13. The usage of simple statistical analysis in the form of a Chi-square test attempted to test the probability of the observed distribution of trees and buffers and the degree it could be attributed to chance. Essentially, the test provided a manner to observe the distribution of data within the four categories illustrated in Table 1.

Table 2. Descriptive Statistics by Locality

Locality	Total Trees	Total Dams	Total Trees Inside Buffers (within grids)	Total area treated by SWC (ha)
Sakou	679	146	535	939
Kouka	198	50	55	487
Loulouka	330	51	66	545

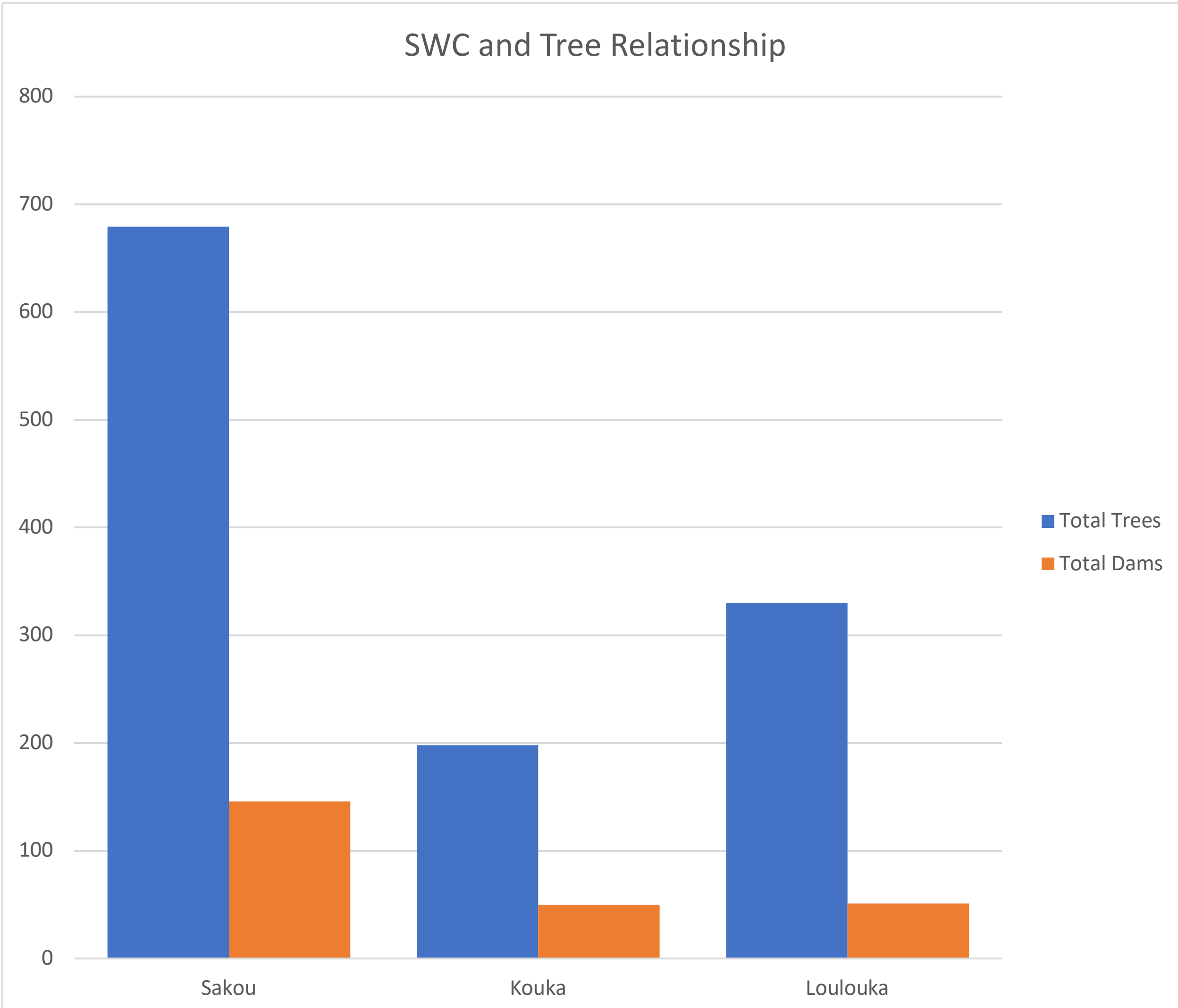

Figure 13. Total number of trees and dams by locality

In this case, the null hypothesis was that there exists no relationship between tree cover and Soil and Water Conservation; therefore, wherever the observed data is incongruent with the model data, the probability that the variables are dependent is supported. For the category most pertinent to the hypothesis, presence of both trees and dams, the expected count was 99.5, with the observed being 130, showing that Soil and Water Conservation contributes to greening. As evident in Table 3, the Pearson Chi-square value is 20.144, indicating that the model fits the data. There are more trees in areas treated with SWC than would be expected based on chance alone.

Table 3. Chi-square Cross Tabulation

			Trees		Total
			Yes	No	
Buffer	Yes	Observed Count	130	218	348
		Expected Count	99.5	248.5	--
	No	Observed Count	155	494	649
		Expected Count	185.5	463.5	--
Total		Count	712	285	997

Pearson Chi-square = 20.144, df = 1, *P<<0· 001.*
Continuity Correction = 19.49, df = 1, *P<<0· 001.*
Likelihood Ratio = 19.732, df = 1, *P<<0· 001.*

Ultimately, the results supported the hypothesis that SWC is driving regeneration of vegetation at the local-level in Sakou, Kouka, and Loulouka. In focusing on the scale of these three villages, SWC improvements have contributed to increased tree cover as substantiated by the Chi-square model. Furthermore, these findings support the ethnographic "ground truthing" gathered by West et al. (2017). The increased presence of trees in areas treated by SWC supports West et. al's account of the positive perceptions of Mossi farmers surrounding dams and *diguettes* regarding SWC and vegetation regeneration.

Conclusion

Central to this work is the framework for human ecology laid out by Fairhead and Leach (1996). Their work emphasizing both ecological and sociocultural methodologies questioned the widespread belief of anthropogenic degradation in the Guinea forest-savanna. Through a novel framework integrating historical data, ethnography and satellite images, they invalidated the myth of human-induced devastation. In doing so, Fairhead and Leach highlighted how false perceptions supported power dynamics that drove unreasonable land policies in Guinea. Narrow perspectives that view vegetation solely in regard to degradation marginalize the work and methods of farmers to improve their lands. Thus, such methodologies proposed by Fairhead and Leach are vital to the frequently misunderstood impacts of greening and SWC in Burkina Faso.

In general, the phenomenon of greening has been mostly documented through "top-down" analysis of satellite images that span the entire extent of the West African Sahel. They have seldom been investigated from the "bottom up." By focusing on local-scale studies and analysis, a unique perspective of the socialized-nature of land becomes apparent; this is critical to understanding the larger processes driving environmental change in the region. In Burkina

Faso, the work of Mossi farmers creating semi-permeable dams as a means of Soil and Water Conservation is perceived to have transformed once degraded land; however, this cannot be fully captured by broad-sweeping analyses of greening through land-use/land-cover (LULC) classification.

As supported by the analysis of Sakou, Loulouka, and Kouka, I demonstrate that high-resolution satellite images are advantageous in the continued study of greening. The prevalence of Soil and Water Conservation strongly correlates with increased tree cover within these three villages. I emphasize the value of interdisciplinary methodologies that consider the complexities of both the environment and human actors in any future studies. Ultimately, such methodology presents the potential to reshape and reevaluate narratives and understandings of environmental change in Burkina Faso and the Sahelian landscape at large.

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