

What are sustainable investments? A case study of Arizona's legacy mining communities and towns

Felix Ampadu^{a,b} 

^aDepartment of Anthropology, Washington University in St. Louis, St. Louis, MO, USA; ^bSchool of Anthropology, University of Arizona, Tucson, AZ, USA

ABSTRACT

In Legacy Mining Communities (LMCs) in the copper-rich state of Arizona, the complex social ties to mineral resources challenge the concept and practice of sustainability. Based on ethnographic fieldwork conducted in Clifton-Morenci and San Manuel, both in Southern Arizona, in this article, I examine sustainable decision-making by LMCs that reflect their unique circumstances. I argue that despite the socio-ecological challenges that pertain to many mining communities in the southwest, legacy communities and towns in Arizona are exploring infrastructure investments that can change existing narratives and help retain social connections to mining. In doing so, I will deepen our understanding of decision-making on sustainability in LMCs from a social sustainability perspective.

IMPLICATIONS

Mining has played a significant role in shaping Arizona's history and economy, yet many mining towns are now grappling with challenges as mines close or reduce operations. This study focuses on two legacy mining communities, Clifton-Morenci and San Manuel, to explore their approaches to sustainability, emphasizing social well-being and the preservation of their unique identities. The study highlights how investments in infrastructure, particularly housing, are perceived as important as a means to address basic needs, preserve community identity, and enhance long-term social well-being in legacy mining communities. Community-driven approaches are critical for shaping sustainable futures, as they reflect each town's unique needs and values. Effective sustainability planning requires interconnected thinking, addressing economic, social, cultural, and environmental factors together. These insights provide valuable lessons for other post-industrial or post-mining communities working to adapt and thrive after the decline of their primary industries.

SOCIAL MEDIA STATEMENT

Despite socio-ecological challenges, Arizona's mining towns, like Clifton-Morenci and San Manuel, are rethinking infrastructure investments to shape the existing narratives about legacy mining towns, drive sustainability, and help retain their social connection to mining.

LinkedIn: www.linkedin.com/in/felixampadu. **X [Twitter]:** @F_Ampadu

KEYWORDS

Arizona; infrastructure investments; legacy communities and towns; mining identity; sustainability

Arizona's mining industry has transformed the copper state and American society, underpinning industrialization and central to innovation in new mining technologies (Knight 1970; Arizona Mining Association 2015). However, dwindling investment and declining populations have contributed to the decay of industrial mining towns in the state, and several have transitioned into retirement communities or have become 'ghost towns' (Varney 1994). But some have survived through alternative economic activities such as tourism; others rely on auxiliary mining income due to their proximity to active mines.

These rural extractive or industrial towns have been characterized as "frontier communities"—geographically and economically isolated (Deavers 1992; Shever, D'Angelo, and Pijpers 2022)—or as "natural resource frontier societies" with reference to exploitation (Bebbington 2013; Watkins 2018). Shever, D'Angelo, and Pijpers (2022) explains how these local communities are disconnected from the isolated mining zones of corporations with their self-contained infrastructure and services. However, the meaning of "frontier communities" or "frontier societies" varies depending on the context. Mark Nuttall (2022, 59–61) describes

frontiers as isolated areas marked by ecological disruption due to resource extraction, although still, these spaces are coveted for their economic potential, leading to contestation, violence, and environmental degradation as they are integrated into global extraction networks.

In this article, I employ the concept of Legacy Mining Communities or Towns (LMCs or LMTs), a term born out of “mining legacies” (MMSD 2002), to highlight particular forms of agency and interventions (Macmillan 2015). The term encompasses not only “orphaned, abandoned, or derelict” legacy mine land, as Worrall et al. (2009, 1429) describe it, but also the mining towns’ and communities’ contributions to the transformation of the state, nation, and mining industry.

Today, LMCs are concerned about their communities’ current and future well-being, both socioeconomically and environmentally, as a core principle of sustainability, defined as “meet(ing) current needs without compromising the future” (United Nations 1987, 15). The communities’ concerns reflect an intuitive understanding of the core principle. The desire to sustain their communities aligns with sustainability discourses, which have evolved since the UN’s original framework. However, some scholars have adopted a more dynamic understanding of sustainability, emphasizing a system’s capacity to endure over an extended period without undermining its own conditions or collapsing under incremental changes (Eriksen 2022, 1). Others, like Strange and Bayley (2008), have further developed this concept by discussing capital approaches to sustainability, which emphasize interconnected investments across economic, social, and environmental domains consistent with the concerns of LMCs. This conceptualization is critical as communities transition beyond a mining economy and focus on creating sustainable social investments (Esteves 2008; Woodcraft 2012) that accommodate change.

While sustainability challenges in Arizona’s LMCs have primarily been studied from an environmental perspective (Ram, Moore, and McTiernan 2016; Ramirez-Andreotta et al. 2016), there is limited ethnographic evidence on the social strategies LMCs employ to develop sustainable investments. I aim to address this gap by utilizing ethnographic interviews with key stakeholders in two LMCs in Southern Arizona – Clifton-Morenci and San Manuel – to enrich the literature on social sustainability from a context-specific perspective. Social sustainability encompasses elements such as quality of life (well-being), equity or social justice, and participatory

governance and democracy (Dempsey et al. 2011; Partridge 2014, 6181–6182; Weingaertner and Moberg 2014). I define social sustainability as the ability of communities to “gain and maintain an adequate and decent livelihood” (Koning 2001, 8). This involves ensuring that social investments not only improve immediate living conditions but also build resilient communities capable of withstanding and adapting to changes over time.

In the following, I address how social sustainability influences decision-making that defines the nature of mining communities. The case studies explore the attachment to mining identity and show how investment in infrastructure, such as housing, aims to achieve social sustainability. I argue that sustainable investment in infrastructure reveals two insights when viewed through the lens of infrastructure as systems of physical, social, and symbolic networks (Elyachar 2010; Larkin 2013). These are 1) aimed at shifting the narratives of LMCs as rural places of temporality – economically deficient and unattractive for living due to the dynamic and cyclical nature of industrial mining towns; and 2) address specific basic needs and protect social values, cultural traditions, and ways of life (Koning 2001; Vallance, Perkins, and Dixon 2011), resulting in the social well-being of current and future generations.

Infrastructure and sustainability

In this article, I build on an existing literature on infrastructure investments, economic diversification, and sustainability, including post-mining communities. Infrastructure has become a focal point in social and urban theory, with attention to its dual nature as both a technical and a social system. This perspective is critical for understanding sustainability in legacy mining communities. Scholars such as Larkin (2013) and Elyachar (2010) emphasize the need to move beyond traditional views of infrastructure as purely physical and argue that infrastructure carries profound cultural and symbolic meanings, influencing societal practices, identity, and community interactions. Larkin’s (2013) framework situates infrastructure within social and cultural contexts, where it not only supports economic activity but also serves as a medium for social and political expression and social transformation to redefine the town’s purpose and identity (Veiga, Scoble, and McAllister 2001). Elyachar (2010) extends this by proposing that infrastructure can act as a catalyst for community empowerment, especially in under-resourced communities like legacy mining towns, and is vital for fostering social cohesion,

resilience, and adaptive capacity as these communities transition from dependence on mining. Community-driven projects, including investments in tourism, clean energy, and local entrepreneurship, appear to be more successful in achieving long-term sustainability than top-down initiatives, and Veiga, Scoble, and McAllister (2001) emphasize the need for projects to be rooted in local values and history, so nurturing community identity while supporting adaption to change. Similarly, Malmgren et al. (2022, 241) note that strong community identity and “heritagization” often drive efforts to maintain town viability even after mines close. These scholars underscore the need for community involvement in planning sustainable transitions and emphasize that, despite the challenges, social ties and community-led efforts play a critical role in the long-term sustainability of post-mining towns.

Infrastructural developments can either integrate or fragment urban spaces, often mirroring and perpetuating socio-economic disparities (Graham and Marvin 2001), and they can perpetuate or disrupt social systems (Latham and Layton 2019; Layton and Latham 2022). This is particularly relevant for legacy mining communities, where infrastructure investments (or the lack of investment) shape who benefits from economic changes and who continue to be marginalized.

Infrastructure can also operate as a socio-technical system (Latham and Layton 2019; Layton and Latham 2022; Klinenberg 2018), emphasizing social hierarchies and inequalities and the capacity of social infrastructure to foster social connections and inclusivity. In this regard, infrastructure investments in legacy mining communities need to consider these complex socio-technical dynamics, ensuring that they do not worsen existing social inequalities but instead contribute to a more equitable and sustainable future. Star’s (1999) conceptual framework for studying infrastructure enhances this understanding through concepts such as embeddedness (how infrastructure is integrated into everyday life) and visibility upon breakdown (when infrastructure only becomes noticeable when it malfunctions). In legacy mining towns, where infrastructure may be aging or deteriorating, its breakdown often exposes the social and economic vulnerabilities of the community, highlighting the necessity for strategic and inclusive infrastructure renewal.

Following this, infrastructure conceptualized through a system thinking perspective (Larkin 2013) provides a comprehensive framework for analyzing its multifaceted nature. By acknowledging infrastructures as socio-technical systems embedded within broader socio-cultural contexts, researchers and policymakers

can better understand their profound impacts on social and cultural practices to influence sustainability decisions.

Sustainable investments (SI)

The concept of Sustainable Investment (SI) intersects significantly with infrastructure, as both aim to ensure the long-term well-being of communities. Strange and Bayley (2008) argue for a capital approach to sustainability, focusing on maintaining and enhancing different forms of capital—natural, human, social, and economic—to ensure community viability. This approach is highly relevant to legacy mining communities, where investments in infrastructure must balance immediate economic needs and broader sustainability goals.

A key element of SI is that it promotes social and economic diversification, especially in communities that have historically relied on a single industry. Meadows (2008) systems thinking framework is invaluable in these contexts. It highlights the interdependent nature of community systems, emphasizing that infrastructural decisions often create feedback loops: improvements in one area (such as housing or transportation) can lead to cascading benefits in others (like employment, health, and social inclusion). Investing in affordable, ‘modern’ housing, for example, may not only improve living conditions but also attract new residents and businesses, boosting the local economy and fostering resilience. This systems approach aligns with Graham and Marvin (2001) view that infrastructural investments need to be inclusive, addressing the needs of both current and future residents. In legacy mining towns, ensuring that new developments – whether in housing, public utilities, or social infrastructure – serve diverse populations is critical to social sustainability. As these communities face economic transitions, infrastructural decisions must actively reduce inequality rather than entrench it.

This literature helps us understand how sustainable infrastructure investment in legacy mining communities cannot be reduced to technical solutions but requires addressing the social dynamics and cultural legacies tied to the community’s identity. In this article, I add to the literature on social sustainability by using Arizona’s LMCs as a case study. I highlight residents’ and local officials’ voices as empirical evidence of the complexity of community social infrastructure investments. As communities continue to recognize the importance of investing in the well-being and development of their towns, infrastructure, as systems or networks, becomes vital to social sustainability.

Arizona's legacy mining communities

The mining legacy is a complex part of Arizona's economy, history, and culture. Prior to European settlement, Native American tribes engaged in the mining of valuable minerals, which were of significant cultural and economic importance to their communities (Sheridan 2012). Precious metals lured early White-American settlers to the territory, leading to the establishment of many Arizona cities and towns, including San Manuel and Clifton-Morenci (Moore 1955). The abundance of mineral commodities made Arizona the leading producer of mined copper in the United States by the 20th century (Tenney 1927), and still, in 2021, the state accounted for an estimated 71 percent of domestic output (Flanagan 2022). Mineral wealth has been paramount in the development of the state.

Many small communities sprang up around the mines to support the workers and their families, with agricultural communities growing to meet the food requirements of the mining camps and towns (Moore 1955). These communities, known as LMCs, were often isolated but self-sufficient and relied solely on the mines for economic survival. Many in remote areas provided full access to healthcare, education, and other essential social services. Today, some of Arizona's best known LMTs (Bisbee, Globe, and Jerome) are popular tourist destinations, known for their unique architecture and mining identities as a result of investment in tourism infrastructure and their proximity to highways or major road networks.

At the same time, as Worrall et al. (2009) pointed out, mining legacies span a continuum of environmental and socioeconomic impacts. Common environmental legacies include physically altered landscapes, open shafts, subsidence, surface tailings storage facilities, contaminated water bodies, derelict plants, eroded landforms, and vegetation loss (Worrall et al. 2009, 1429). Recognizing these legacy environmental issues needed to be effectively managed to ensure the continuance of the mining companies' social license to operate (Sheehy and Dickie 2002), the mining industry took the initiative to clean Abandoned Mine Lands. In partnership with other stakeholders – such as governments and affected communities, the industry has also been exploring legislation since 2009 to ensure further that the process of cleaning these abandoned mine lands conforms to standard practices in the industry and protects companies from any legal liabilities when they take up the legacy cleaning of the Abandoned Mine Lands (Bridgeford 2022).

Socioeconomic impacts are closely linked to the legacies of environmental impacts, even with the shift from mining to other primary industries in some towns (Worrall et al. 2009). Primary concerns include job losses, population decline, reduced economic productivity, a lack of social infrastructure investments, and low quality of social life beyond immediate communities, reflecting the “Boom and Busts” nature of the copper resource economy (Carter 2012). Today, many of the mining towns in Arizona are working to balance their complex history with a commitment to sustainability. Two copper mining towns – San Manuel and Clifton-Morenci in southern Arizona (Figure 1), are examples of communities looking at investment in social infrastructure as a fulcrum for sustainability.

San manuel

San Manuel was Arizona's first master-planned mining company town, completed by Magma Mining Company in 1954 (Briggs 2014). The town was home to mine employees and their families, with stores, schools, a hospital, a bank, and parks. It is currently unincorporated and located in Pinal County, Arizona, with an estimated population of 3,489 in 2021 (U.S. Census Bureau 2021a). Over its 44-year mining production life (1956–2000), the San Manuel Kalamazoo mine was the largest underground mining operation in North America and one of the most extensive operations of its type in the world in terms of total ore (Briggs 2014). It was an essential contributor to the economies of both Pinal and Pima counties.

The sudden closure of the mines in 1999, which the company claims was “due to a sustained period of low copper prices” (BHP 2002), changed the community, leading to workers losing their jobs and impacting the community's social and economic life. The population's demographics have further shifted over time, making it increasingly a retirement community (Table 1).

After the closure, longtime residents estimate that about 75% of houses became vacant. However, with low prices of homes in San Manuel compared to its nearest city, Tucson, residents say there has been increased interest in home ownership, leading to people from within and outside the state moving into the town to buy houses; there now seems to be a need for more homes (Figure 2). Since 2020, residents have banded together as a community revitalization coalition to advocate for the town's social and economic revival; community members say they want the community to grow but still maintain its small, family-oriented identity.

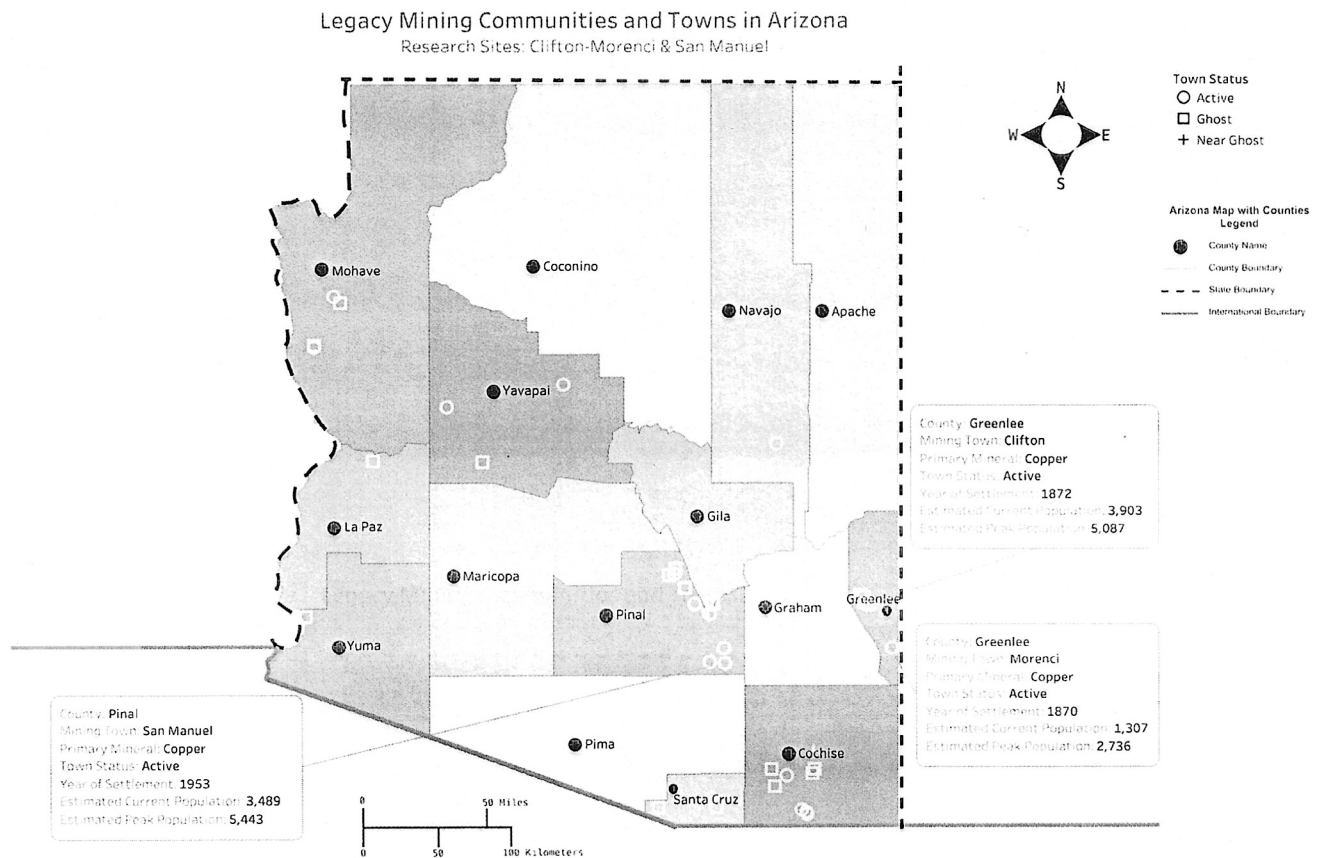


Figure 1. Map of Arizona showing selected historic mining towns and settlements throughout the state's counties. Active, Ghost, and near Ghost towns are defined based on population, economic, and social factors due to the "boom and bust" of mining activities. Source: Created by Author with data in appendix A.

Table 1. Population and demographic trends for case study sites.

Town	Estimated Population For Selected Years			Population Summary Indicators for 2021 ACS					Older Population by Age	Income and Earnings
	2021	2016	2011	Median age years	Sex ratio-males per 100 females	Age dependency ratio	Old-age dependency ratio	Child dependency ratio	65 Years and Older	Median Household Income
Clifton	3,903	3,583	3,247	30.3	118.9	70.9	13.0	57.9	7.60%	\$69,707
Morenci	1,307	1,742	1,976	31.5	111.8	33.2	2.4	30.8	1.8%	\$71,419
San Manuel	3,489	3,725	4,060	52.1	122.8	69.1	44.4	24.7	26.30%	\$44,784

Source: Created with data from the American community Survey (ACS), 5-year Estimates.

Clifton-Morenci

Clifton-Morenci, two communities about four miles apart, are sister towns and are considered a single research site for this study due to their proximity and complex social and economic ties. Both communities are located in Greenlee County. Clifton was a formal mining and union town (before the demise of the labor union) and serves as the seat of the county government; it has a current estimated population of 3,903 (U.S. Census Bureau 2021b). The town's demographics have changed partly because of a series of historical and sociopolitical upheavals, including racial

tensions, labor union strikes, and flooding (O'Leary 2018). Morenci, like San Manuel, is an unincorporated company mining town (one can only live there if one works for the company) and has an estimated population of 1,307 (U.S. Census Bureau 2021c). The Morenci active mine, operating since 1939, is currently operated by Freeport-McMoRan and is one of North America's largest open-pit copper mining operations. In 2019, the Morenci mines produced 1 billion pounds of copper. The mine's ore reserve (the rock remaining to be mined and milled) has been estimated at over 314 billion pounds of copper (Briggs 2016), leading

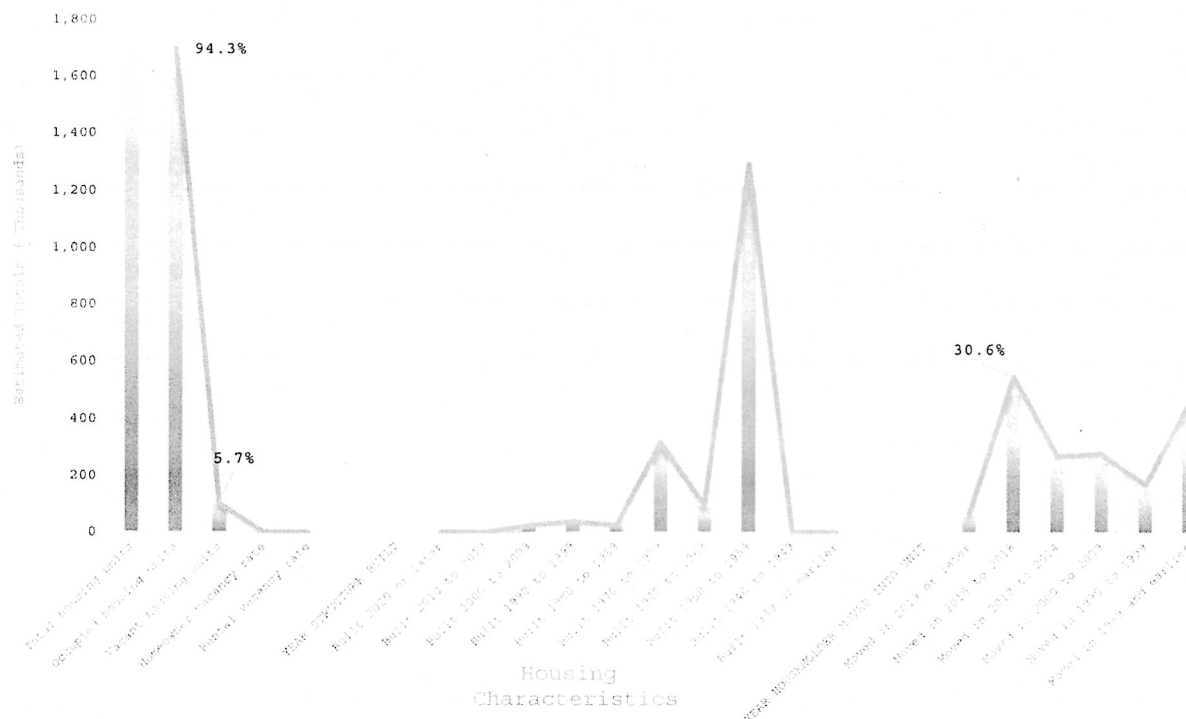


Figure 2. Selected housing characteristics for San Manuel, indicating estimated population, housing occupancy, year structure was built, and year householder moved in. Source: American community Survey 2021, 5-year Estimates (U.S. Census Bureau 2021d).

to a projection that the mine will last another 28 years (Freeport-McMoRan 2023). The mining operations in 2021 employed about 3,700 people and generated more than US\$ 1.1 billion and US\$ 256 million in economic benefits for Arizona and Greenlee County, respectively (Freeport-McMoRan 2022).

The town of Morenci has been moved and rebuilt to make way for the expansion of the open-pit copper mine. Since the company town of Morenci cannot provide housing for all, some workers live in Clifton or travel to and from Safford, Arizona, and Lordsburg, New Mexico, about an hour's drive each way. The county and surrounding towns largely depend on the mine's economy, and some residents and county officials in Clifton are concerned about the town's future when the mine closes.

Methods

In this article, I draw on data from a larger research project that examined how mining communities in southern Arizona are pursuing the sustainability of their townships. The choice of San Manuel and Clifton-Morenci, described above, reflects their distinct mining contribution and history in Arizona, and their economic impact and mining ties. Their selection provides valuable insights into the challenges and approaches that shape sustainable investments in the

regions. Such narratives encompass a range of factors, including the benefits and challenges of mining dependence, economic growth, environmental impact, labor and community power dynamics, and changes in the global market. I adopted a multi-sited ethnography case study approach to examine sustainable culture in LMCs (Marcus 1995). During a 16-month study from June 2021 to September 2022, primary data were gathered through ethnographic fieldwork, including participant observation, attending mining conferences, community events, and town board meetings. Secondary data, including archival records, news articles, maps, minutes of meetings, surveys, census data, video documentaries, and academic and grey literature, were used to ensure rigor (Cardano 2020), provided context for the findings, and allowed a more comprehensive understanding of the research topic.

In addition, interviews were conducted with three main groups of stakeholders. Group one consisted of 21 interviews with residents, community groups, and former and current mineworkers. Group two comprises six interviews with key local officials (two county supervisors, the town mayor, the town secretary, and two fire officers). The final group included three interviews with mining company officials – mine site community manager, corporate social responsibility manager, and operations manager, an interview with the president of a mining association, and an

interview with a mining consultant. A total of 32 interviews were conducted, and over 100 informal conversations with various individuals, both inside and outside the communities, were engaged throughout the fieldwork. In both towns, interviewees were over 18 years old (33 – 82), with 13 female and 19 male participants. Due to the migratory nature of mining work and life, many interviewees had social and economic connections to either one or both towns and other mining towns in Arizona. Most participants had lived in these communities for over 20 years, and the longest residents had been in the community for over 60 years, while the newest residents had been there for a minimum of four years.

Participants were selected using the snowball sampling technique within social networks because the sensitive socio-political nature of mining made access to miners difficult (Bernard 2017). Most interviews were conducted in person at the field site and the chosen location of the participants. However, due to logistical constraints and the challenges posed by the COVID-19 pandemic, three interviews were conducted via video conference and four by phone. The qualitative data collected through interviews, field notes, and meeting minutes were analyzed using the qualitative data software MAXQDA2022. The transcripts of interviews were coded using inductive thematic analysis, followed by a deductive categorization based on previous extensive scoping research knowledge of sustainability in mining communities (Kuckartz and Rädiker 2019). The data codes are connected with theory.

Results

Environmental concerns resonate with discussions about sustainability in post- and active mining communities in the Southwest. At the same time, the case studies reveal contrasting themes that reflect the unique characteristics of these LMCs. Two key topics emerged from most of those interviewed: 1) investment in housing infrastructure and 2) social ties and attachments to the mining identity that influence decision-making and define the nature of these LMCs. Social sustainability for these communities was discussed in terms of alternative livelihood economic activities, investment in housing infrastructure, and environmental and sociocultural issues. Residents also spoke of their diverse understanding of decisions that define the nature of their communities, often contradicting the community's dominant narratives about social sustainability.

All residents acknowledged the lack of investment in infrastructure and shared dominant narratives that

some infrastructure investments can provide opportunities to meet the unmet needs of the communities. However, a small percentage of residents, in both interviews and informal conversations, expressed their doubts about the viability of investment in housing infrastructure for sustainability. Their reasons varied, but the major concerns relate to the aging population, future access to water resources (particularly in Clifton-Morenci), and geographical isolation, making access to major cities and social services challenging.

Secondly, some residents questioned dominant narratives of mining identity that emphasize community values, beliefs, and priorities that informed the community's decision on social sustainability. Such views represent those who say they do not feel as attached to the town as others because they do not hold the same socioeconomic ties to the community. They also point to generational differences between miners and their descendants.

For those residents who expressed uncertainty about housing infrastructure for sustainability and a lack of a sense of attachment to the community, sustainability is perceived as a personal decision about whether to continue living in the community if their well-being becomes unachievable. Sustainability is broadly conceived in this study as a stewardship approach to ensuring that the present and long-term well-being of communities (industrial or LMCs) are provided and maintained by all stakeholders. The following themes reveal the diverse narratives regarding sustainability in the communities.

Investment in housing infrastructure

In defining the nature of the social sustainability of LMCs, economic diversification has become a critical concern. One of the approaches to social sustainability revolves around investment in housing infrastructure to help create alternative livelihood opportunities. In both communities, some residents and town officials consider housing as key for social and economic sustainability for two reasons: a) the need for more affordable housing and b) old houses in need of renovation. These respondents anticipate supporting new businesses and industries by providing improved affordable housing options, associated job creation, and a more diverse economy. Community infrastructure investments – like the renovation of town community-centers and parks – are funded through a combination of county government support, small business or big company initiatives, and community-driven coalitions. However, major infrastructure projects such as roads, sanitation, and internet access

require government support at multiple levels—county, state, and federal.

Community members point out that such investment can help strengthen a sense of mining town identity—small towns with close-knit, family-oriented values that have become a part of the cherished legacy left behind by the nature of company mining towns. Thus, communities see diversification through investment in housing infrastructure as developing a sustainable culture, including the interconnectivity of social, economic, and environmental systems. In the context of LMCs, a sustainable culture involves finding ways to preserve community identity while creating a more diverse and resilient economy that can sustainably support the community's needs through infrastructure investments.

In San Manuel, residents are taking the initiative to revitalize their community by collaborating with local representatives and small businesses to address community needs. Through the efforts of the community revitalization coalition, the community has made significant strides in social infrastructure to promote its vision of social sustainability. For the San Manuel community, social sustainability means investing in infrastructure that binds the community, such as bringing in small businesses, reopening the community center, and building children's playgrounds. These efforts reflect what many community members describe as maintaining a small-town identity while pursuing growth opportunities.

San Manuel has emerged as a desirable option for potential homebuyers because of affordable housing prices and proximity to a major city, as attested by its residents. The surge in home purchases has resulted in a rise in occupied housing units and fewer vacant homes (see Figure 2). Consequently, some community members feel that it is imperative to invest in housing not only to meet the current and future demands of the town but also to foster economic and employment opportunities. One resident pointed out, "We don't have a place for anyone to live. So whatever businesses are established in town are going to have to either hire locally, or they're going to have to bring in workers." A community organizer also emphasized the importance of creating sustainable infrastructure investments to address the community's difficulties in attracting economic investments. The following statement underscores the community organizer's apprehension:

I've talked to two housing developers and said, OK, what is it going to take to get houses built on our side of the county? And essentially, they said, you need industry, and so I talked to people in industry, and

they say, well, you need housing. This is one of the big issues in a lot of rural communities. They've had issues similar in Kearney and Hayden and such that bringing in larger industries is not doable without the personnel to support it. Now, also, like I said, we aren't able to retain young professionals, so those who have the degree to operate these kinds of industries aren't living locally. The closest they're living is Maricopa, where the industry currently exists. So, these are the struggles I'm having in trying to balance bringing up the economy here when nobody wants to play the ball (interview, resident, San Manuel, August 27, 2022).

Other residents talked about developing the town's highway road system (which is currently a dead-end) so that vehicles can pass through the community to other towns. The idea is that highway infrastructures serve as networks and systems that can open the community to opportunities.

The company town of Morenci is currently grappling with a space for housing mineworkers and their families, which has resulted in an opportunity for nearby towns like Clifton to satisfy the increase in housing demand. Although the town of Clifton has invested in wastewater treatment plants to improve the system, housing investment for several years has been lacking, leading to deteriorating, inadequate, and insufficient housing for current residents. Most existing homes do not meet the standards and needs of workers and their families. Many homes are in disrepair, making them uninhabitable or undesirable for potential new residents. Therefore, constructing housing for mineworkers is essential to the economic development plan for local town and county officials. They believe investing in housing infrastructure will address current needs and diversify the economy by attracting alternative industries not dependent on mining. Some residents, town officials, and county officials shared their insights in exploring the challenges and opportunities of creating a sustainable industry beyond mining through infrastructure investment. Below are two key insights:

People don't need houses right now; they need something to do to sustain them here. I'm not a pessimist. If Clifton is going to survive, it will have to find something other than the Mine to sustain it (interview, Clifton town official, September 8, 2022).

Homes and roofs are key to the sustainability of everything that we're discussing right now. Without any homes, we can't attract anybody to come in here. We can't have people retire and remain here if they want to remain here [...] we need housing in this county to build the sustainability that we need to keep people here and bring other businesses here because we can't do it without any home (interview, Greenlee County supervisor and resident, September 20, 2022).

Social connections to the mining identity

As noted above, both towns are expected to move away from their historical reliance on mining and towards a more diversified and sustainable future. Industries considered include mining heritage tourism, renewable energy, and warehousing facilities, among others, including support for entrepreneurship and small business development. However, people maintain complex social ties and connections to mining. As some residents in San Manuel explained, people were not just mineworkers; the Mine was their identity. Their mining identities were tied to all things – jobs, homes, hospitals, local stores, family fun fairs – associated with the quality of life that comes with living in a company mining town. For these people, the cyclical market of the mineral world and the closure of a mine are part of a lived experience that distorts their lives and takes away their identity.

The concept of mining identity is closely intertwined with the history, culture, and economic structure of mining communities. Mining identity sets itself apart in several ways, unlike other industries, such as high-tech (electronics and telecommunication), manufacturing, or defense. Its historical roots, company town structure, close-knit communities, economic vulnerability, and geographical isolation all contribute to a unique sense of identity that differs from other sectors in Arizona. Mining communities are typically found in rural or semi-rural areas, while high-tech, manufacturing, and defense industries are usually located in urban and suburban areas, significantly impacting social and cultural dynamics. The high-tech sector is characterized by innovation and individualism, manufacturing by tradition and stability (although this is changing), and the defense industry by patriotism and government dependency. These identities can also evolve over time due to economic, technological, and social changes. However, the mining industry also emphasizes “national security and economic interests” regarding “critical minerals” (Schulz et al. 2017), potentially creating a nationalistic identity tied to patriotism, security, and the protection of the nation.

While some new residents understand the significance of social connections to the town’s identity, others do not share the same attachment. In Clifton-Morenci, some residents expressed their concerns about the future, when generations may no longer share the same ties to the town because of different career goals and values. Additionally, some residents may choose not to stay or invest in the area because they lack generational ties to employment as

miners or ranchers. However, the interviews revealed an underlying desire for social and cultural connections that motivate investment in infrastructure to change the narrative of LMCs as undesirable, closed temporalities, that is, as economically unattractive for living due to the dynamic and cyclical nature of the mining economy that supports livelihood. These social and cultural connections are crucial in community decision-making regarding sustainable investment in infrastructure to preserve the town’s identity:

You have this town that has this historical aspect to it, and so many rare little things that really created an identity [the company town structure], and then this group of people [miners] that stuck through the hard times that really banded together and helped each other out. I mean, you’ll find repairs on houses that are obviously like four miners came over and were like, hey, I got some scrap in my truck, but we could fix that right now, and they did. I would say it’s a unique community that has challenges and benefits that are unlike a community I’ve been in, and I’ve been all over the US (interview, San Manuel Revitalization Board Member, September 14, 2022).

When I worked for Southwest Gas, I used to go to the district managers’ meetings down there in Tucson. And every time the meeting was over, man, I’d get my briefcase and notebooks, clothes, and I’d head back to God’s country [Clifton]. I said I’m getting away from all the hustle and bustle. I’m going back to the mountains; I said where I belong. I’m headed back to God’s country. And I always used to say that, and people still remember me for that from Southwest Gas. That was how I used to describe this place over here. (...) I was born and raised there, and I love it there (interview, Greenlee County official, September 20, 2022).

Discussion

There are both challenges and opportunities in the two LMCs regarding sustainability. The challenges involve navigating discussions about what it means to be sustainable in active and post-mining towns, including with regard to aging infrastructure, economic reliance on mining, geographical remoteness, and shifting demographics. Opportunities exist to invest in infrastructure to attract new industries and revitalize community spaces to strengthen the social fabric.

Conceptualizing infrastructure through a system thinking perspective extends the analysis of infrastructure beyond its immediate impacts, offering an opportunity to understand infrastructures as interconnected systems with feedback mechanisms. The relationship between housing and economic development is tied to

the systemic thinking of the challenge to attract businesses and create jobs, where there is a lack of adequate housing. Investment in housing is seen as a first step in building the infrastructure necessary for economic growth. New or renovated homes can accommodate workers in potential new industries, enabling economic diversification. This perspective suggests that changes in one component can ripple through and affect other components within the system (Andrew and Petkov 2003; Meadows 2008). For LMCs, investing in infrastructure is seen as a way to strengthen the complex systems sustaining society—economically, environmentally, socially, and culturally. Residents' discussions about the necessity of housing for economic diversification and community well-being reflect a “capital approach” to sustainability (Strange and Bayley 2008). Approaching infrastructure as a system also draws attention to long-term impacts on community resilience and well-being. Conversely, a lack of investment in housing can limit economic growth and affect the community's social and cultural identity.

Infrastructure is embedded within broader socio-cultural contexts (Elyachar 2010; Larkin 2013). Narratives about housing infrastructure investment and attachment to a mining identity illustrate how infrastructure is intertwined with socio-cultural dynamics. In San Manuel, a view of infrastructure through a system lens helps to understand the sense of community that brings people together through

shared interests in maintaining the system. The revitalization coalition in San Manuel worked with local representatives and small businesses to invest in infrastructure that supported the community's small-town identity and attracted economic opportunities. Investments like the community children's playground reflect social values and practices aligned with a small-town mining identity.

The call for housing infrastructure is a critical aspect of rethinking social sustainability. It shifts narratives about LMCs as temporary and undesirable places to live while highlighting the importance of a holistic view of SI that promotes social, cultural, economic, and environmental aspects of the community. The conceptual map (Figure 3) illustrates the complexities of sustainable decisions in LMCs from a system-thinking perspective. It shows how sustainable culture involves making socially responsible decisions and taking actions that support a diverse and resilient economy that meets the community's needs. In this map, however, the decision-making process can be influenced by subtle “power dynamics” (Lukes 2005) that can define what becomes SI, impacting what is a critical focus for sustainability. In this sense, power dynamics constitute the positions of knowledge held by key stakeholders in defining sustainable and unsustainable investments.

In Clifton and San Manuel, some community members explained that proposals to build solar farms

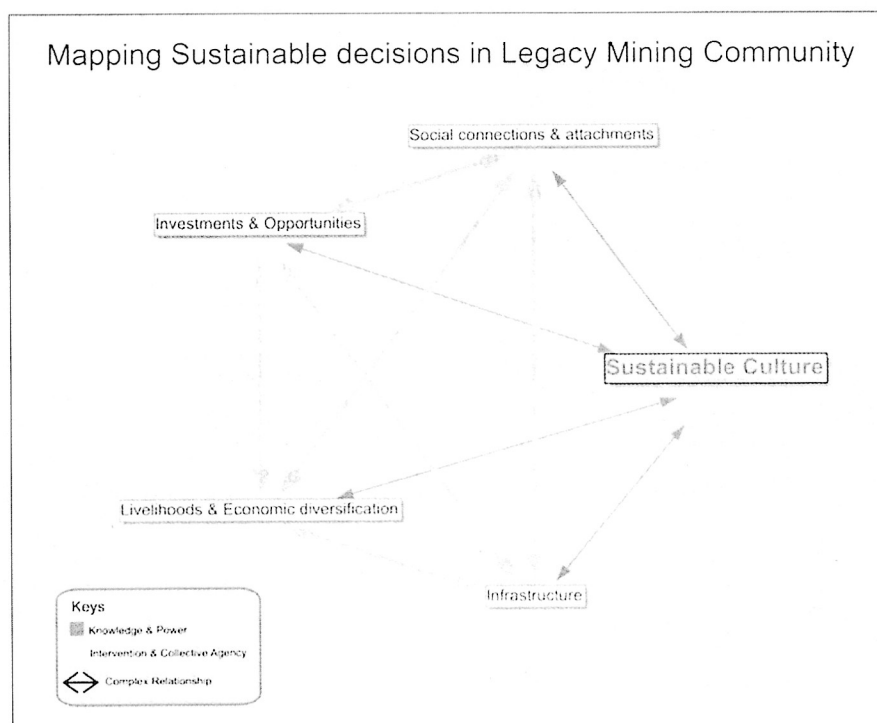


Figure 3. Conceptual map of complex sustainable decisions in LMCs. Source: Created by Author.

considered clean SI might not necessarily be good SI infrastructure for the community because its economic benefits in terms of employment were not substantial. These power dynamics – where decisions about SI are actively contested and negotiated – define the boundaries of the community's vision of a sustainable culture through infrastructure investment. Nonetheless, such power dynamics can also mobilize the community's collective agency (as indicated by the blue directional arrows on the map) to address challenges. Through a participatory process, the communities can then negotiate access to policies and actions tailored to their circumstances.

Klinenberg's (2018) concept of social infrastructure emphasizes the importance of spaces like housing, community centers, and playgrounds in fostering social connections and community life. In San Manuel, community revitalization efforts demonstrate the importance of social infrastructure in promoting social sustainability. However, in both communities, challenges such as geographical isolation and limited access to major cities and social services hinder connectivity. These issues relate to Graham and Marvin (2001) analysis that infrastructural gaps can create fragmented communities and deepen socio-spatial inequalities. This underscores the need for a comprehensive approach to sustainability in mining communities where infrastructure is seen as a critical connection between the various sustainable dimensions: social, cultural, economic, and environmental.

Conclusions

Housing infrastructure investment is a crucial factor for social sustainability. According to the diverse perspectives shared by residents in this study, this investment can be considered the cornerstone for achieving sustainability in LMCs. In this article, I have focused on the complexity of sustainability in specific contexts, requiring a comprehensive and systems-thinking approach to address the interdependent components that define sustainability.

I have emphasized that sustainability in mining communities involves interconnected economic, social, cultural, and environmental decisions. Achieving sustainable outcomes necessitates focusing on developing infrastructures that function as feedback mechanisms, allowing for the identification of opportunities and challenges in one area that may influence others over time. Consequently, any investment in infrastructure must be considered within the broader strategy of cultivating a sustainable culture.

Sustainability in mining communities is context-specific, necessitating tailored approaches to address the unique sustainability challenges of each LMC. This requires considering each community's distinct characteristics, including local culture, economy, and environment. Insights from this study on how housing is a critical SI in these two towns can facilitate discussions on sustainable infrastructure for LMCs, helping to identify contested issues and adaptive responses that align with community needs. Further studies are required to explore the application of systems thinking in infrastructure development for post-mining communities. This could emphasize the interdependencies among various infrastructure components and their broader social, economic, and environmental impacts. Further research is also needed on how infrastructure projects reflect and influence community identity, practices, and interactions. This includes studying the symbolic and cultural meanings attached to different types of infrastructure.

The challenges faced by these LMCs are not unique. Around the world, towns lose their economic base, whether due to declines in mining, manufacturing, or other industries, and struggle to sustain themselves. For anthropologists, the important lesson here is the significance of community-driven efforts in shaping the future of their towns. While external investments are critical, community social fabric and collective agency are central in determining whether these towns can thrive. Understanding the actual and perceived areas of need is central to how the elements of social sustainability influence the decision-making that defines the nature of such towns.

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No potential conflict of interest was reported by the author.

Notes on contributor

Felix Ampadu is a Lecturer in Sociocultural Anthropology and Scholar at the Center for the Environment at Washington University in St. Louis. His research focuses on sustainability in legacy mining towns in Arizona, and bringing ethnographic insight to questions of sustainability of rural communities impacted by extraction.

ORCID

Felix Ampadu  <http://orcid.org/0000-0002-5867-0248>

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Appendix A

Table A1. Dataset of map of Arizona showing selected historic mining towns and settlements throughout the state's counties.

Dataset- Selected Legacy Mining Communities and Towns in Arizona								
County	Mining Town	Primary Mineral	Town Status	Year of Settlement	Latitude (generated)	Longitude (generated)	Estimated Current Population	Estimated Peak Population
Gila	Winkelman	Copper	Active	1877	32.9876	-110.7709	292	N/A
Cochise	Warren	Copper	Active	1905	31.41159	-109.87832	4957	25000
Maricopa	Vulture City	Gold	Ghost	1863	33.85746602	-112.8322158	N/A	N/A
Coconino	Two Guns	N/A	Ghost	N/A	35.117931	-111.0935624	N/A	N/A
Pima	Total Wreck	Silver	Ghost	1879	31.89564	-110.59286	N/A	200
Cochise	Tombstone	Silver	Active	1878	31.7129	-110.0676	978	10000
La Paz	Swansea	Copper	Ghost	1909	34.17072913	-113.8459203	N/A	N/A
Pinal	Superior	Copper, Silver & Gold	Active	1875	33.2939	-111.0962	2679	N/A
Greenlee	Stargo	Copper, Silver & Gold	Ghost	1930	33.06784	-109.36007	N/A	1194
Pinal	Silver King	Silver	Ghost	1875	33.32767	-111.08687	N/A	N/A
Pinal	San Manuel	Copper	Active	1953	32.5998	-110.6309	3489	5443
Santa Cruz	Ruby	Lead, Silver & Zinc	Ghost	1907	31.461111	-111.2375	N/A	2000
Pinal	Ray	Copper	Ghost	1909	33.183333	-110.9975	N/A	N/A
Pinal	Pinal	Silver	Ghost	1878	33.278056	-111.139167	N/A	2000
Cochise	Pearce	Gold	Near Ghost	1895	31.9051	-109.8206	15	1500
Santa Cruz	Patagonia	Silver & Lead	Active	1867	31.5395	-110.7562	804	N/A
Pinal	Oracle	Gold & Silver	Active	1870	32.6109	-110.7709	3335	N/A
Greenlee	Old Morenci	Copper	Ghost	1870	33.12249772	-109.3833319	N/A	N/A
Mohave	Oatman	Gold	Active	1906	35.0264	-114.3836	43	3500
Greenlee	Morenci	Copper	Active	1870	33.0509	-109.32806	1307	2736
Mohave	Mineral Park	Gold & Silver	Ghost	1871	35.365278	-114.1425	N/A	N/A
Gila	Miami	Copper	Active	1909	33.3995	-110.8709	1490	N/A
Greenlee	Metcalfe	Copper	Ghost	1870	33.11355745	-109.3605492	N/A	N/A
Pinal	Mammoth	Copper & Gold	Active	1887	32.7226	-110.6407	1219	N/A
Cochise	Lowell	Copper	Active	1880	31.42868	-109.89364	4957	25000
Navajo	Linden	Copper, Silver & Gold	Active	N/A	34.2972748	-110.1586559	2523	N/A
Graham	Klondyke	Gold	Ghost	1905	32.83548269	-110.3323131	N/A	500
Pinal	Kearny	Copper	Active	1958	33.057	-110.9107	2198	2892
Yavapai	Jerome	Copper	Active	1883	34.7489	-112.1138	445	15000
Gila	Hayden	Copper	Near Ghost	1911	33.0048	-110.7854	374	N/A
Santa Cruz	Harshaw	Silver	Ghost	1877	31.467222	-110.706944	N/A	2000
Mohave	Goldroad	Gold	Ghost	1901	35.0449	-114.37772	N/A	N/A
Gila	Globe	Copper & Silver	Active	1876	33.396	-110.7872	7185	N/A
Cochise	Gleeson	Copper	Ghost	1890	31.733889	-109.829722	N/A	N/A
Greenlee	Duncan	"Copper"	Active	1870	32.7152	-109.1004	787	862
Cochise	Courtland	Copper	Ghost	1887	31.770145	-109.808611	N/A	N/A
Gila	Copper Hill	Copper	Ghost	1908	33.430278	-110.764444	108	500
Cochise	Contention City	Silver	Ghost	1879	31.768889	-110.201944	N/A	N/A
Yavapai	Congress	Gold	Ghost	1884	34.1625	-112.8507	1665	N/A
Greenlee	Clifton	Copper	Active	1872	33.05116	-109.29669	3903	5087
Gila	Christmas	Copper, Silver & Gold	Ghost	1880	33.063333	-110.740278	N/A	N/A
Mohave	Chloride	Gold & Silver	Active	1863	35.4144	-114.1994	296	5000
Cochise	Charleston	Silver	Ghost	1879	31.635833	-110.1725	N/A	N/A
Yuma	Castle Dome city	Copper, Silver, Lead, Gold & Zinc	Ghost	1869	32.96546636	-114.4626943	N/A	N/A
Cochise	Bisbee	Copper	Active	1880	31.4481	-109.9284	4957	25000
Yavapai	Bagdad	Copper	Active	1882	34.5718	-113.1748	2383	N/A
Apache	Alpine	Copper, Silver, Lead, Gold & Zinc	Active	1876	33.8481	-109.1431	136	600
Pima	Ajo	Copper	Active	1884	32.3772	-112.8646	3039	7049