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Urbanization and Environmental Challenges in Sahelian Cities: The Case of Niamey, Niger Republic

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Abstract

Population growth and rapid urbanization in Niamey are placing increasing pressure on the urban environment. These pressures result in a multitude of environmental problems that affect both people and ecosystems. This study aims to identify the main environmental problems in the city of Niamey, their severity, their sources, their impacts, and adaptation strategies. A household survey was conducted on 625 households across Niamey's various municipal districts. The data was analyzed and processed using the R software. In total, eight (8) problems were identified, including air pollution, water pollution, the proliferation of solid waste, urbanization, lack of green space, flooding, loss of biodiversity, and sand encroachment. Air pollution was the problem most frequently cited by households (20%), followed by the proliferation of solid waste (16%) and water pollution (12%). The results show that the problems vary by municipal district, with AC I and AC II affected by air pollution, AC III by solid waste, AC IV by water pollution, and AC V by flooding. An analysis of environmental issues highlights the vulnerability of the city of Niamey and underscores the need to strengthen management measures.

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Introduction

Global population growth has been accompanied, over the past few decades, by unprecedented urbanization, making it one of the main drivers of contemporary socioeconomic and environmental transformations. In 2007, the global urban population reached approximately 3.3 billion people, or nearly 50% of the total population, marking a historic turning point when, for the first time, the number of urban dwellers exceeded that of rural residents [1]. Henceforth, this trend has continued at a steady pace. In 2024, nearly 58% of the world's population corresponding to approximately 4.7 billion

people lived in urban areas [2]. United Nations projections indicate that this proportion will reach nearly 60% by 2030 approximately 5 billion people and then 68% by 2050. This growth will be concentrated primarily in low and middle-income countries, particularly in Africa and Asia, where a combination of strong population growth, rural-to-urban migration, and economic transformation is accelerating urbanization. At the same time, the land area occupied by cities is projected to reach nearly 5.8 million km² by 2030, leading to increasing land development, ecosystem fragmentation, and greater pressure on natural resources [3].

Beyond its economic and social impacts, this rapid urbanization is also one of the main drivers of environmental degradation worldwide. Pressure on natural resources, increased air, water, and soil pollution, rising waste production, biodiversity loss, and the effects of climate change now pose major challenges to sustainable development. These -environmental problems, exacerbated by human activities in urban areas, threaten not only the functioning of ecosystems but also the health, safety, and well being of populations [4] [5] [6] [5]. Since the last third of the 20th century, these concerns have taken central stage on scientific and political agendas due to their scale, complexity, and interconnections.

Niger is also concerned about accelerated urbanization. Since independence in 1960, the country has experienced continuous growth in its urban population. Its urbanisation is characterised by the combined effects of strong population growth, internal migration, and the expansion of urban centers. In 1960, the urban population was estimated at approximately 196,000, representing 5.7% of the national population [7]. This proportion rose to 16.2% in 2014 nearly 2.78 million people before reaching approximately 4.60 million people in 2023, corresponding to nearly 17% of the total population [8]. Although Niger's level of urbanization remains below the global average, its growth rate is among the highest in the Sahel region. This trend is reflected in the rapid expansion of built-up areas and increased demand for infrastructure, housing, drinking water, energy, and urban services, while also intensifying pressure on natural resources and ecosystems. Niamey, the largest city of Niger, the political and economic capital is a prime example of these transformations.

Its sustained population growth is driven by both high natural birth rate (5.3 children per women) and by rural migration. The later is a result of recurrent drought, the degradation of agricultural land, and the effects of climate change [9] [10] [11]. Consequently, this trend may lead to and inadequately planned urbanization. This is accompanied by the expansion of outlying neighborhoods, sometimes outside any regulatory framework, exacerbating difficulties in accessing housing, drinking water, sanitation, transportation infrastructure, health and education services, and community facilities [12]. However, while population growth contributes to intensifying pressures on the environment, it is not the sole cause of environmental degradation. This degradation results from a complex interaction between patterns of land use, resource

management practices, shortcomings in urban planning, and the limitations of environmental policies.

The multidimensional and interdependent nature of these problems makes them particularly complex to understand and calls for integrated approaches to effectively guide public policies for sustainable urban development.

From this perspective, a systematic characterization of the main environmental problems in the city of Niamey appears essential. Such an approach will make it possible to strengthen scientific knowledge on urban environmental dynamics in Niger and provide decision-making tools for more sustainable urban management. It is in this context that this study was undertaken to establish a typology of the main environmental issues affecting the city of Niamey. More specifically, the study aims to: (i) classify the main environmental problems affecting the city; (ii) analyze their sources and severity; (iii) assess the Citizens' perception related to their impacts; and (iv) identify the adaptation and management strategies implemented by various stakeholders to mitigate their effects.

Materials and Methods

Study Area

The city of Niamey is located in western Niger between 13°20' and 13°35' north latitude and between 2°00' and 2°15' east longitude and is defined by Ordinance No. 2010-54 of September 17, establishing the General Code of Local Governments of the Republic of Niger. It covers an area of 393.3027 km² and is bordered to the south by the canton of Lamordé, to the north by the canton of Hamdallaye, to the east by the canton of Liboré, and to the west by the canton of Karma (Figure 1). Due to its geographic location, it is divided into two parts by the Niger River: the left bank and the right bank. The left bank is home to most of the city's development, comprises the four (4) municipal districts (ACN1, ACN2, ACN3, and ACN4), and includes ninety (90) administrative neighborhoods and thirty-seven (37) affiliated villages and tribes [8]. The main economic activities of households in this city are agriculture either rain-fed or irrigated, livestock raising, fishing, forestry, and trade [14].

The climate in the Sahelian region is semi-arid, characterized by an average annual rainfall of 550 mm and monthly temperatures ranging from 32.5°C in January (the coolest month) to 40.9°C in April (the

hottest month) [15]. The city has only one rainy season per year, from May to September. Niamey is characterized by a diverse landscape consisting of plateaus, sandy terraces, and valleys.

The city's vegetation consists of private plantations and areas in the Niger and Gouti Yéna valleys. There are also trees along the roadsides, remnants of green belts, and a few public spaces [13].

Sampling

The choice of Niamey is justified by the fact that it is experiencing rapid growth, similar to other major African cities. With a birth rate of 5.3 children per woman, its population has increased 34-fold, rising from approximately 30,000 inhabitants in 1960 to 1,633,000 in 2026 demonstrating its demographic significance in the country's urbanization [8]. This has led to accelerated environmental degradation, which is becoming an increasingly serious concern. The city is cosmopolitan, as all of Niger's ethnic groups are represented including the Hausa, Zarma-Sonrai, Fulani, Tuareg, Kanuri, Gourmantché, and Toubou. The city of Niamey has 169,154 households [8].

The sampling method used is random and stratified. It thus covers all municipalities of Niamey across administrative districts and administrative villages to ensure a diverse range of respondent profiles. To determine the number of households to be interviewed in the five municipal districts, Slovin's formula (1960) was applied. It is expressed as follows:

$$\frac{N}{(1+Ne^2)}$$

Slovin's formula: $n = \frac{N}{1+Ne^2}$ Where n = expected sample size; N = total number of households; e = margin of error (4% was used). Thus: $N = 169,154$; $e = 0.04$.

The questionnaire was thus administered to 625 households selected at random from the population. 125 households per municipal district. For each municipality, the surveys covered 75% of the neighborhoods and 25% of the administrative villages. The neighborhoods and villages selected by municipal district are listed in the following table 1.

Data Collection

The socio-anthropological survey was conducted to gather the necessary data. Survey data were collected

using a questionnaire consisting of both closed-ended and open-ended questions in the city of Niamey. The survey form used consists of three (3) main sections. The first part focuses on the sociodemographic characteristics of the respondents, including gender, age, sex, educational level, occupation, marital status, and profession. These elements provide a better understanding of the characteristics of the surveyed population. The second part of the questionnaire addresses the identification of environmental problems observed by the population as well as an assessment of their severity. This section aims not only to highlight the various sources of these problems and their impacts. The third part of the questionnaire focuses on the inequalities experienced by the population of Niamey. It helps identify the vulnerability factors faced by the population as well as the coping strategies used to mitigate their effects. The survey was conducted using the OpenDataKit (ODK) software on smartphones in local languages and in French.

Data Processing and Analysis

The data were analyzed using the R software package. A univariate analysis, based on counts, frequencies, and percentages, was used to describe the characteristics of the respondents and the environmental problems they perceived. A multiple component analysis (MCA) was then conducted to explore the associations among the categories of the qualitative variables. The results were supplemented with Sankey diagrams to represent the causes and consequences of environmental problems and bubble charts to facilitate the visualization of the relationships and severity of the problems.

Results and Discussion

Identification of Major Environmental Problems in the City of Niamey

Among the eight environmental problems identified by the population across the city of Niamey, air pollution ranks first, with an intensity of 8 and a frequency of 20%. The following figure provides an overview of waste burning in the city of Niamey.

It is followed by the proliferation of solid waste, which has an intensity of 7.8 and a frequency of 16. The third place in the ranking is occupied by water pollution, with an intensity of 7.5 and a frequency of 12%. Urbanization (6.2; 12%) and flooding (5.8; 10%) are considered moderate problems in the city of Niamey while lack of

green spaces (5.5; 8%) and sand encroachment (4.5; 4%) are perceived as the least severe problems in the city of Niamey (Figure 2).

Environmental problems vary from one municipality to another (Figure 3). However, the major problems in terms of intensity and frequency are mainly related to pollution. Thus, in Municipal Districts I and II, air pollution (intensity: 8; frequency: 20%) represents the most significant environmental problem. In Municipal District III, the main issue is the proliferation of solid waste, which records the highest intensity (8.7) and a frequency of 20%. In Municipal District IV, water pollution is the main concern, with an intensity of 7.5, followed by the proliferation of solid waste, which has an intensity of 7 and a significant frequency. Air pollution ranks first in two municipalities and is among the three most frequently cited environmental problems in four out of the five municipalities.

In Municipal District V, flooding constitutes the major environmental constraint, with an intensity of 8 and a frequency of 20%. Flooding is also cited among the most frequent environmental problems in four municipalities (II, III, IV, and V), with a frequency above 10% and an intensity greater than 6.

Regarding sand encroachment, it is the least frequently reported problem, along with the lack of green spaces. These issues are among the least cited environmental problems in Municipal Districts IV and V. Unplanned urbanization recorded the highest frequency in Municipal District IV.

Relationship between Various Environmental Issues and Sociodemographic Parameters

Perceptions of environmental issues vary according to the sociodemographic characteristics of respondents. The factorial plan derived from Multiple Correspondence Analysis (MCA) reveals a configuration of categories around the first two dimensions, which explain 8.6% and 8.2% of the total variance, respectively. The first dimension primarily contrasts young people under 25 and those with secondary and tertiary education who are associated with air pollution and biodiversity loss with older adults (ages 55–64 and 65 or older) and those with primary education, who are more closely associated with waste proliferation and urbanization. This axis thus reflects a differentiation in environmental perceptions based on age and educational level. The second dimension distinguishes young people under 25 who are

associated with sand encroachment and water pollution from adults aged 25–54 of both genders, who are more closely associated with urbanization and flooding. It also reflects differing profiles in the perception of key urban environmental issues.

Sources of Environmental Problems

Figure 6 presents the main sources associated with the environmental problems identified in the city of Niamey. Biodiversity loss is primarily associated with the overexploitation of species, climate change, and land degradation. Air pollution is linked to several sources, including natural dust, road traffic, waste incineration, urban concentration, lack of vegetation, road construction activities, deforestation, and industrial activities. Water pollution is primarily associated with domestic wastewater, agricultural products, and a lack of sanitation. Figure 10 illustrates wastewater observed in certain areas of the city of Niamey. It highlights wastewater discharges and stagnant pools in urban areas, which are manifestations of water pollution and inadequate sanitation.

As for urbanization, it is driven by population growth and rural-to-urban migration. The lack of green space in Niamey can be attributed to land-use pressure and the fact that green spaces are not designated in certain housing developments in the city.

Furthermore, the proliferation of solid waste is primarily due to the scattering of plastic bags and trash, as well as the behavior of the population. Figure 12 illustrates the proliferation of solid waste observed in certain areas of the city of Niamey. It highlights the accumulation and scattering of waste in urban areas, reflecting the challenges associated with its collection, management, and disposal.

As for flooding, it is mainly caused by rising groundwater levels and heavy rains. Finally, the main causes of sand encroachment are deforestation and seasonal winds.

Impacts of Environmental Problems in the City of Niamey

Just like their causes, the impacts of environmental problems are diverse and multifaceted. For example, the loss of biodiversity leads to soil erosion and the disruption of ecosystems. The lack of green spaces results in rising surface temperatures and stronger winds.

As for air pollution, its impacts include respiratory problems, throat irritation, eye irritation, and fires. Water pollution, meanwhile, causes the destruction of aquatic biodiversity and an increase in the mosquito population. Furthermore, urbanization exerts growing pressure on land and also contributes to insecurity. The proliferation of solid waste, for its part, leads to health problems, the degradation of the urban landscape, and soil contamination. Floods result in the loss of human life and the loss of arable land. Finally, sand encroachment leads to a reduction in the river's navigability. All of these impacts are illustrated in Figure (13) below.

Adaptation Strategies in Response to Environmental Problems

In response to the environmental problems identified in Niamey, the surveys proposed various adaptation strategies, combining preventive and corrective measures. The main strategies are summarized in Table 2 and include, in particular, awareness-raising, reforestation, improved sanitation, waste management, the creation of green spaces, and the strengthening of flood protection infrastructure. However, strategies vary depending on the issues at hand. Biodiversity loss is linked to species conservation, sustainable management of fishery resources, ecological restoration, and reforestation. Air pollution primarily calls for awareness campaigns, a reduction in waste incineration, and the development of green spaces. Water pollution mainly requires improvements in sanitation, wastewater treatment, and the dredging of drainage channels. To address the proliferation of solid waste, strategies focus on improving collection, recycling, and increasing public awareness. To address flooding, the main measures involve cleaning and constructing drainage channels, raising levees, and regulating land use in vulnerable areas. Finally, mitigating the effects of urbanization, the lack of green spaces, and sand encroachment relies on urban planning, the creation and development of green spaces, as well as reforestation and the restoration of degraded land.

Perception of Environmental Problems

Analysis of the bubble chart reveals a ranking of Niamey's environmental problems based on the intensity and frequency with which they are perceived. Air pollution emerges as the dominant problem with an intensity of 8 and a frequency of 20%, followed by the proliferation of solid waste (7.8; 18%), and water pollution (7.5; 16%). This ranking is consistent with the

findings of Narcisse (2014) in Yamoussoukro, where air pollution, urbanization, and wastewater were among the primary environmental concerns. In Niamey, these results are set against a backdrop of rapid urban growth and increasing pressure on urban infrastructure and services. Niger's National Urban Environment Strategy (2001) specifically identifies population pressure, flooding, and deforestation as among the capital's main environmental problems. Air pollution is thus one of the main challenges faced [16]. Its high levels can be attributed to the population's daily exposure to dust, road traffic, human activities, and waste incineration. This situation is particularly significant in the Sahelian context, where atmospheric dust constitutes a major component of urban pollution. [17] also highlights the health effects associated with exposure to fine particulate matter. The high level of public awareness of this problem can therefore be explained both by its visible nature and by its perceived health effects.

The proliferation of solid waste the second most significant problem in terms of intensity and frequency reflects the city's persistent challenges in waste management. The work of [13] [18] also underscores the significance of this issue in Niamey. The accumulation of waste in public spaces and its inadequate disposal can further contribute to other environmental nuisances, notably air and water pollution. Water pollution, with an intensity of 7.5 and a frequency of 16%, also reflects the shortcomings of the sanitation and wastewater management systems, as previously noted by [19].

Flooding and biodiversity loss occupy an intermediate position. This situation can be linked to urban expansion, the occupation of vulnerable areas, and the gradual transformation of natural spaces. [20] identify several neighborhoods in Niamey that are particularly vulnerable to flooding. Furthermore, [21] show that Niamey's urban growth is accompanied by a marked differentiation in the landscape structure, between built-up areas and sectors with greater vegetation cover.

Finally, the lack of green spaces and sand encroachment rank lowest in the resulting hierarchy. However, their low frequency does not mean they are of no environmental importance. Green spaces, in particular, play a role in thermal regulation and improving urban environmental quality [22]. Thus, the results primarily reflect a prioritization of issues based on how they are perceived by the population, rather than an absolute measure of their environmental importance.

Urbanization and Environmental Vulnerability

Analysis of the Sankey diagram regarding sources reveals a multitude of phenomena depending on the types of environmental problems. Biodiversity loss stems from the overexploitation of plant species, climate change (CC), and land degradation. In the city of Niamey, the overexploitation of natural resources manifests as increased demand for firewood and unsustainable agricultural practices. These findings are supported by studies by [23], who noted that human-induced deforestation is the primary cause of environmental disruption observed in the form of heat waves, floods, droughts, and strong winds in the city of Niamey. Indeed, the degradation of vegetation cover is a global ecological problem. It has a direct impact on the livelihoods of millions of people, especially the most vulnerable living in the world's arid regions, where more than 500 million hectares of land are degraded [24]. In Niger, the degradation of vegetation cover is a major factor contributing to low agricultural productivity, food insecurity, and poverty [25]. The loss of biodiversity has far-reaching consequences in the city of Niamey, chief among them being soil erosion, ecosystem disruption, and rising temperatures.

Air pollution stems primarily from natural dust, road traffic in various neighborhoods, and the incineration of waste at landfills and health centers. It is also linked to high urban density, which generates household dust; the lack of vegetation in certain areas of Niamey; road construction projects underway throughout the city; as well as deforestation and industrial activities. However, these findings are consistent with those of [26], who states that in African cities, pollution from toxic gases results primarily from motor vehicle traffic, domestic fires, and, to a lesser extent, industrial emissions. Traffic related emissions are responsible for significant pollution in various African capitals. The consequences of air pollution are primarily health related. They cause various illnesses, respiratory problems, eye problems, throat irritation, eye discomfort, and fires. As for the lack of green spaces in the city of Niamey, this leads to rising temperatures as well as a loss of biodiversity. These green spaces serve as windbreaks and constitute an ecosystem that preserves biodiversity. This situation is evidenced by the heat felt throughout the city, especially during the months of March and April, which confirms the importance of these green spaces in an urban setting. The city's green spaces face threats, whether from municipalities due to various housing developments or from residents who engage in excessive logging within

these areas [27]. In addition to these threats, Niamey is experiencing unprecedented demographic and spatial expansion, which is degrading forested areas, biodiversity, and the well-being of the population [13]. Although laws and regulations regarding the management of green spaces, sanitation, and waste management exist, not all of them are enforced, and they lack supporting measures, resulting in the shortcomings observed in these areas. The following photo provides a glimpse of an instance of waste burning in the city of Niamey.

As for the proliferation of solid waste, it is primarily linked to behavioral factors, as well as to the use and exponential spread of plastic bags in the city of Niamey. These bags are taking over the entire city, leading to a deterioration in the aesthetics of the landscape and ecosystems. Indeed, waste in Niamey comes from a variety of sources. In addition to household waste, waste originates from hospitals, prisons, factories, and businesses in the city and is improperly disposed of throughout the city [28]. Regarding the waste problem in Niamey, it is worth noting a clear correlation between rapid population growth in urban areas and the lack of an appropriate waste management policy [29]. In fact, residents are exposed to nearby landfills, open ditches, and undeveloped land. This waste creates an environment conducive to the proliferation of germs responsible for all kinds of diseases and infections (such as tetanus), as well as arthropods (flies, mosquitoes) and rodents [14]. The following photos provide an overview of the landfills and residents' exposure to waste in the city of Niamey.

The proliferation of waste in the city has a negative impact on human and animal health and on the environment [30]. [18] cited malaria as the primary disease caused by the proliferation of waste. Waste leads to groundwater contamination, degrades air quality, and causes odor nuisances.

In fact, the situation in Niamey is that of a city that is more or less unsanitary due to the behavior of the population as well as the meager resources made available to the departments responsible for the city's waste management. Several neighborhoods are not served by regular waste collection. There are not enough trucks or collection centers, resulting in a significant portion of waste being left in the city in gutters, on streets, and so on [30]. Furthermore, there is a clear imbalance between waste production and waste management, as this waste is a major source of pollution

in the city. In reality, the current proliferation of waste in Niamey is linked to rapid population growth. The population of Niamey relies heavily on the use of plastic bags. These ubiquitous bags pollute the entire city despite the enactment of laws regulating their use. The consequences of the proliferation of solid waste in the city are as varied as they are numerous. It leads to soil contamination, unsanitary conditions in the city, the spread of disease-carrying mosquitoes, and the degradation of the city's landscape.

With regard to water pollution in the city of Niamey, it is primarily caused by the discharge of domestic wastewater, agricultural runoff, a lack of sanitation, and, above all, inadequate sanitation infrastructure. Finally, the wastewater problem is exacerbated by the lack of storm drains throughout the city. Studies by [31] show that wastewater falls into several categories: domestic and similar wastewater from residential homes, barracks, schools, prisons, public and private office buildings, commercial establishments, and any facilities or activities in the informal sector. More than 80% of this domestic wastewater is discharged onto the ground and onto roads. Around water bridges, laundry runoff generates wastewater that is discharged there. In addition, there is industrial and similar liquid waste from industrial facilities and health care facilities, etc.

Most of these and other types of liquid waste are discharged into the environment due to a lack of adequate treatment facilities. According to [32], the proliferation of small industrial facilities located a few kilometers from the Niger River has contributed to an increase in wastewater production, the management of which poses significant environmental problems in the Niamey Urban Community (CUN). This wastewater originates from domestic and industrial activities. Physicochemical analysis reveals that this wastewater is heavily polluted. Furthermore, according to [33], the Niger River is the primary recipient of wastewater discharges from the city of Niamey, the capital of Niger, originating from industrial, domestic, hospital, and agricultural activities. The major problem with this wastewater is that it is partially discharged into the Niger River without prior treatment. In fact, industrial, urban, and hospital wastewater is discharged at various locations throughout the city of Niamey and then drained directly into the river without any treatment [28].

Nevertheless, water pollution leads to the destruction of aquatic biodiversity and contributes to an increase in the mosquito population in residential areas. Wastewater has

a direct impact on public health because it pollutes surface water and groundwater. In fact, wastewater contains plastic particles, microbial pollutants, and traces of medications that can threaten water safety, food security, and human health [34]. Whether it is the rainy season or not, Niamey's neighborhoods face wastewater that is a source of disease and detracts from the neighborhood's appearance. In fact, in Niamey, waste management (both liquid and solid) stems from a behavioral issue. Wastewater is discharged either directly onto the streets or into storm drains [28]. Wastewater in the city of Niamey comes from domestic (household), industrial (agri-food), and stormwater sources [35].

As for urbanization, the main cause is rapid growth. Indeed, in identifying the causes of environmental problems, the lack of green space stems from the fact that it is not included in the city of Niamey's land use plan. This shortage is further exacerbated by land-use pressure and population growth. In reality, unoccupied spaces are scarce in Niamey, and the city's boundaries are encroaching on neighboring municipalities. This situation has led to intense pressure from developers on land reserves intended for the construction of public facilities and the development of green spaces [18]. However, these green spaces intended for the well-being of the population and the conservation of biodiversity are being subjected to so called "modern" developments by the wealthiest residents, under the watchful eye of the authorities. This situation is similar to that of the Niamey city belt, which is currently the subject of several controversies. Houses and buildings already constructed in this area are currently being demolished in order to reclaim part of the city's green belt. Today, this ecosystem (the green belt) has become the final destination for nearly all of the city's household waste, a refuge for squatters and criminals, and a dumping ground for all kinds of debris. The pressure exerted by waste on this area is cause for concern, especially since the public and authorities seem to have resigned themselves to accepting this protected zone as a giant garbage dump [36]. It is important to emphasize how vital green spaces are in a city due to their protective role. They help reduce air pollution through the capacity of carbon stocks to sustain biomass [37] [13]. This is consistent with the findings of [38] in the city of Kumasi, which highlight that urban green spaces contribute to climate resilience by improving air quality, reducing heat waves and flood risks, and enhancing health and well-being. Urban green spaces are a strategy for strengthening urban resilience [39]. They play a crucial role in providing solutions to the effects of climate change [40].

Figure.1 Geographical location of the city of Niamey

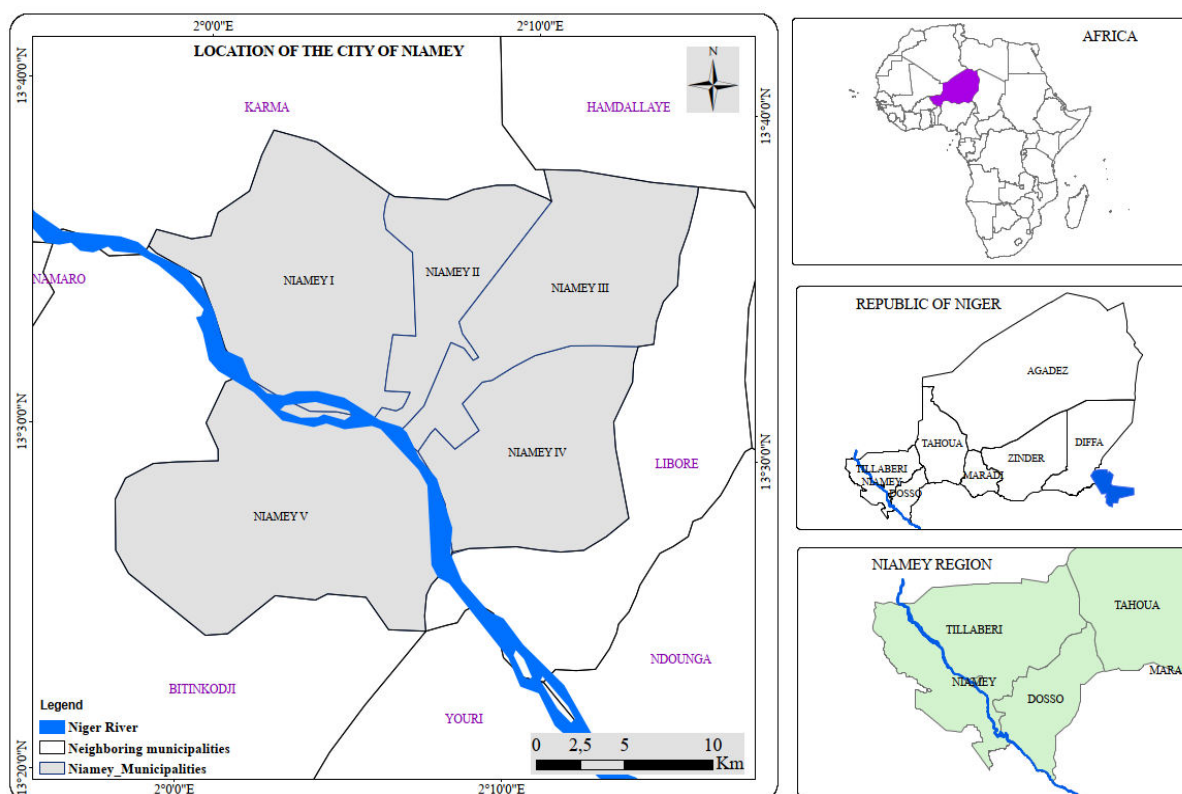


Figure.2 Environmental Problems in the City of Niamey

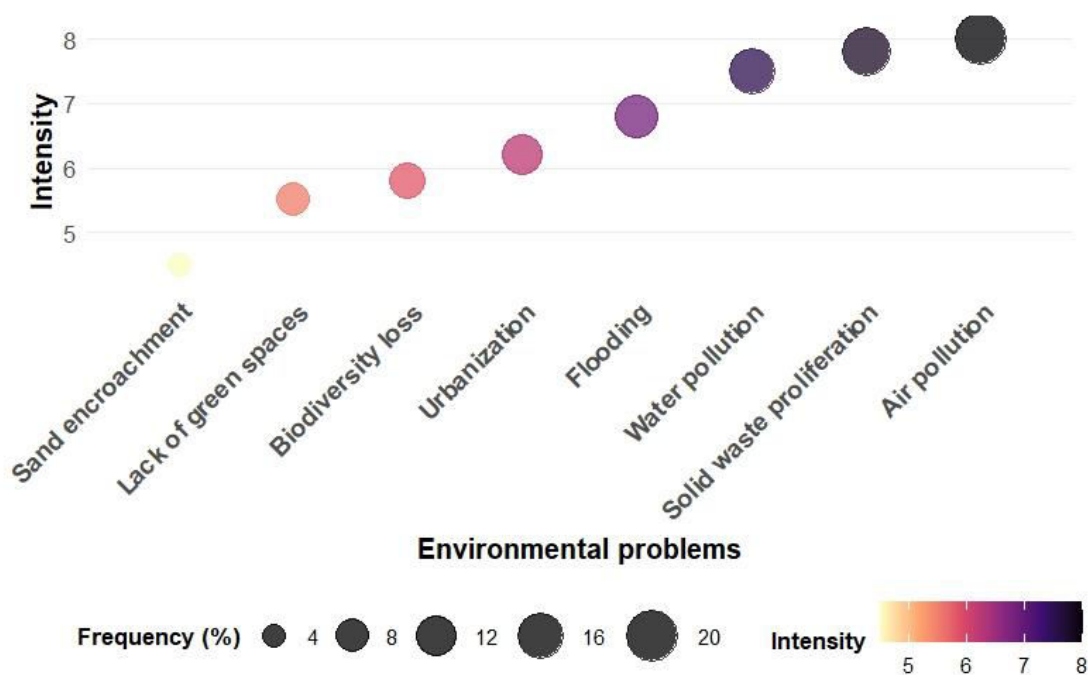


Figure.3 An instance of waste burning in a neighborhood of Niamey



Table.1 List of Neighborhoods and administrative villages by Municipal District

Municipal District	Neighbourhoods	Administrative villages
Municipal District 1	Yantala, Satu, Plateau, Koira kano, Cité chinoise, Bobiel	Gabagoura Lossougoungou
Municipal District 2	Banifandou, Boukoki, Dar es salam, Kalley plateau, Lazaret, Zongo	Gorou Kaina (Alpha Koira) Bossey Bangou château
Municipal District 3	Cite caisse, Cite faycal, Kalley est, Nouveau marche, Terminus, Lacouroussou	Kongou Gorou Kongou Gorou Tourakou
Municipal District 4	Aéroport I, Gamkalley, Route Filingue, Saga, Talladje Est 5o M, Kobontafa	Saga Gorou I Saga Gorou II
Municipal District 5	Banga Bana, Gaweye, Karadje Lamorde Kirkissoye, Nordire	Saguia, Ganguel

Table.2 Key Strategies for Adapting to Environmental Problems in Niamey

Environmental Issues	Key Adaptation Strategies
Loss of biodiversity	Species conservation; sustainable management of fishery resources; ecological restoration; reforestation
Air pollution	Awareness-raising; ban on waste incineration; creation of green spaces and urban parks; reforestation
Water pollution	Wastewater treatment; gutter cleaning; sanitation; improvement of drainage systems
Urbanization	Job creation; public awareness; improvement of urban planning
Lack of green spaces	Creation of new green spaces; development and maintenance of existing spaces
Increase in solid waste	Improvement of waste collection; recycling; increase in drop-off points; public awareness; enforcement of regulations
Flooding	Construction and cleaning of drainage channels; raising of levees; relocation of at-risk populations; control of development in flood-prone areas
Sand encroachment	Reforestation; restoration of degraded land; combating deforestation; and protection against wind erosion

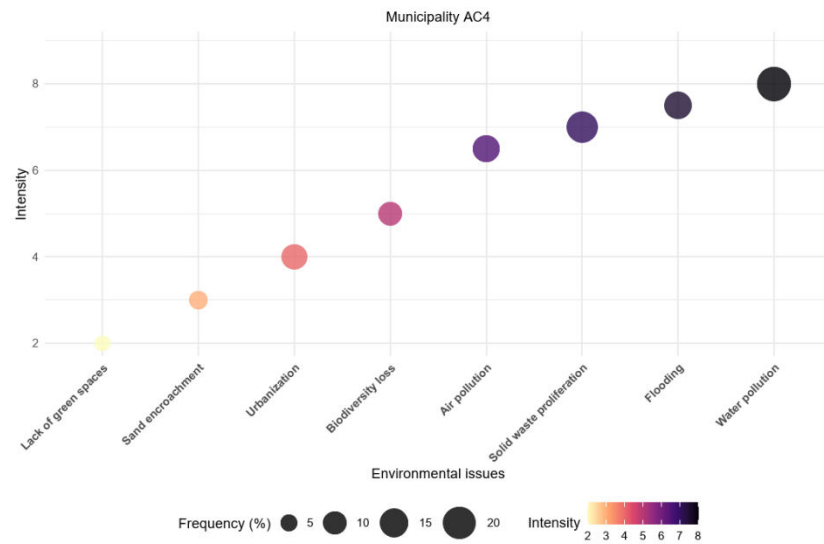
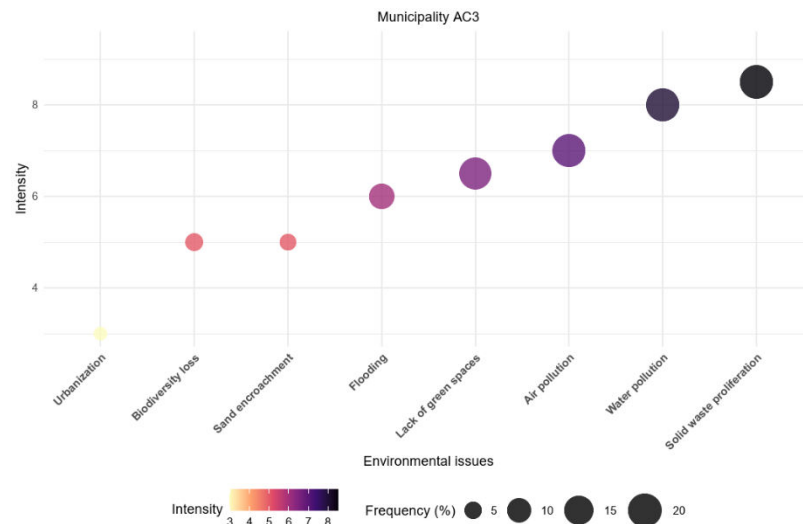
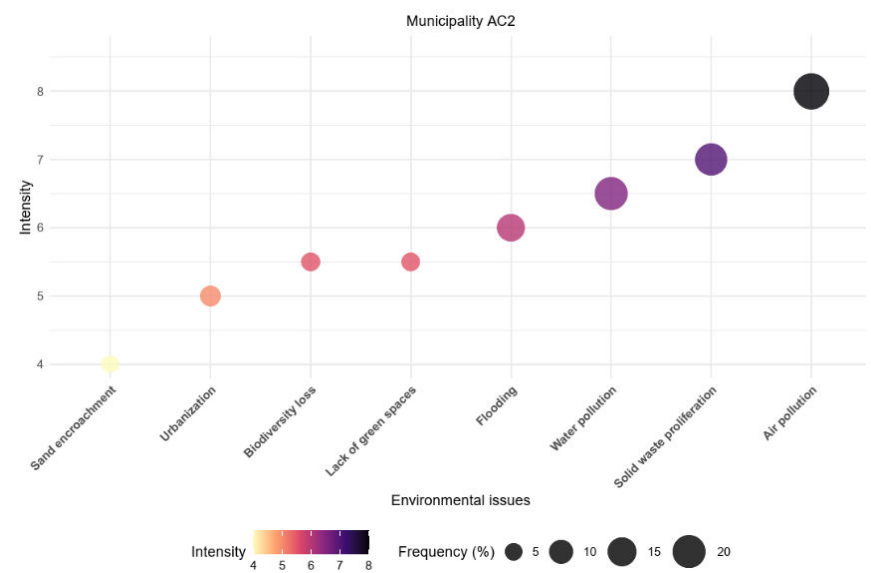


Figure.4Severity and Frequency of Environmental Problems in the 5 Municipalities of Niamey

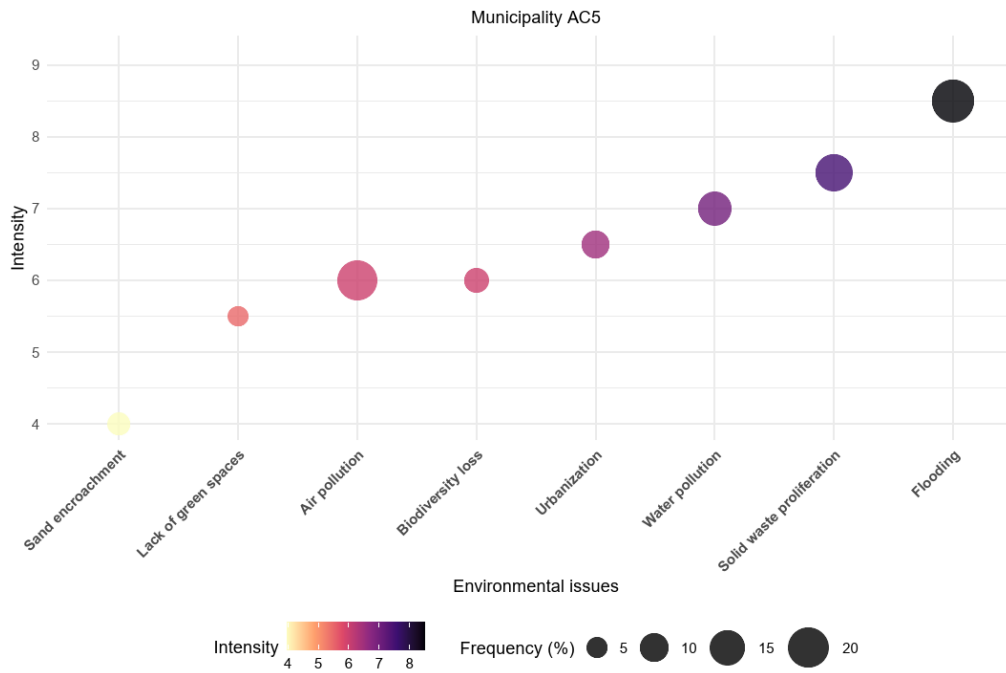


Figure.5 Relationship between environmental issues and socio professional factors

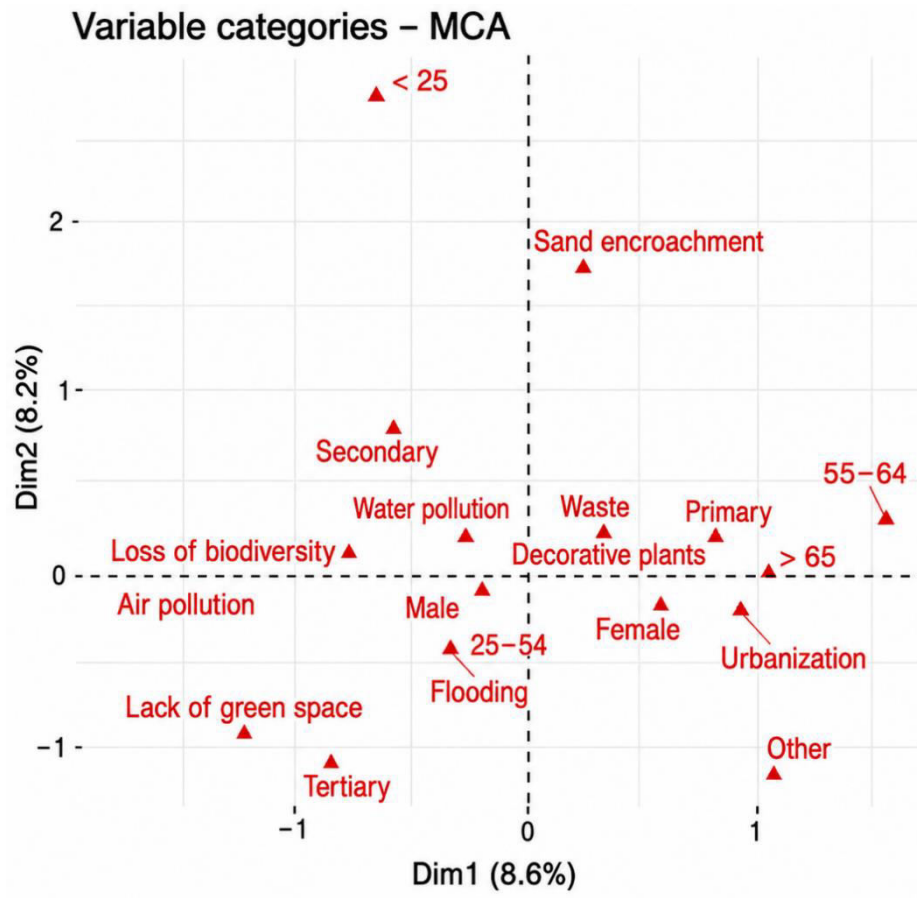


Figure.6 Sewage being discharged in a neighborhood of Niamey



Figure.7 Waste left out in the open in a neighborhood of Niamey (Source: 2025 survey)



Figure.8 Sources of Environmental Problems in the City of Niamey

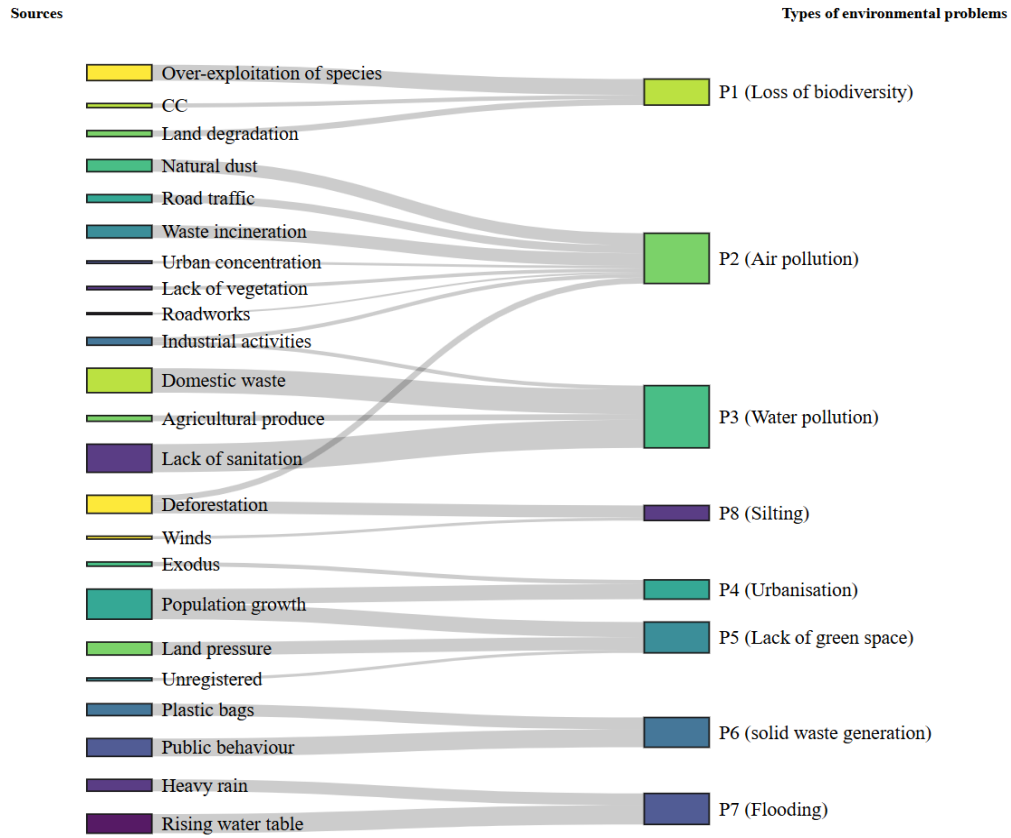
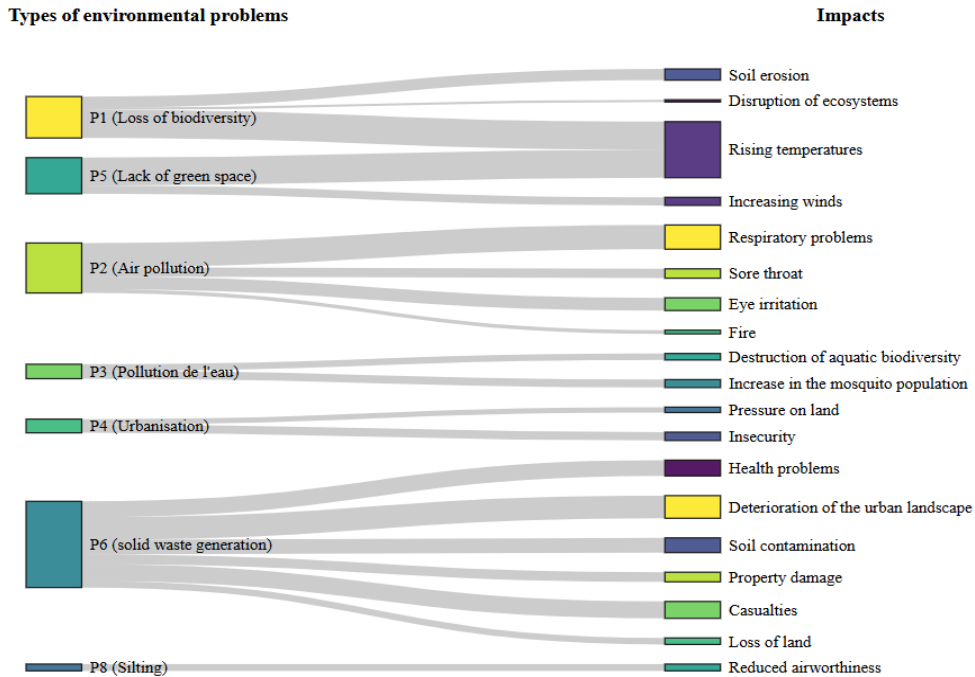


Figure.9 Impacts of Environmental Problems



These benefits, expressed as ecosystem services, reduce the vulnerability of urban communities [41] [42]. Indeed, evidence has shown that urban green spaces, through their services, contribute to climate resilience (Clarke *et al.*, 2019) in the cities of Chicago, New York, and Baltimore (United States), and [43] in European cities.

Floods are caused by climatic phenomena such as heavy rains and rising groundwater levels. This flooding problem is worsening year after year because residents living along the river build or settle on the riverbed or return to their homes which have been destroyed by the floodwaters immediately after the rainy season. Apart from these causes, [44] report that two types of flooding are observed in Niamey. The first, which is gradual, is linked to the river overflowing its minor channel. The second type is described as sudden because it is linked to violent downpours, the effects of which are generally devastating. As for sand encroachment, the causes are deforestation and the winds that occur during hot dry seasons. In this study, the problem with the most direct impact on the population is the phenomenon of flooding. Floods result in loss of life (victims) as well as significant property damage (collapsed homes). Added to this is the loss of agricultural and pastoral lands, which are so vital to the population. All these consequences are often compounded by the refusal of residents living along the river to leave the area and relocate to safer places.

Since sand encroachment is a problem of no less significance in the city of Niamey, its consequences include, among other things, reduced navigability of the river, the burial of roads and gardens, and a reduction in arable land.

Management and Adaptation Strategy

In Niger, particularly in Niamey, the management of environmental problems is based on shared responsibility among the population, local communities, and public authorities. The proposed strategies appear well suited to the identified problems, but their effectiveness depends on the availability of infrastructure, financial resources, institutional capacity, and community participation.

Indeed, in African cities, the lack of infrastructure constitutes a major constraint to the sustainable management of the urban environment [45]. To address the proliferation of solid waste, the proposed strategies include, among others, improving waste collection, sorting, recycling, and recovery. The development of

local initiatives for reuse and recovery can promote more sustainable waste management [46]. However, for these systems to be effective, there must be better coordination among authorities, operators, and the public. [47] thus emphasizes the importance of linking governance, technical resources, and social participation. Community-based systems and the informal sector can also complement municipal efforts, particularly in the collection and recovery of recyclable materials [48]. In the context of Niamey, the awareness campaigns proposed by [13] therefore appear necessary to influence behavior and reduce waste generation and littering. Regarding air pollution, the proposed measures including public awareness campaigns, air quality monitoring, the reduction of emissions from traffic and waste incineration, and the expansion of urban greenery are consistent with the identified sources of exposure. A sustainable reduction in exposure requires, above all, coordinated actions targeting pollution sources, tailored to local realities [49]. Reducing individual exposure may nevertheless be relevant when sources are localized and controllable [50]. From this perspective, the World Bank's guidelines (2021) which focus in particular on reducing exposure to particulate matter and improving air quality reinforce the relevance of these strategies. With regard to water pollution, improving sanitation, treating wastewater, rehabilitating drainage systems, and limiting direct discharges appear to be appropriate measures for Niamey. However, the widespread implementation of sewer systems and wastewater treatment plants may be difficult to sustain when investment and operating costs are high and institutional capacities remain limited (Hutton *et al.*, 2004). Decentralized, phased solutions tailored to different neighborhoods could be prioritized. The recovery and reuse of treated wastewater also represent a promising avenue, provided they are governed by appropriate health and environmental standards [51]. In African cities, wastewater reuse already exists, often in informal forms, underscoring the need for better regulation [23].

The results of this study show that Niamey faces several environmental problems, the most prominent of which at the city level are air pollution, water pollution, and the proliferation of solid waste. However, when analyzed at the municipal district level, each district faces specific and distinct challenges. Niamey's Municipal Districts I and II appear to be particularly vulnerable to air pollution, while Municipal District III is confronted with the proliferation of solid waste. ACN IV is notably affected by water pollution, and AC V faces a risk of flooding. This distribution reflects the combined

influence of anthropogenic, urban, and climatic factors on the capital's environmental conditions.

These issues pose significant challenges to quality of life, public health, and the preservation of ecosystems. In light of population growth and the city's rapid expansion, it is necessary to strengthen prevention and mitigation measures while improving the enforcement of environmental regulations, particularly in the areas of air pollution, water pollution, and waste management. Addressing these challenges is an essential prerequisite for making Niamey a more sustainable and resilient city.

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