



Multifaceted Impacts on Marginalized Communities: Makoko, Kibera, and Kivalina: A Review

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ABSTRACT

This article examines the impact on marginalized communities in three specific communities: Kibera, Makoko, and Kivalina. Marginalized communities are those excluded from mainstream social, economic, educational, or cultural life [1]. These communities are impacted by a myriad of factors, including but not limited to rising sea levels, pollution, flooding, coastal erosion, climate change, and a lack of space. These factors have a direct impact on marginalized communities, affecting their quality of life and causing them to struggle with a number of issues such as poverty, poor sanitation, food insecurity, insufficient electricity supply, unemployment, and a lack of access to clean water [1]. We will research the connections between three different marginalized communities and their impact. What is the impact on Makoko, Kibera, and Kivalina? How does it affect them? We will answer this question by examining the standard of living of marginalized communities before, during, and after the impact. Our research methodology included reviewing, analyzing, and summarizing data from journals and case studies.

Keywords: impact, marginalized communities, Kibera, Makoko, Kivalina.

Introduction of the Makoko and Impacts

Makoko, a heavily populated community in Lagos, Nigeria, is situated in the lagoon. It is also known as the "African Venice." It's a settlement mainly built on stilts above water. The community comprises neighborhoods, each with its own unique character and way of life. Many residents rely on fishing and informal trade for their livelihood [1].

Despite its vibrant culture and strong community ties, Makoko faces numerous challenges. The settlement often experiences marginalization and lacks access to basic services like clean water, sanitation, healthcare, and education [1]. Environmental factors (rising sea levels, pollution, and poor waste management) additionally exacerbate these issues even further.

Makoko's residents frequently encounter social and economic exclusion, limiting their opportunities for advancement and perpetuating poverty cycles. Government policies and urban development plans often overlook or actively displace the community, leading to instability and insecurity for its residents [2].

Impacts on the Community

As aforementioned, the Makoko community faces numerous issues collectively rather than facing one single troublesome issue.

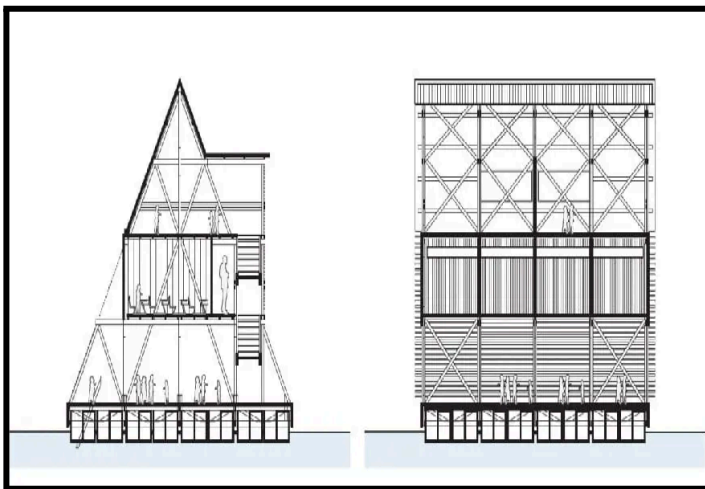
Environmental Challenges: Rising sea levels pose a major threat. The community already experiences frequent flooding, which disrupts daily life and damages homes and other residential buildings. The pollution from industrial activities in Lagos and within the community also contaminates the water, which affects residents' health and the local ecosystem. Ultimately, deteriorating the conditions for many individuals in Makoko [3].

Health Issues: Limited access to clean water and sanitation facilities results in widespread health problems. Furthermore, waterborne diseases like cholera and typhoid are common; these waterborne diseases can spread to vulnerable individuals [4]. The lack of healthcare services makes addressing these issues difficult. Poor living conditions also contribute to high rates of respiratory and skin infections [5].

Educational Barriers: Many Makoko children lack access to quality education. The schools in Makoko are often overcrowded and underfunded. Economic pressures sometimes force children to work instead of attending school [6].

Economic Marginalization: Makoko's economy is mainly based on fishing and small-scale trade [7]. The community's economic activities are often not recognized or supported by formal institutions, making it challenging for residents to improve their financial stability [8].

Makoko before Impacts



Prior to the disaster, Makoko's infrastructure issues were well documented. The community faced overcrowding in its sole primary school and recurrent flooding that threatened existing structures. The floating school was proposed as a potential solution, offering a sustainable and adaptable learning environment. The Makoko floating school, designed by Nigerian architect Kunlé Adeyemi and constructed in 2013, has received international recognition. This innovative building utilized local materials, such as wood and bamboo, and rested upon 250 plastic barrels. Although the school has

garnered several accolades, it faced challenges, including delays in opening and concerns regarding its safety. Ultimately, the structure collapsed during a severe thunderstorm in 2016, highlighting the fragility of the floating city's infrastructure and drawing attention to the ongoing struggle of the Makoko community to secure safe and sustainable living conditions amidst the threats of demolition and environmental challenges [9] & [10].

Healthcare in Makoko is mainly supplied through an informal network of unregistered clinics that address fundamental health issues. The delivery of babies was primarily overseen by traditional birth attendants who operated in conditions with high maternal mortality rates. In January 2011, Doctors Without Borders established a floating clinic that, unfortunately, was operational for less than a year, underscoring the temporary nature of formal healthcare services in the community [11]. Arctic Infrastructure, an engineering corporation, has been working on a proposal to construct a healthcare facility with support from the Swiss government, suggesting ongoing initiatives to enhance healthcare infrastructure [12].

Makoko during Impacts

Makoko has experienced various impacts over the years that have shaped its development and quality of life. By examining past data and historical records, we can gain a deeper understanding of how these challenges have evolved and affected the community. Its uncontrollable environmental disasters resulting from floods, pollution, and other natural disasters have resulted in both short-term and long-term effects on the community that need to be addressed immediately before its influence continues to spread among the population. In this section, we will evaluate the environmental impact of natural disasters and explore the trends of these environmental factors and their effects on communal health, education within the community, economic shortcomings, and more. Many of these impacts are unfortunately not long-term and have proved to be huge issues immediately after the environmental disaster [13].

Environmental Impacts Over Time

Makoko has faced severe flooding for decades. Historical data indicates increased rainfall and rising sea levels have worsened this issue. A major flood in 2004 distributed hundreds and caused extreme damage to homes and infrastructure [14]. In recent years, the flooding has become more frequent, which impacts the community's daily activities harshly. These floods not only damage properties but also create harsh living conditions, contributing to disease spread. Overall, the main environmental impact that makes the conditions deteriorate is flooding [15].

High population density in Makoko leads to significant air pollution. There is a problem of overcrowding, which results in widespread use of wood and charcoal for cooking, releasing large amounts of smoke and particulate matter into the air. This ultimately results in health issues among residents, particularly affecting children and the elderly [16]. Another form of environmental impact is the inadequate waste management that has led to severe land pollution in Makoko. The community lacks formal waste disposal systems, resulting in solid waste accumulation in living areas. This creates a bad environment and serves as breeding grounds for pests and disease vectors [17]. Industrial activities in Lagos and a lack of proper sanitation facilities have led to extreme levels of water pollution in Makoko. The pollution and lack of sanitation pose significant health risks, including waterborne diseases such as cholera and typhoid, which have been documented in health reports from the early 2000s. Pollution and habitat destruction also impacted aquatic life in the lagoon. Historical data from environmental studies show a decline in various fish species' populations, which many Makoko residents rely on for their livelihood. The extinction of these species disrupts the local ecosystem and the community's economic stability.

Health Impacts Over Time

Because of the lack of sanitation, poor housing structures, and insecurity of tenure in many of Makoko's slum communities, many environmental issues have evolved to directly affect the health of many within the community [18]. One of the most prominent issues within these slums is air pollution, which occurred as a result of overcrowding due to the large population within the Makoko community but not enough housing space. This has led to a shortage of oxygen, which has caused breathing problems within the past couple of years. Because of this, suffocation is common among infants, and heart conditions are one of the most common diseases. Because overcrowding is one of the main sources of air pollution, many airborne diseases also happen to be common within the community. These include chicken pox, tuberculosis, smallpox, measles, and more. Unfortunately for this community that's already suffering from many unpredictable environmental problems as it is plus the unsanitary conditions because of their housing situation, other issues plague the community, including land pollution and water pollution. Due to the limitation of space and access to clean water, many people in Makoko defecate in the same water they use to cook and wash their clothing [19]. There's no system of waste collection, and many non-biodegradable wastes, such as plastic, glass bottles, nylons, etc. are left on the surface of the water, which is a huge problem for the environment. Because of the abundance of stagnant water in this location, mosquitoes and other insects are another issue the community must face. These bugs transfer diseases from human to human, which can be disastrous and almost extinction-worthy in overcrowded communities like Makoko. Plus, the stagnant waters also result in many waterborne diseases such as typhoid fever, malaria, diarrhea, dysentery, and more, and other water-related diseases such as dengue fever and leptospirosis.

63 million people lack access to safe drinking water, and 111 million have no sanitation. 85,000 children die every year in the country from diarrhea caused by unsafe drinking water and poor sanitation [19].

Educational Barriers Over Time

Historical records from the 1990s and early 2000s show the data on school enrollment in Makoko. Children couldn't go to school because they had to work to help their families and due to economic pressures. Reports from educational NGOs reported that just a tiny fraction of school-age children were actually in formal education [19]; many of those who did start school ended up dropping out, and they mainly dropped out because of money problems and the need to help at home or with family work.

For years, Makoko schools have been in a terrible state. Historical reports describe classrooms that were overcrowded and students didn't have the basics—no textbooks, no pencils, and desks. Many schools were just makeshift buildings that were vulnerable to flooding and other hazards. Funding for education was also minimal. This meant teachers were paid poorly, and there weren't enough resources to teach effectively.

Economic Marginalization Over Time

Makoko, an informal settlement in Lagos, Nigeria, has faced severe economic marginalization for decades, exacerbated by frequent flooding and inadequate infrastructure. This community, home to around 250,000 residents, primarily relies on fishing and small-scale trading for sustenance [20]. According to a study by the Heinrich Böll Stiftung Foundation, Makoko's residents often suffer significant economic losses during flood events, with damage to homes, businesses, and essential infrastructure leading to prolonged recovery times and increased poverty levels [21]. During the major flood event of 2012, Makoko experienced substantial economic losses, estimated at over \$500,000 in direct damages to homes and businesses. The recurrent nature of these floods compounds economic hardships, as recovery efforts are often slow and underfunded.

The impacts of flooding have attracted many empirical studies explicating the extent and providing pragmatic ways of resolving the challenges. For instance, Krichene et al. (2021) investigated the long-term impact and transmission channels of tropical cyclones and fluvial floods on economic growth. The study found that both tropical cyclones and fluvial floods bring about 6.5% and 5.0% decline in economic growth, respectively [22]. Further, higher levels of development were found to be effective in mitigating economic growth losses associated with fluvial floods. The study noted that on average, the costs of coastal environmental degradation linked to flooding and coastal erosion could be estimated at over US\$ 3 billion by 2100 with an anticipated 400% increase in the number of affected people [22]. The analysis of collected data based on multi-regression and spatial estimation techniques revealed that flooding aggravated poverty levels, while the majority of the affected flood victims were the poor [22].

Efforts to spur economic development in Makoko amidst environmental challenges have included innovative projects like the Makoko Floating School. This project aimed to provide a sustainable, flood-resistant educational facility to the community. Despite its initial success, the structure eventually collapsed due to poor maintenance and environmental stressors. Reports from The Guardian highlight that such initiatives, while well-intentioned, require more robust planning and support to ensure long-term sustainability [22]. Additionally, various NGOs have worked to improve local economic conditions by providing microloans and vocational training, aiming to diversify income sources and enhance community resilience against flooding impacts. Effective implementation of integrated flood risk management approaches, as suggested by the World Bank, could potentially reduce economic losses by up to 30%, fostering a more resilient economic environment for Makoko's residents [22].

Makoko after Impacts

Makoko's location on the Lagos Lagoon makes it highly susceptible to flooding, which is worsened by the decades-long obstacle of climate change. Rising sea levels and increased rainfall have intensified the frequency and severity of these floods, affecting the housing and sanitation conditions in these areas. However, recent news of large flooding occurring in the area did bring greater awareness of the need for more climate-resilient infrastructure [23].

Permanent Infrastructure Damage:

Constant flooding in the area has resulted in much permanent damage done to infrastructure in the area, but has also built resilience and strengthened the resolve for better infrastructure in the

area. The Makoko Floating School, a building project of Makoko developed in 2013, was abandoned in March 2016 due to safety concerns resulting from constant flooding. The project collapsed soon after in June of that same year; however, this only urged for more public awareness of the issue and encouraged a stronger, safer prototype to be built as a replacement. The new design was meant to last even longer than its predecessor and built to withstand more extreme climate conditions, demonstrating how the people of Makoko only rise to face challenges rather than shy away from obstacles. As a result of harsh flooding in 2016, many houses and schools collapsed, which was a common occurrence for communities in West African nations. This occurred mainly as a result of poor materials and weak enforcement of regulations, but the people learned to rebuild the school to adapt to changing water levels and withstand the harsh storms and flooding of the area [24].

Economic Challenges and the Limitations on Urban Development:

A study from 2021 that investigated the long-term impact and transmission channels of tropical cyclones and fluvial floods on economic growth found that tropical cyclones and fluvial floods bring about a 6.5% and 5.0% decline in economic growth [25]. Another study by Bolle et al. back in 2021 found that on average, the costs of coastal environmental degradation linked to flooding and coastal erosion could be estimated at over \$3 billion by 2100 with an anticipated 400% increase in the number of affected people [26]. The harsh weather conditions not only resulted in economic decline and disadvantages but also led to health risks including diarrhea, skin infections, injuries, communicable and noncommunicable diseases, acute respiratory infections, and vector-borne diseases in public healthcare families, according to a study by Saulnier et al [27]. in 2018. Another study by Mtapuri et al. showed that flooding hinders development through four main channels: displacement of human populations, damage of plants, collapsing of buildings, disruption of vulnerability, and acting as a nondiscriminatory agent [28]. Impacts from environmental causes not only result in immediate noticeable differences but also prevent urban development and vulnerability within structures that the people of the town would've never noticed because of flooding that brings down the buildings before other factors can impact them.

Introduction to Kibera

“Kibera, located in Nairobi, Kenya, is widely seen as one of Africa's largest slums/home to a shantytown. The population of the area is about 250,000 to 1 million people, but exact numbers are hard to come by due to the informal nature of the settlement. Kibera, which originated in the early 20th century as a settlement for Nubian soldiers returning from World War I, has since become a very lively but tough urban space with very intricate social and economic patterns.”[29]

The people of Kibera represent a fascinating combination of resilience and resistance to adversity. It can be seen as a major hub of cultural diversity, entrepreneurship, and social solidarity on the one hand. The residents have built strong informal economies, creative ventures, and community-based organizations to tackle various social problems. On one hand, Kibera's greatest problem is that there is no clean water and sanitation and very limited educational and health care facilities. The issues of poverty are the other factors that cause the people to have a poor quality of life.

The effects of residing in Kibera spill over their local environment and spill out to the bigger urban and national development picture (Kibera as a Physical and Social Entity by putting it in the context of the capital of Kenya and its national surroundings). “The informal economy in Kibera, for instance, serves as a very important part of Nairobi's general economy, being a big supplier of essential goods and services that are not delivered by the formal markets.”[29]Furthermore, the interaction among the social and political sectors in Kibera is sometimes also a mirror of the whole country's situation, for example, problems arising with land tenure, governance challenges the local and central governments face, and policies directed at urban poverty.

IMPACTS

Socioeconomic Impacts:

In Kibera, poverty is high, and there is a lot of unemployment. The majority of people are crammed into substandard living conditions and have poor infrastructure, and also, there is limited access to clean drinking water, proper sanitation, and medical care. However, the community with small side businesses that are mostly informal and under the table: small shops, restaurants, and garage-type stuff for producing things for residents also occupies a place. On top of this, the community is also considered a home to several community-based organizations that basically are working to make certain every person has a quality life, and they also offer an educational chance to everyone.

Health and Education:

One of the main issues of the Kibera community is the shortage of healthcare facilities and their resources. “The high prevalence of communicable diseases, such as cholera and tuberculosis, is exacerbated by poor sanitation and overcrowding.”[30] Educational institutions, while numerous, often suffer from overcrowded classrooms and limited resources. However, local NGOs and international organizations have made significant efforts to address these issues, improving healthcare delivery and educational opportunities.

Cultural and Community Dynamics:

Regarding Kibera's very hard situation, it is surprising that Kibera people are known to have a very strong community and cultural impression on the whole world. Kibera is open to different ethnic groups, and the place is a center for cultural activities that include music, dance, and art. These shared cultural activities play a very crucial part in promoting the solidarity of the community and thus the resilience of the community. The adaptability and creativity of the local people and their ability to form new governance mechanisms that would relate to the way that informal settlements work while they are yet so organized in the development of their own area.

Kibera before Impacts

This portion of the study will provide an in-depth discussion on the adversities experienced in Kibera, including poverty, high criminality rates, insufficient education, and inadequate housing and facilities.

Poverty

Unemployment and poverty are the biggest concerns of Kibera residents, as the informal settlements harbor a “50% unemployment rate. In comparison, the opposing 50% employed portion of the population makes only about \$1-\$2 dollars a day”[31]. Staggering states of poverty mean that most residences are unable to afford basic healthy and day-to-day necessities.” Part of Kibera’s workforce gathers income by setting up roadside shops and cleaning houses. However, these jobs only generate an income of 50 cents, fostering incentives for quick and easy money sources, including waste dumping and illegal logging.”[31] The job scarcity is primarily driven by social stigma developed against the slum, presenting very few work opportunities for its residents outside of the slum. Kibera also faces problems of gender inequality, as female-headed families were shown to face higher rates of poverty.

High criminality rates

Poverty and low income are the main driving forces for the significantly large number of criminal activities within Kibera. In order to support their families, residents undertake illegal businesses, including selling illegally-obtained wood from tree cutting and selling drugs and alcohol. Lack of education and job opportunities also force the youth into prostitution and drug use at a young age for income.” Lack of employment also contributes to early morning drinking, which causes problems of violence, crime, and rape. 98.8% of crime survey respondents conducted by the Security Research and Information Centre (SRIC) with support from the Government of Kenya and UNDP Kenya reported witnesses of crime committed during the duration of the study.”[34]

Insufficient Education

There are no public schools in Kibera, with a population of uneducated youth comprising 43% of the female youth and 29% of the male youth. Poor living conditions for the youth cause those who are not engaged in school through 8th grade to find themselves engaged in a cycling culture of drugs, alcohol, violence, and rape, which causes young females to leave school due to teenage pregnancy. Young girls face fewer opportunities for education in Kibera as gender discrimination undermines the importance of educational rights for women and forces young girls to become youth mothers or child brides.

Inadequate Housing and Facilities

The land resided by the residents is owned by the government. Only 10% of the population are shack owners, with some of these owners renting their shacks out to tenants. The remaining 90% are tenants with no rights. “An average shack measures 12 by 12 feet and is built out of mud on a dirt or concrete floor with a tin roof. A shack charges a monthly rent of 700 KES and houses about 8 or more people that often sleep on the floor.”[31]

“Only 20% of Kibera has electricity, with a majority of the slum relying on unsafe and poor-quality electricity. While UN-Habitat is working to provide electricity access to other portions of Kibera, this access is still deemed unaffordable, driving the residents to purchase illegal connections from local cartels. There is also little to no water access in the slum, with



many residents still relying on water from the Nairobi Dam”[31][36], whose unclean waters cause illnesses such as typhoid and cholera. The Kibera slums do not have toilet facilities. Rather, they make use of a latrine—a hole on the ground that is used by 50 shacks, then is emptied of its contents, which are dumped in the river. Even though the degraded environment in Kibera continues to breed multiple illnesses, there are no government clinics or hospitals within the informal facilities. Low income and poverty mean that its residents are unable to afford proper treatment and basic medicine; their medical facilities are centralized solely on charitable organizations. However, the population is encouraged to take a free HIV test and even take free ARV medicine.

Kibera during Impacts

This study will dive deeper into these challenges, which include poverty and unemployment, poor basic facilities, limited education, gender discrimination, and low mortality rates.

Poverty :

Studies report that people living in Kibera only earn money equivalent to about 1-2 dollars a day. On top of that, the government owns the land, with only 10% of the population being shack owners and the rest 90% living their lives as tenants with no rights. Since Kibera is located near an industrialized area in Nairobi, up to 50% of the workforce is employed where they perform unskilled jobs. However, the other 50% are still unemployed. They do find ways to do informal jobs, like selling everyday items like food or running small services like hair salons, though this contributes very little to their earnings.

Poor facilities:

People living in Kibera also have to deal with poor facilities. “About 20% of Kibera has access to electricity, and a lot of the power comes from illegal practices like tapping it from the city grid. Until a couple of years ago, people had to use the water from the Nairobi dam”[30], which was really unhygienic and caused diseases like cholera and typhoid. Two pipelines have now been built, through which people can access water by paying 3 shillings for about 20 liters(about 5.3 US liquid gallons). “Due to high costs, illegal taping takes place for accessing water as well. However, the tapping points are not constructed properly”[37], resulting in sewage often entering these pipes. Sanitation and sewage are other problems that the public faces. About 50 shacks share one hole in the ground (called a latrine) to defecate. After these holes are full, they are discarded into the river. Public toilets are paid and unsafe to use during the nighttime. A common method people use due to these restrictions is that they defecate in plastic bags and throw them into different areas in the streets. These plastic bags are also referred to as “flying toilets.

Education:

On any given day, only about 40% of children in Kibera have the ability to go to school. A common reason for this is once again cost. Basic education tuition plus school supplies, uniforms, and other materials can cost a lot. An average worker is typically a parent of 4 children, earning around 3000-9000 shillings per day. Even as low as Grade 5, the cost for the education of the children in the typical household would be about 7700 shillings. Oftentimes, older siblings have to sacrifice their education to help earn for the family. Plus, gender inequality

is also present in Kibera. It is said that educating girls is a “waste of money” and prioritizes male children over females when there is not enough money to educate everyone. The girls who do have a chance to go to school often miss school when their menstrual cycle takes place since proper facilities are not provided for them.

However, typically girls are expected to take care of their household and their family. They often have to marry when they are young and become mothers at that age. There is still a lack of awareness on how to use condoms safely, resulting in many young girls ages 16–25 having unwanted pregnancies. The only solution to this is abortion, which can be very dangerous in Kibera.

Low Mortality Rate:

In Kibera, the average age is 30 years. This is due to the wide spread of infectious diseases and the lack of basic facilities like clean water and proper healthcare. Diseases like malaria, typhoid, measles, intestinal worms, cholera, tuberculosis, dysentery, meningitis, and HIV/AIDS are common in Kibera.

Kibera after Impacts

This paper will discuss the impacts of the Kibera after the impacts. The results of these impacts include challenges faced by the residents, the government’s response to the effects, the community’s strong resilience and determination, and improvements for the future.

Impacts that continue to challenge the residents:

The Kibera slum in Nairobi, Kenya, has faced severe environmental and social challenges even after significant interventions. An article describing the slums of Kenya explained that the “workers in Kenya are working on issues that range from human rights to maternal health to conservation” [35]. The ongoing challenges in Kibera remain daunting, with residents still grappling with limited access to essential services, inadequate infrastructure, and persistent poverty despite past attempts at intervention. Despite the money donated to Kibera, people live with less than 1 dollar a day even after 30 years of the impact.

“Despite the challenges that have come with these impacts, Kenyan residents remain resilient and determined to overcome them in the future. The Kibera community has demonstrated remarkable resilience despite persistent challenges as residents continue working tirelessly to improve their living conditions and access essential services.”[32] Despite limited resources and ongoing hardships, the Kibera community has demonstrated remarkable resilience despite persistent challenges, as residents continue working tirelessly to improve their living conditions and access essential services. The Kenyan government has also stepped up efforts to address the long-standing issues in Kibera, implementing new policies and initiatives to improve the residents’ infrastructure, service delivery, and economic opportunities.

Some ways that the impact has implemented better things for the future include net positive population growth. Urbanization is growing, and people are slowly transitioning from the slums to the cities. “More than 34% of Kenya’s total population lives in urban areas, and of this, more than 71% is confined in informal settlements” (UN-Habitat, 2009) Kenya’s average settlement rate is 5%, which will continue to improve as the years go on. Additionally, improved

sanitation and access to clean water have helped reduce the spread of waterborne diseases.”[33]

Health:

The health condition has improved over the years. While the residents of the Kibera slum in Nairobi, Kenya, continue to face significant challenges, such as limited access to essential services and persistent poverty, the community has demonstrated remarkable resilience and determination to overcome these obstacles. Despite the daunting challenges, the resilient Kibera community remains resolute in its efforts to secure a better future. The sanitation has also improved over the years, along with the health conditions. The journey towards a better future for the Kibera community remains arduous, yet the resilience and determination of its residents continue to inspire hope for meaningful, lasting improvements. The resilience and determination of the Kibera community, combined with the Kenyan government's increased efforts, provide a glimmer of hope for a brighter future where the residents can access essential services, improve their living conditions, and break the cycle of persistent poverty. The residents of Kibera continue to display an unwavering spirit, channeling their collective resilience to drive incremental yet meaningful progress, even in the face of daunting challenges. The residents of Kibera have shown remarkable fortitude in the face of ongoing adversity, demonstrating a deep-rooted determination to forge a better future for their community.

Education:

The education in the Kibera community has also seen improvements in recent years. Despite the persistent challenges, the resilience and determination of the Kibera community continue to inspire hope for a brighter future. The Kibera community's enduring resilience and the Kenyan government's renewed efforts have paved the way for gradual yet meaningful progress, instilling hope that the residents' access to essential services, living conditions, and economic opportunities will continue to improve in the years to come. Despite the daunting obstacles, the Kibera community's indomitable spirit and unwavering commitment to progress have fueled incremental yet meaningful improvements in education, sanitation, and healthcare within the slum.

Introduction to Kivalina

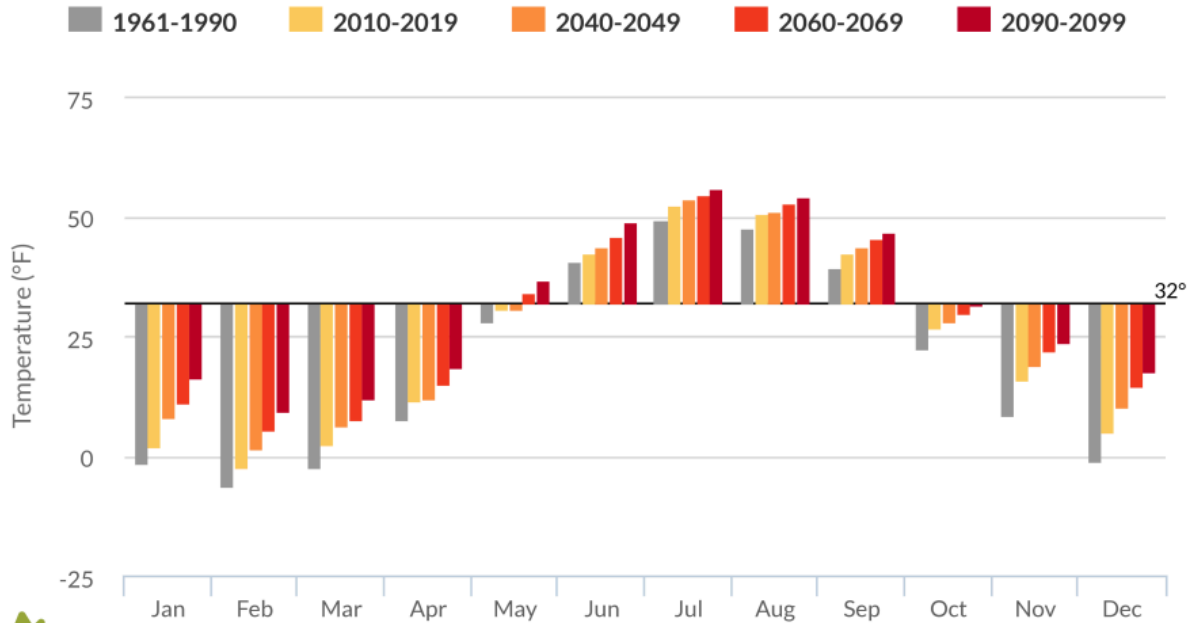
Kivalina, a small Inuit village located on a barrier island off the northwest coast of Alaska, epitomizes climate change's severe and multifaceted impacts on marginalized communities. Historically dependent on a subsistence lifestyle, Kivalina's residents have witnessed unprecedented environmental changes over the past few decades. Rising temperatures have led to the thawing of permafrost, coastal erosion, and diminishing sea ice, which are critical for their traditional hunting and fishing practices. A 2020 study by Bronen and Chapin highlights how these changes have exacerbated the community's vulnerability, noting that the lack of sea ice has not only made hunting more difficult but has also increased the risk of storm surges, threatening the very existence of the village.



Moreover, the physical impacts of climate change in Kivalina are compounded by socio-economic and political challenges. According to a 2021 report by the U.S. Government Accountability Office, Kivalina's efforts to relocate to a safer area have needed more funding and bureaucratic hurdles [38]. This situation underscores the intersection of environmental and social inequities, as marginalized communities like Kivalina often lack the resources and political clout to respond to climate threats effectively. Climate adaptation strategies must prioritize the unique needs and circumstances of indigenous and marginalized populations to mitigate disproportionate impacts and support resilient futures.

Average Monthly Temperature for Kivalina, Alaska

Historical CRU 3.2 and 5-Model Projected Average at 10min resolution, Mid-Range Emissions (RCP 6.0)



Due to variability among climate models and among years in a natural climate system, these graphs are useful for examining trends over time, rather than for precisely predicting monthly or yearly values.

IMPACTS

1. Erosion and Rising Sea Levels:

Kivalina is losing land to severe coastal erosion and rising sea levels, with the village expected to become uninhabitable within a few decades. The delayed formation of protective sea ice in the fall and its earlier melt in the spring expose the island to damaging storm surges and wave action. [39]

2. Thawing Permafrost:

Warming temperatures are causing the permafrost underlying Kivalina to thaw, leading to ground subsidence and increased flooding risk. This destabilizes buildings and infrastructure, threatening homes, roads, and the water and sanitation systems.

3. Threat to Traditional Livelihoods:

Changes in sea ice patterns and the warming climate disrupt the availability of marine mammals, fish, and other wildlife critical for subsistence hunting and fishing. This not only threatens food security but also undermines the cultural practices and identities of the Inupiat people.

4. Health and Well-being:

The combination of erosion, flooding, and permafrost thaw leads to contamination of drinking water sources, increasing the risk of waterborne diseases. Additionally, the stress and

uncertainty of potential displacement contribute to mental health challenges among the residents. [40]

Kivalina before Impacts

Kivalina suffers from Arctic Amplification caused by the sea ice-albedo feedback, which uses greenhouse gases. The permafrost is melting; there is increased coastal erosion and less snow covering ice and land. Seasons for marine organisms have changed, and thus the locals must change their patterns of gathering resources in somewhat unfavorable conditions. A change in weather patterns and an increase in storms are causes of some of these new symptoms. Increased flooding. Ice advance day, the day when snow comes and allows ice to grow, has happened approximately a day later each year.

Amenities like running water and waste management systems are privileges that many cannot imagine living without today. However, one island, Kivalina, thrived without these modern conveniences due to its people's knowledge of the land. Prior to climate change, Kivalina inhabitants relied mainly on the surrounding area for resources. There were certain seasons for whaling, fishing salmon, and collecting eggs; however, these seasons have started to come later and later each year. Some resources, such as sod and wood, from Kivalina were used to build homes to support its roughly 400 inhabitants. The island also hosted important features like permafrost that protected against erosion. Steady weather patterns also kept both animal life and geologic formations on the island predictable. In doing so, inhabitants could better understand when and where animals would be to find food, and they were also better sheltered from strong waves during storms. The consistent nature of these events could be seen as a convenience to the people, as they could prepare for the upcoming events and had a higher survival rate if something were to go wrong. The balance between the inhabitants and the island is the main aspect of Kivalina's culture. If climate change is not stopped, these people will be forced to go elsewhere, and the culture will cease to exist.

Kivalina during Impacts

STORM DAMAGE:

In November 2000, shore ice on the beach of Kivalina was late in forming, the result of unusually warm fall temperatures and a shift in seasons [41]. Usually, shore ice develops by early November and provides a cushion that dissipates the full force of crashing waves. If there is no ice, there is usually icy slush, which reduces the wave energy. But when a storm hit Kivalina in October 2004, there was no natural ice barrier and no slush. The loose sand, gravel, and beach grass met the waves directly, and huge chunks of the coast washed into the sea [41]. The storm damaged the leach (waste water drain) field system for the washeteria. In a community without piped water and sewer, the washeteria provides the only public facilities: three washing machines and three small bathrooms serving a population of 400 residents [41]. As a result of the storm, Kivalina went an entire winter without any public washing facilities. Since the storm, the washeteria has never worked properly, causing more closures as the damaged drain field froze, thawed, and refrozen [41].

DECLINING TRADITIONAL SUBSISTENCE:

Food safety refers to the practice of harvesting, preparing, and storing foods in ways that prevent foodborne illness. Food security means having nutritious foods and not having to live in hunger. In Kivalina, climate change is increasing exposure to unsafe foods and the risk of food insecurity [42]. The traditional subsistence lifestyle and diet provide protection against cardiovascular disease, hypertension, type 2 diabetes, stroke, obesity, osteoporosis, and some cancers. Traditional foods provide a wide range of essential micronutrients, including iron and vitamins A, D, and E. The fruit and leaves of Arctic berries contain high levels of antioxidants and may help reduce the incidence of obesity and type 2 diabetes [42]. Northern fish and sea mammals are also high in omega-3 fatty acids, an important anti-inflammatory substance. The percentage of wildlife harvested for subsistence in rural Alaska is about 60% fish, 20% marine mammals, 14% land mammals, 2% shellfish, 2% birds, and 2% wild plants [42]. There are substantial regional differences, but harvest percentages have remained fairly consistent since the 1980s, although the amount harvested has decreased. Climate change is making the harvest of many subsistence species more difficult, either because the season or the conditions have changed or because the wildlife themselves have adjusted their range or the time of their migration. Kivalina residents expressed concerns about the decline in walrus, bowhead and beluga whale, caribou, and trout in the Wulik River [43]. Mortality events, including fish kills, have occurred on several occasions, corresponding with large slumps in the river and high turbidity levels. The population of the Western Arctic Caribou Herd is at about 401,000, down from a record high of 490,000 seven years ago [43]. During this period, wildfires have increased, and destruction of lichen on winter grazing land may be one explanation for the caribou decline. Climate change is expected to dramatically alter the species that are available for harvest in the Arctic coastal plain and the coastal marine environment. As temperatures rise, methods for traditional food preparation and storage are less likely to prevent pathogens that cause illness. Just as the useful period for ice cellars has shortened, so also has the period when fish, seal, and caribou can be preserved on drying racks [43].

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