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Yahaya Maazou Moussa

Urban green spaces and their contribution to the resilience of the big cities in West Africa: Case of Niamey, Niger

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JURY :

Président :	**Adama Diaw**, Professeur Titulaire, Faculté des Sciences Economiques, Université Gaston Berger.
Rapporteurs:	**Mohamed Ben Omar Ndiaye**, Professeur Agrège, Faculté des Sciences Economiques, Université Cheikh Anta Diop, FASEG/UCAD
	Diatou Thiaw Niane, Maître de conférences agrégé, Faculté des Lettres et Sciences Humaines, Université Cheikh Anta Diop, FLSH/UCAD
	Agbodji Ega Akoété Damien, Maître Titulaire, Faculté des sciences économiques et de gestion, FASEG/Université de Lomé
Directeur de Thèse **:**	**Ibrahima Thione Diop**, Maître de conférences agrégé; University Cheikh Anta Diop UCAD

DEDICATION

- ✓ *This PhD dissertation is firstly dedicated to my late father Yahaya Maazou, my mother Fassouma Baraou, my wife Habiba Adamou, my daughter Maimouna, and to all my brothers and sisters.*
- ✓ *Secondly, i dedicate this dissertation to all my professors from primary school to the universities*
- ✓ *Finally, i dedicate this dissertation to the late director of the Wascal program of UCAD, Pr. Fatou Gueye, and May Allah Grant Her Aljanna Firdaoussi.*

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ABSTRACT

In recent decades, cities in West Africa are becoming large due to the high population growth rate. This urbanization is accompanied by the transformation of the environmental and social conditions affecting the dwellers' livelihoods and well-being, thereby making them more vulnerable to climate change. Thus, this study attempts to investigate the contribution of urban green spaces to climate resilience in Niamey City as the case of the big West African cities. Specifically, it aims to: i) Analyze urban green spaces accessibility: the current state in Niamey city; ii) Analyze the determinants of the urban green spaces management practices in Niamey city; and iii) Assess the contribution of the urban green spaces to the climate resilience in Niamey city. For that, the qualitative and quantitative methods were applied to the primary and secondary data. The qualitative relies on semi-structured interviews, focus group discussions, and personal observations, while the quantitative relies on the primary data from the survey (390 respondents), geospatial data, and secondary data. For the first specific objective, the green index per capita, proximity to green spaces indicator, and qualitative indicators such as safety, comfort, attractiveness, and maintenance were used. For the second objective, the multinomial logistic model was used; and the partial proportional odds model for the last objective. The results showed that despite the urban green spaces are not currently in good condition with the accessibility of 6.04 m^2 per capita, they contribute significantly to the respondents' climate resilience. Thus, the respondents close to the green spaces are more likely to be climate resilient. In addition, the respondents who perceive the regulating and cultural services are more likely to be climate resilient than those who perceive the provisioning services. This performance is attributed to the urban green space management practiced by the respondents, which is influenced significantly by shade as the benefits they get from urban green spaces. In light of the results, this study suggests promoting projects that aim to develop urban green areas across the city to make them more accessible to dwellers, thereby increasing their climate resilience.

Keywords: Urban green spaces, Climate Resilience, West African Big cities, Niamey, Niger

RESUME

Au cours des dernières décennies, les villes d'Afrique de l'Ouest deviennent de plus en plus grandes en raison du taux de croissance démographique élevé. Cette urbanisation s'accompagne d'une transformation des conditions sociales et environnementales affectant les moyens de subsistance et le bien-être des habitants, ainsi les rendant plus vulnérables au changement climatique. A cet égard, cette étude tente d'investiguer la contribution des espaces verts urbains à la résilience climatique de la ville de Niamey comme un cas des grandes villes d'Afrique de l'Ouest. Spécifiquement, cette étude vise à : i) Analyser l'accessibilité des espaces verts urbains : l'état actuel de la ville de Niamey; ii) Analyser les déterminants des pratiques de gestion des espaces verts urbains dans la ville de Niamey; et iii) évaluer la contribution des espaces verts urbains à la résilience climatique de la ville de Niamey. Pour ce faire, les méthodes qualitatives et quantitatives ont été utilisées. La méthode qualitative repose sur des entretiens semi-structurés, des discussions de groupe et des observations personnelles tandis que la méthode quantitative fait appel aux données primaires d’enquête (390 répondants), les données géospatiales et les données secondaires. Pour le premier objectif, l'indice vert par habitant, l'indicateur de proximité aux espaces verts, ainsi que les indicateurs qualitatifs des espaces verts telles que la sécurité, le confort, l’attractivité et la maintenance ont été utilisés. Pour le deuxième et dernier objectifs, le modèle logistique multinomial et le modèle de cotes proportionnelles partielles ont été respectivement utilisés. Les résultats ont montré que bien que les espaces verts urbains ne soient pas actuellement en bon état avec une accessibilité de 6,04 m^2 par habitant, ils contribuent de manière significative à la résilience climatique des répondants. Ainsi, les répondants qui sont proches des espaces verts sont plus susceptibles d'être résilients au changement climatique. En plus, les répondants qui perçoivent les services de régulation et culturels sont plus susceptibles d'être résilients que ceux qui perçoivent les services d'approvisionnement. Cette performance est attribuée à la gestion des espaces verts urbains pratiquée par les répondants, qui est influencée significativement par l’ombrage comme avantage qu’ils en tirent. Au regard des résultats obtenus, cette étude propose de promouvoir les projets qui visent à développer les espaces verts urbains à travers la ville pour les rendre plus accessibles aux résidents et ainsi accroitre leur résilience climatique.

Mots clés: Espaces verts urbains, Résilience climatique, Grandes villes Ouest-Africaines, Niamey, Niger

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ABBREVIATIONS

CO2: Carbon Dioxyde;

FAO: Food and Agricultural Organization of United Nations;

GHG: Greenhouse Gas;

IIA: Independence of Irrelevant Alternative;

INS: Institut National de la statistique ;

IPCC: Intergovernmental Panel on Climate Change

MEA: Millennium Ecosystem Assessment;

PCA: Principal Component Analysis;

RGPH: Recensement General de la Population et de l'Habitat ;

RIMA: Resilience Index Measurement Analysis;

SDG: Sustainable Development Goals;

UNFCCC: United Nation Framework Convention on Climate Change;

USAID; United Stated Agency for International Development;

WFP: World Food Program;

WHO: World Health Organization;

GENERAL INTRODUCTION

a. Background of the study

In the world, 55% of the population live currently in urban areas expected to reach 65% by 2050, with 90% of this increase will come from Asia and Africa (United Nations, 2018). This high rate of urbanization leads to urban green space depletion reducing its areas to less than 1 m^2 per capita in Africa, especially in poor cities (R. White. 2017). Thus, only 37% of the urban population has access to open public spaces (Sylla, 2021). This decline of urban green spaces as the cities become compact reduces their potential to boost resilience to climate change (Anderson, B., J.E. Patiño Quinchia, 2022). In this region, cities are also well known to cope with severe pressures with diverse challenges, notably the extreme poverty and seemingly chaotic urban development processes that go with the unclean air, unsafe streets, insufficient public services, and unreasonable commutes (Lindley et al., 2018). Alongside these challenges, due partially to the increasing amount of anthropogenic GHG emissions projected to be 1.5^{o}C, climate change has the potential to affect the growing African cities severely (Herslund et al., 2016). Among the cities, those in West Africa are more likely to be severely affected by the extreme heat that can reach under different climate scenarios 145 to 196 days per year, the increased flooding risk, and many other disasters by 2090s (IPCC. 2019).

It is admitted that the change that has already occurred with the transformation of the landscape to accommodate housing contributes to the loss of high-quality land and threatens the livelihoods and well-being of the residents in different cities (D'Amour et al., 2017). Thus, the change in land use for housing around the world requires an increasing focus on how to use land efficiently and fairly, which has become progressively more scarce and expensive in the cities (Du & Zhang, 2020). In this sense, the theory of spatial capital resulting from the spatial economic theory by Von Thunen (1826) highlighted the need to invest in urban land to increase its value by creating places with specific socio-economic and ecological potentials. This spatial economic theory is based on the neoclassical economic theory considers the land as another form of capital regarding the deterioration of the land and the natural resources it shelters, contrary to the classical and pre-classical economic theories, which consider land as an essential factor alongside labor and capital (Marcus, 2010). Likewise, the urban planning theories such as compact city theory, the theory of spaces, garden city theory, smart growth theory, and the modern compact city theory advocate for the use of spaces efficiently and sustainably. In this regard, the urban professionals and city leaders adopt increasingly the concept of "urban resilience" which is, however, problematic in terms of precision and operationalization (Ahern, 2011). As a result, its measurement should consider the key attributes, either quantitative or/and qualitative or objective, or/and subjective, depending on the information available (Bousquet et al., 2016). It is defined recently as "the ability of an urban system and its socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance". Thus, the urban green infrastructure, defined as an interconnected network of green spaces that conserve natural ecosystem value and functions while providing associated benefits to urban populations, is one strategy to enhance urban resilience (Meerow et al., 2016). In this sense, urban green spaces are considered the solution to increasing urban climate resilience through flooding risk reduction, urban heat island reduction, energy consumption reduction, air quality improvement, carbon storage, conservation of wildlife habitat, and provision of recreation and leisure amenities (Saleh & Weinstein, 2016, Staddon et al. 2018, Francesca et al. (2021)). However, urban green spaces can adversely affect human health, such as increased exposure to allergenic pollen, infections transmitted by arthropod vectors, particularly mosquitoes, and risk of injuries due to poor design or maintenance (Braubach et al., 2017). This poor design and management also leads to sap on cars, undermined foundations of houses, increased fire risk, nuisance noise, downed power lines, damaged roofs, and unpleasant odors. Again, it increases the risk of animal attacks on passers, especially in cities having more green spaces (Byrne, 2014). As a result, the United Nations in 2015 defined the Sustainable Development Goal (SDG) eleven (11.7) which aims to build the sustainable communities and cities by 2030 *by providing universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.*

According to Depietri & McPhearson, (2017), the target interventions (policies) at different levels need support in terms of information about the availability, accessibility, and quality of urban green spaces for the specific population group to ensure their development. Indeed, the quantity, quality, and accessibility of urban green spaces are the primordial aspects to be considered for the effectiveness assessment of green spaces and ecosystem services provision

(Wright et al. 2012). These different aspects depending on the maintenance of urban green spaces that requires more resources in all the cities (Fratini & Marone, 2011). Nevertheless, the related resources are not appropriately allocated face to unexpected planning (Arshad & Routray, 2018). Therefore, urban green space design and maintenance become poor leading to the urban green spaces depletion and compromising their accessibility of the dwellers, especially for low-income communities forcing them to leave or lockout from enjoying the benefits of the green spaces (Kabisch et al. 2015; Staddon et al. 2018; Biernacka, 2019; Du & Zhang, 2020). This point made by the environmental justice theory in 1987 stipulates that the environmental benefits that enjoy people in their different areas have to be independent of their skin color (black and white) or their belonging to a specific group of people (poor and rich) (Schlosberg, 2007). Also, it has been supported by the economic theory of infrastructure according to which the infrastructure resources like ecosystems should be openly accessible to all communities without discrimination so that they can benefits from (Frischmann, 2005). As a result, the resilience sought through urban green spaces should consider the well-being and social equality by allowing all communities to access urban green spaces (Hoang & Fenner, 2016). Optimally, the evaluation of the contribution of the urban green spaces to climate resilience, according to Mathey et al. (2011) should consider the green spaces at the regional, city and district scales by looking the different type of green spaces such as green belt, green park, etc. Regarding these different spatial scales, the holistic approach is needed to interconnect green spaces' psychological, social, ecological, and physical benefits to climate resilience (Demuzere et al. 2014).

b. Problem Statement

Cities in West Africa experience a substantial depletion of green spaces, which already occupy a tiny percent of the total land space due predominantly to the high rate of urbanization (Mensah, 2014). This alarming situation exacerbates the climate change impacts (Nero et al., 2019) which disrupt permanently or temporarily the ecosystem services, increase the cities' vulnerability to shocks such as heat waves, flooding events, droughts, and even food crises, and decrease the climate resilience (Geest et al., 2019). The growing evidence of the effects of climate change and natural hazards emphasizes the need for better city planning and design to build resilience in this region (du Toit et al., 2018). To this end, West African cities must build urban infrastructure, reform the institutional architecture and policy, and share knowledge and other resources to scale up the best mitigation and adaptation practices (Lwasa et al., 2014). In line with that, the municipalities adopt urban plans for the development of rainwater storage systems that help floodplain dwellers reduce the flood risk (Douglas, 2018). Thus, Lwasa et al. (2014) argued that the rainwater storage system through the urban agriculture sector (a form of green space) plays a vital role in mitigation and adaptation to climate change. In addition to these provisioning services, the regulating, cultural, and supporting services from urban green spaces are essential to sustain the local communities, and their resource depends increasingly (Cilliers et al., 2013). These ecosystem services from urban green spaces for climate resilience in West African cities depend on urban green space accessibility and management (Anderson, B., J.E. Patiño Quinchia, 2022b). However, the management of urban green spaces, in addition, to being challenged by urbanization, faces the insufficient operation of urban planning regulations and socioeconomic and political challenges (Mensah & Roji, 2021). As a result, this management poses a severe problem in the different big cities, thereby decreasing the quantity and quality of urban green spaces (accessibility), jeopardizing their potential benefits (ecosystem services), and even generating adverse effects (ecosystem disservices) (Nero et al. (2019); Mngumi, (2020); Mensah & Roji, (2021)). Thus, most empirical studies on West African cities focus on urban green spaces management problems, with very few attempts to analyze the urban green spaces' accessibility or/and analyze the determinants of urban green space management practices, and then evaluate their contribution to urban climate resilience. However, there is broad literature across the World, particularly in Europe, the United States, and Asia, which has evidenced the potential of urban green spaces to contribute to climate resilience. To our knowledge, this nexus between urban green spaces and climate resilience has not yet been addressed in Niamey, neither the analysis of the determinants of their management practices nor the analysis of their accessibility.

c. Rationale of the Study

The City of Niamey is an emblematic example of a fast-growing West African city, which is likely to become the fastest-growing City in the world at an estimated growth rate of 5.2% for the next 15 years, from 2015 to 2030 (Massy-Beresford, 2015). During the dry season and droughts, the City's population increases by 20 percent because of employment opportunities (World Bank, 2017). Also, the City of Niamey alone hosts more than 39% of Niger's urban population due to its high birth rate (Illiassou et al., 2015). The latter is expected to reach 3.72% leading the City to 1.492.414 inhabitants by 2024 (INS, 2019). These statistics give to the City of Niamey the status of one of the West African big cities. Indeed, the big city is defined as an attractive urban area where people enjoy the different amenities and many opportunities for income generation (Ellis-young & Doucet, 2021). As the metropolitan area, a *big city* is defined by the United Nations Department of Economic and Social Affairs as an urban agglomeration, including the surrounding areas at a lower settlement density with strong economic and social linkages to the central City (Takeaways et al., 2018). Thus, Figueiredo et al. (2018) defined metropolitan areas as the functional urban areas with a population over 500 000.

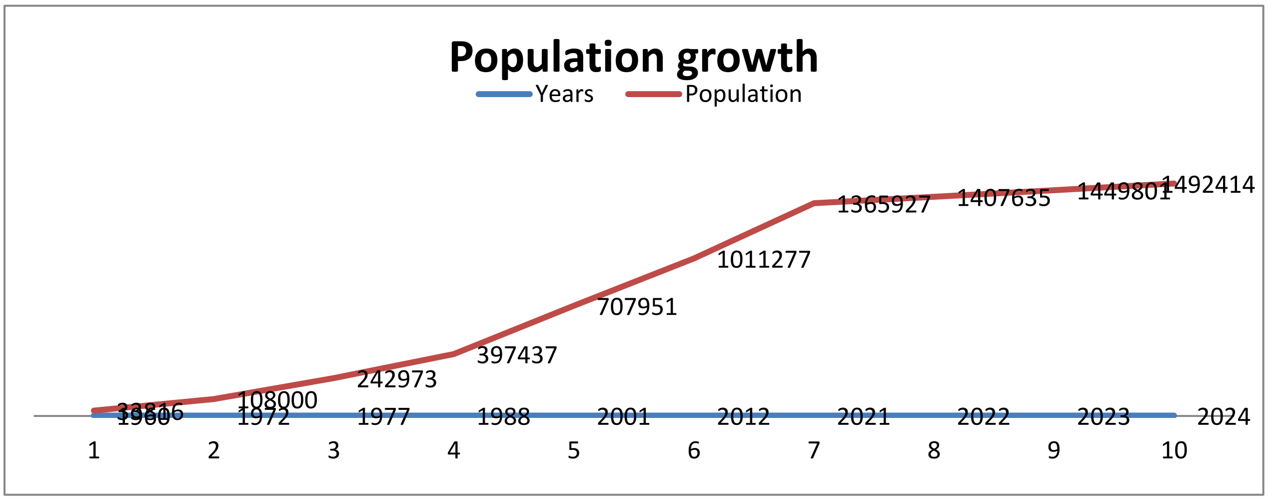


Figure 1: Population growth per year from 1960 to the projection 2024, Source: INS (2019)

The urbanization pace of Niamey goes with the increasing demand for plots of land for the new neighborhoods developed according to the horizontal urban planning model. However, these new plots are developed in an uncoordinated patchwork of municipalities, urban planning, and land registry agencies; as a result, the land is often bought without the provision of an urban service network such as water and electricity (Hungerford & Moussa, 2017). Thus, this inefficient land use leads to an increase in the flood-prone areas' occupation with increased frequency and intensity of flooding affecting 1,083 people and destroying 60 households that are estimated to be low resilient (Boubacar et al., 2017). The number of victims increased in 2020, with 119 809 affected people, over 52% of its total area (Tarchiani et al., 2021). Building urban resilience is crucial, especially in the booming Niamey city, where low rainfalls and high temperatures characterize the climate; and inadequate land use planning leads to the loss of urban vegetation such as green belt and street trees (Hungerford & Moussa, 2017) with already few urban parks (Banon et al., 2021). As a result, Dimé and Nakoari, (2021) revealed that anthropogenic deforestation is the leading cause of environmental disruption noticed in terms of heat waves, floods, drought, and high winds in Niamey City.

d. Research Questions/Objectives/Hypotheses

a. Research Questions

The main research question is: How can urban green spaces contribute to climate resilience in Niamey city? Specific research questions are:

1) Are urban green spaces accessible to all dwellers of the city of Niamey?

2) What are the determinants of the urban green spaces management practices in the City of Niamey?
3) What is the contribution of urban green spaces to the climate resilience of the City of Niamey?

b. Research Objectives

The study's main objective is to investigate the urban green spaces and their contribution to climate resilience in Niamey city. More specifically, it aims to:

1) Analyze the accessibility of urban green spaces related to the current state in Niamey city.
2) Analyze the determinants of the urban green spaces management practices in Niamey city;
3) Evaluate the contribution of urban green spaces to climate resilience in Niamey city.

c. Research Hypotheses

The expected results of this study are:

1) Urban green spaces are not evenly accessible to all citizens in the city of Niamey

2) Urban green spaces benefits affect significantly and positively the management practices of urban green spaces in the City of Niamey;
3) Urban green spaces through the ecosystem services significantly increase the climate resilience of the City of Niamey.

e. Significance of study

This study contributes to the urban resilience literature by showing how urban green spaces can contribute to climate resilience in the context of rapid urbanization. Thus, it provides knowledge to the policy makers, planners, and designers who interested in enhancing the urban climate resilience. For this assessment, the approach used makes a significant contribution, especially in West African cities where secondary data are scarce, consisting of asking people to assess their anticipatory, absorptive, and adoptive capacities to the climate shocks. In addition, the econometrical model in general and the partial proportional odds model in particular used previously rarely applied. The variables included in this model result from Taylor's conceptual framework of urban climate resilience. Among these variables, the study focuses on the ecosystem services, the proximity to the public green spaces reflected the accessibility, and the climate shocks perceived by the dwellers. Significantly, this study offers a green index per capita as a mean to capture the efforts of the government in the urban green spaces provision. Thus, it is valuable by making a signal to urban planners, managers, and decision-makers on the factors to be addressed for better delivering and managing urban green spaces likely to enhance urban climate resilience in line with many national and international agendas, such as the Kyoto protocol, the Paris agreement, the Sustainable Development Goals, and the Great Green Wall initiative.

f. Methodology brief

To address the three specific objectives above, this dissertation uses quantitative and qualitative methods using primary and secondary data. The primary data was collected from households, remote sensing (geospatial data), semi structured interviews, focus groups and personal observations, and secondary data was from National Institute of Statistic (INS) and High Commissionership of Niamey Nyala Program. As for methods, the green index per capita, proximity indicator and qualitative indicators such as safety, comfort, and attractiveness are employed for the first objective based on the primary data (geospatial data, semi structured interviews, focus groups, and personal observations). Moreover, the econometrical modeling methods such as multinomial logistic model and partial proportional odds model are mobilized respectively for the second and third objectives based on the primary data from 390 households selected via stratified random sampling method. For the third objective, the millennium ecosystem assessment (MEA) is used to classify the ecosystem services from green spaces, and the subjective approach is used to calculate the climate resilience index.

g. Organization of the Study

This study is organized in five chapters: **Chapter 1**: discusses the concepts and theories related to the research problem; **Chapter 2:** defines the data sources, the data collection techniques and instruments, the data processing, and methods and techniques of analysis needed to carry out the study; **Chapter 3**: analyses the accessibility of urban green spaces in the city of Niamey by using the per capita green index, the proximity indicator and the qualitative aspects of urban green spaces; **Chapter 4**: analyses the determinants of the urban green spaces management in the city of Niamey by applying the multinomial logistic model from sample size; and **Chapter 5** assesses the contribution of urban green spaces to the climate resilience of the city of Niamey by using partial proportional odds model as particular case of ordered logistic model from likewise sample size.

CHAPTER ONE: THEORETICAL AND CONCEPTUAL FRAMEWORK

1.1. Introduction

This chapter gathers the set of the theories and concepts that allow understanding the outlines of the topic. Therefore, the urban planning theories which explain the efficient and sustainable use of land considered as the capital by the spatial capital theory. According to the spatial capital theory, this kind of the land use should improve urban life while benefiting everyone without discrimination as highlighted by economic infrastructure resources theory and the environmental justice theory. For that, the self-green governance approach as form of governance approach explains the way the people act for this urban capital. Furthermore, this chapter reviews the concept of urban green spaces, the concept of resilience, and the interconnection between them through the climate change exposure and the ecosystem services from urban green spaces. Finally, it describes the different approaches of the climate resilience assessment and provides a conceptual framework that underpins the overall study as illustrated in Figure 2.

1.2. Theoretical framework

1.2.1. Urban Planning Theories

Urban sprawl, characterized by a high-density population, extensive land use, and high pollution level, constitutes a barrier to a resilient and sustainable city by causing much destruction of the urban landscapes (Dieleman, 2016). To this effect, the theory of spaces underpinned by fundamental, relational, and relativity space theories offers a new horizon to include green spaces in urban design to maintain the urban ecosystem balance by breaking up the border between the buildings and the green open spaces. For that, the natural green space can be expanded horizontally or vertically on building components such as the floor, wall, roof, or multilevel form (Firmansyah, 2014). Similarly, the compact city theory proposed the intensive and innovative use of urban space (land), like vertical city’s growth, which encourages the integration of green spaces with a significant positive impact on life satisfaction through reducing anxiety and noise and increasing safety and cleanliness (Mouratidis, 2019). As for the garden city theory, it looks closely at the uncontrolled urban growth and the weak links between cities and their surrounding areas to slow down the increased urban social costs (Belij et al., 2019). The original idea of the garden city theory was to surround the social city/central city with satellite towns, all with a limited number of inhabitants, where the green space serves agricultural products in addition to recreational or hygienic purposes. According to the garden city principle, the city should have three hundred meters (300 m) of the green belt that prominently occupies more than half of the city's landmass along the channels of the waterways serving the sports and recreation zone (Howard, 2010). Recently, the modern compact city theory appeared as a combination of the compact city theory and the garden city theory. This theory describes the model that provides a functional urban design supporting sustainability and underlining the importance of ecosystem services. It allows adding green spaces such as green roofs in the building facades, railway lines, street trees, and greenways across the buildup areas where it is not feasible to create large green spaces (Russo. 2018). This theory aligns with the smart growth theory whose principles are to create a compact city livable, and workable urban neighborhoods with environmental, ecological, economy, and social benefits (H. Khalil & Khalil 2010). These theories, by explaining the way to create liveable cities subscribe to the religious' point of views. Indeed, Bagader et al. (2006) quoted by Mensah & Roji (2021) argued that the most practiced religions in the World, notably Islam and Christianity, encourage their believers to preserve vegetated areas wherever they live. For instance, according to the Holy Quran, through several verses, Allah (God) calls the "Muslims to cultivate the habit of preserving the natural green vegetation as such acts please." Likewise, according to "the Holy Bible in Genesis (2:8-15), the Lord God placed the man he first created into any other place than the Garden of Eden and commanded him to work and keep the garden safe".

1.2.2. Spatial Capital Theory

The spatial capital theory analyses the way urban form influences predominately the overall aspects of urban life. It offers an exciting opportunity to discern urban form in terms of density, diversity, and accessibility, influencing the proximity and distance to urbanity for urban life. On the other hand, it provides a way to capture the effects of this urban form on the land value by taking into account both the exchange value and the use value for the social, cultural, environmental, and economic capital. In this regard, the theory of spatial capital states that the fundamental value of the land results not only from investments in fixed capital such as infrastructure in terms of buildings, and roads but also from the way the spatial form of the land is shaped with specific socio-economic and ecological potentials. Indeed, in the classical economic theory, the land was alongside labor and capital as factors of production. With the land's deterioration, the neoclassical economic theory summarized the factors of production to labor and capital by considering land as another form of capital. This view is reviewed by the spatial economic theory of Von Thunen (1826), which considered the land as a spatial extension location. Therefore, the theory of spatial capital is interested in the urban form in which the green areas and other amenities are distributed across the floor space and the additional spaces, creating particular relation between spaces, thereby increasing the value added of these spaces for human well-being and social cohesion (Marcus, 2010).

1.2.3. Economic Theory of Infrastructure

The theory of infrastructure has been developed by Frischmann (2005) in respond to the question about the way to manage the infrastructure resources such as transportation systems, environment resources, communication networks, and so one that provide both public and private benefits. This theory is widely based on demand-side economics rather the supply side to better understand how value is created and realized by individuals who obtain access to infrastructure resources. The analysis of demand-side highlighted that the infrastructure resources are essential to generate value used as inputs into a wide range of production processes whose output is often public and nonmarket goods, thereby generating positive externalities that benefit society. The management of these infrastructure resources in an openly accessible manner may be socially desirable when it facilitates the increase in participation in activities that yield scales returns. The key point of this theory is that resources are openly accessible to all within the community regardless of the identity of the end user, in particular for the resources that may be available to all naturally because their characteristics prevent them from being owned or controlled by anyone. As a result, Frischmann argued that the restricted access to various infrastructure resources such as information, internet, and ecosystems may prevent society from realizing the total value of these resources. However, for the natural resources and environmental services, he suggested that the value of the ecosystem services should be quantified by creating a market to avoid congestion and degradation problems, thereby avoiding the negative externalities.

1.2.4. Environmental Justice Theory

The environmental justice theory appeared as a result of 'environmental racism' in 1987 in the United States of America. It describes the disproportionate relationship between high levels of pollution exposure for people of color (African-American people) and the low level of environmental benefits they enjoy. This environmental justice is the response to the environmental racism that people of color lived during this period. The theory has been developed by scholars who attempt to understand the relationship between people and the environment by exploring a wide range of environmental aspects. Thus, they focus on inequity due to the distribution of a range of goods such as green space, public transit, and fresh food and the nature of environmental protection. Thereby, the environmental justice theory endeavored to examine why minority communities were devaluated in the first place (Schlosberg, 2007). One of the key recent developments of environmental justice theory has been refining the understanding of the various mechanisms and processes of environmental injustice (Sze & London, 2008). According to Gallagher et al., (2008), environmental injustice is not just a single harmful event/action/result but rather a complicated history of political, social, and economic interactions leading up to, and continuing beyond, the contested instance of perceived injustice. Recently, environmental injustice has been fueled by the so-called green gentrification, which means the transformation of the city districts into green that enhances their property values by making them attractive to the affluent communities, thereby pushing the poor to displace to another place (Gould and Lewis, 2018).

1.2.5. Green Self-governance Approach

Green self-governance is a specific form of governance in which the citizens play a significant role in realizing, protecting, and managing green spaces. It indicates how the citizens manage the green spaces across the residential areas through some practices or activities depending on the resources under some rules for the amenities and social cohesion improvement. The citizens can act autonomously from external forces via this form of governance. It responds to the criticism of traditional centralized governance, which relies on the top-down approach (Mattijssen et al., 2018). As proposed by Mattijssen et al. (2017), the green self-governance approach goes beyond the physical urban green space management. It has the potential to contribute to urban green space management, social cohesion, and environmental education, among other benefits, while removing the authorities' financial constraints. Regarding these bottom-up approach's advantages, the local authorities recognize the legitimacy and autonomy of citizens that act with a sense of stewardship. Therefore, the citizens are considered among a wide range of stakeholders involved in urban green space management, where the local authorities play an essential role, especially in supporting them (Mattijssen et al. 2017).

1.3. Conceptual framework

1.3.1. Urban green spaces and Ecosystem Services

The term "urban green space" is defined as "an umbrella term for all areas of land that consist predominantly of unsealed, permeable, soft surfaces such as soil, grass, shrubs, and trees…whether or not they are publicly accessible or publicly managed. Thus, It includes all areas of parks, play areas, and other green spaces specifically intended for recreational use, as well as other green spaces with other origins" (Swanwick et al.,2003). Ii is also used to refer only to the open spaces or public open spaces within the urban environment and consists of parks and recreational spaces, gardens, lawns, brownfield and wasteland areas, and woodland (Keane & Grant-smith, 2014). However, the consensual definition of urban green space among ecologists, economists, social scientists, and planners is: "public and private open spaces in urban areas, primarily covered by vegetation, which are directly (e.g., active or passive recreation) or indirectly (e.g., positive influence on the urban environment) available for the users" as defined by the Journal of Environmental Protection (Haq, 2011). To take into account the multi-functionality of the urban green spaces, urban green spaces are assimilated into the urban green infrastructure, which is defined as "Spatially and functionally integrated systems and networks of protected landscapes supported by protected, artificial and hybrid build landscapes infrastructures that provide multiple and complementary ecosystem and landscape functions to the public, in support of sustainability"(Ahern, 2011).

Significantly, urban green space is distinguished from other urban spaces by its ability to provide social connections, health and wellbeing, community livability, economic prosperity, climate modification, stormwater management, and resiliency to extreme weather events (Mukherjee & Takara, 2018). These benefits are translated into ecosystem services classified as provisioning, regulating, cultural, and supporting services by Millennium Ecosystem Assessment (MEA) in

2005. Therefore, these ecosystem services communicate the contributions of urban green spaces and vary according to the performance of urban green spaces. Otherwise, the urban green spaces provide the adverse effects called ecosystem disservices which counters these ecosystem services (Thomas Elmqvist et al., 2013). These ecosystem services are given in the table below:

Table 1: Ecosystem services from urban green spaces

Provisioning (the products obtained from the ecosystem)	**Regulating** (Benefits obtained from the regulation of ecosystem)	**Cultural** (Nonmaterial benefits obtained from ecosystem)	**Supporting/Habitat** (services necessary for the production of all other ecosystem services)
• Food supply • Medicinal resources and aromatic plants • Fresh water, • Wood supply, • Fiber and fuel…	• Temperature regulation • Pollution regulation • Noise reduction • Flood regulation • Maintenance of soil fertility • Pollination and seed dispersal • Biodiversity support…	• Learning and Education; • Cohesion; • Culture; • Spiritual enrichment • Tourism • Recreation and leisure; • Children fulfillment • Aesthetic information…	• Nutrient cycling; • Soil *(formation, retention, and fertility*); • Species maintenance (*biodiversity*) …

Source: Thomas Elmqvist et al. (2013)

1.3.1. Urban Green spaces and Climate change

The higher temperatures, the varying humidity, the wind conditions, and the other impacts associated with climate change may damage the biodiversity of urban areas, leading to changes in species composition and vegetation structure (Mathey et al., 2011). Thus, climate change has the potential to gear the ecosystem degradation and reduce the effectiveness of ecosystem services which results in losses and damage to people and society (Geest et al., 2019). As a component of the ecosystem, the green spaces decline, leading to increased heat waves, violent wind, and flooding, amplified by climate change. Green spaces in urban areas provide natural cooling by reducing air and surface temperature within dense, hot cities via shading and evapotranspiration and also reduce storm water runoff by balancing the water flows (Mathey et al., 2011). They also provide energy and resources that significantly and effectively affect citizens' natural capital and adaptive capacity (Kabisch et al., 2017). Additionally, urban green spaces have the potential to reduce greenhouse emissions by removing the CO_2 from the atmosphere via photosynthesis as regulating services and increase adaptation by providing human health and well-being as the provisioning, supporting, and cultural ecosystem services (Pauleit et al. 2017). These services guarantee urban climate resilience through urban green space management activities. However, the management of urban green spaces through some practices using gasoline-powered maintenance equipment release carbon dioxide into the atmosphere in the form of fossil fuel emissions, thereby leading to global warming, which in turn leads to the climate. As a result, urban green spaces become net emitters of carbon unless secondary carbon reduction is made (Nowak (2018). In addition, the presence of certain animals and insects within urban green spaces increases the use of pesticides which may lead to reduced air and water quality (Demuzere et al., 2014). Likewise, scientists at the University of Washington revealed that certain types of plant species, such as woody trees, staple crops, and other plants under high CO_2 in the atmosphere, do something unusual, manifested by thick leaves which exacerbate the effects of climate change while reducing their carbon sequestration function (Marlies Kovenock and Abigail Swann, 2018).

1.3.2. Resilience: Concept and definition

The term 'resilience' derives from the Latin word "resilio" which means to 'bounce back or rebound. It was used scientifically in English by Francis Bacon in the first decades of the 17th century to describe the strength of echoes (Alexander, 2013). Over time, the concept of resilience stimulates the debate among scientists about a primary perspective, which is still ongoing. Some believe it is an ecological concept, while others attribute it to physics (Brooks, 2006). However, the term resilience is used first in social sciences studies such as psychology and psychiatry for cognitive systems and social interaction between individuals, communities, and institutions (Waller, 2001). The concept of resilience has been developed first in the form of engineering resilience as the ability to bounce back to a single equilibrium (one stable state), then in the form of ecological resilience as a measure of robustness or buffering capacity before a disturbance forces a system from one stable equilibrium to another, and last in the form of evolutionary resilience as the ability to adapt in reaction to a disturbance *(Becker, Per*, 2014). Therefore, the concept of resilience has been subject of several definitions which are similar in terms of some system's characteristics such as robustness, recoverability, redundancy, intelligence and adaptability etc. Solicited recently by different disciplines, the concept of resilience has become more visible even though the scholars are not unanimous; some consider it as a process of the system, while others believe that resilience is a result reflecting the system's ability (Kong et al., 2022). To this effect; urban planning and design researchers apply resilience to protect better urban green spaces and biodiversity for the ecosystem services. Thus, urban resilience appears as the city's ability to simultaneously maintain human and ecosystem functions over the long term (Lehmann, 2019). According to the 100 Resilient Cities program, *resilience* is defined as "the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow, no matter what kinds of chronic stresses and acute shocks they experience"(Keane & Grant-smith, 2014). Its measurement calls for the appropriate indicators, which include the service delivery and regulatory functions of urban spaces with the municipal planning processes, communication systems, business environment, and structural and infrastructure-related factors (CoP, 2016). Thus, It requires suitable indicators and measures that consider its key attributes, either quantitative or/and qualitative or objective, or/and subjective, depending on the information available (Bousquet et al., 2016).

1.3.3. Resilience Assessment Approaches

Admittedly, there is substantial literature on resilience assessment, but there remains to be a consensus on resilience measurement. Thus, despite the development of several resilience measurement indices, such as the climate disaster resilience index, integrated resilience index, socio-ecological index, and urban resilience index, there is empirically and theoretically a need for consensual resilience measurement indices (Alfani et al., 2015). However, the most appropriate way to measure climate resilience for a particular context is to look at the elements to include in the measurement. For instance, a multidimensional index is required for the climate resilience measurement for urban areas, which are complex systems. As a result, the objective approaches are generally employed in developed countries, especially for metropolitan areas and megacities, which need socioeconomic and biophysical data mostly lacking in developing countries (Dhar & Khirfan, 2016). In the case where data are unavailable, the subjective decision from directly the people's perception is solicited for selecting the components/dimensions instead of selecting the components with the risk of leaving out key elements. Thus, this subjective approach appears as an alternative to the objective approach or as complementary (Of et al. 2014).

The objective approach involves measuring resilience directly through defined indicators or stated variables derived from measuring observable items (Clare et al., 2017).The multidimensional approach defines these indicators or variables by considering several dimensions (Alfani et al. 2015). Therefore, the indicators such as income level, access to food, and access to essential services such as health, assets, and social safety nets are included at the household or individual level. At the community level, the quality of the environment and natural resources management institution, access to communal resources, quality of protective infrastructure, levels of peace and security, availability of contingency resources or social safety nets, and social participation in the community are considered. At the national scale, indicators such as transparency, access to information, control of corruption and fraud, accountability, participation, and engagement are included. Significantly, these different scales are intimately intertwined as an individual's resilience is influenced by the community's resilience, which is widely influenced by the national level (Tanner et al., 2016). As a result, aggregating composite indicators are used with the increased risk of correlation between the allocated variables' weights (Brooks, 2006).

Although the objective approach is guided by an overarching conceptual framework usually designed by technical experts external to the individuals or households, it remains the norm dictating a broad degree of understanding of resilience processes at all scales (Jones & Tanner, 2017). Under this approach, resilience is seen as a latent variable broken down into multiple capacities that assign proxy indicators as measures (Clare et al., 2017). Thus, the application of the objective approach has certain shortcomings, such as the difficulty of getting the relevant indicators from social, political, and economic factors, the need for a broad sample size that is time-consuming and costly, and the failure to consider the people's self-assessment (Jones & Tanner, 2017). In light of these weaknesses of the objective approach, Jones & Tanner, (2017) revealed that the resilience contains not only the tangible variables such as livelihood, income, but also the subjective variables such as the risk perception, beliefs, culture, social norms, and social cohesion. Through this subjective approach, the relevance of resilience indicators remains in the hands of the households driving their development processes (Tyler et al., 2016). Basically, this approach is highlighted in the literature via two indicators of resilience:

1) Indirect independent indicators estimated based on the households' well-being regressed on selected variables (Alfani et al., 2015)

Indeed, household resilience within the city is determined by comparing pre and post-disaster well-being to maintain general well-being (Of et al. 2014). According to Alfani et al. (2015), the smaller the difference in well-being, the more resilient the household. However, this measure requires panel data which are scarce in many contexts. Also, using cross-sectional data requires two groups; the treated groups experienced the shocks, and the control groups did not; disasters such as drought usually hit all the people without exception, insofar as it is the same city.

2) Direct indicators are constructed with several dimensions that are not latent as considered in the objective approach but are measurable variables estimated using the Principal component analysis or Partial Least Squares (Jones & Tanner, 2017).

Indeed, despite the lack of consensus about the number of dimensions to be considered, many studies maintained three capacities such as the capacity to adapt, capacity to absorb, and capacity to anticipate perceived through the four points Likert scale ranking, not at all likely=1, not very likely=2, very likely=3, and extremely likely=4 (Jones, 2018).

In sum, as each city regarding its main challenges and characteristics at different scales, should adopt its proper urban resilience measurement index (Beceiro et al., 2022), this study adopts subjective approach consisting directly of asking people their resilience-related capacities in the face to the climate shocks. Thus, this study expects the following relationship between the urban green spaces, their management and accessibility for the ecosystem services, and the urban climate resilience.

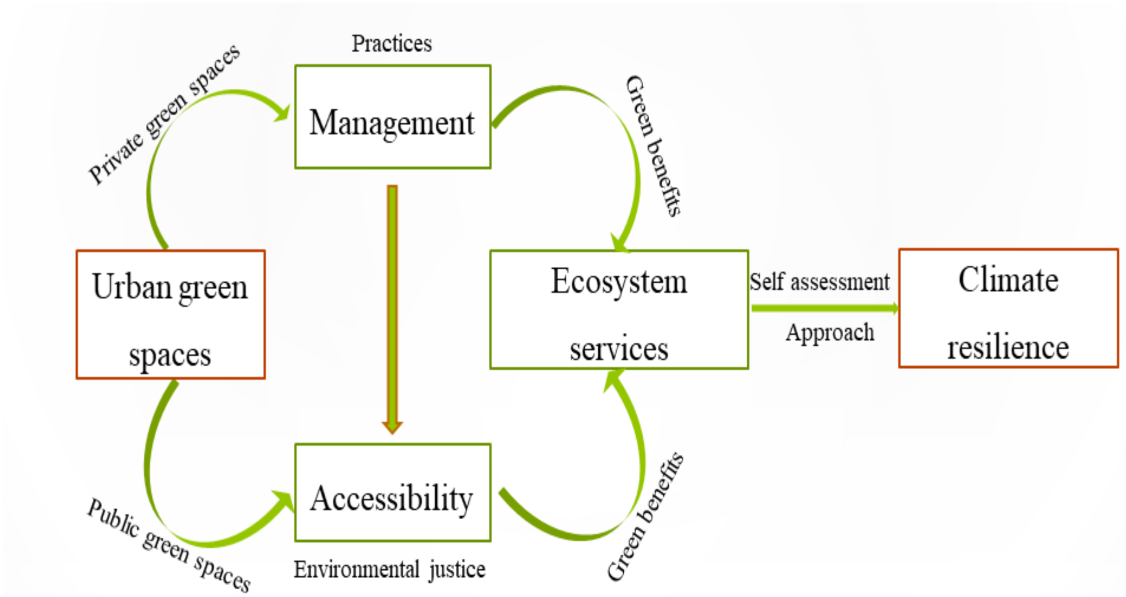


Figure 2: Conceptual framework for the study

CHAPTER TWO: RESEARCH METHODOLOGY

2.1. Introduction

This chapter describes the study area, the data collection as well as the different methods used for the analyses. Thus, the socioeconomic characteristics of the unit of analysis are defined as well as the geographical and climatic characteristics of the study area. Regarding the research objectives, the quantitative and qualitative data from primary and secondary sources are used and analyzed via descriptive, content, and econometrical methods. Thus, the observation, the structured and semi-structured interviews, and the focus group discussions were conducted for data collection relying on the self-reported (subjective) approach.

2.2. Study from Niamey City

The City of Niamey was initially located in the villages of Fulani koira, Gaweye, Kalley, Maourey, and Zongo since the late 19th century, which are now become residential neighborhoods. The first occupants were Zarma, Songhai, Maouri, and Fulani, whose activities were and still as today fishing and agro-pastoralism but not full-time. The City of Niamey has considerably grown due to its status as the administrative and political capital of the Niger republic. Its population is multiplied by 34 from about 30,000 inhabitants in 1960 to 1,026,849 in 2012, i.e., at the scale of fifty years, according to National Statistical Institute (INS, 2012). It becomes the epicenter of exodus, where people from rural areas come looking for better opportunities. Most of them do not return to their original areas; thereby, living in the slums exposes them to the risk of flooding. Therefore, it has now a multi-ethnic city with a diversity of national and foreign communities, notably Zarma-Sonrai, Hausa, Fulani, Tuareg, Kanuri, and others, dominated by Zarma followed by Hausa. The city also hosts many strangers from Benin, Mali, Burkina Faso, and Nigeria (Urban-ARK, 2017). The households in this city generally engage in informal economic activities with modest gains and limited public support for their livelihood (Issoufou,2017). These informal activities are the characteristic of West African cities' everyday economic activities dominated by commerce which is maintained by clerical work (INS, 2012). In addition, they practice urban agriculture, including husbandry highly considered a critical livelihood activity that consists of the cultivation of cash and food crops throughout the year, either under rain-fed or irrigated conditions (Moussa et al., 2019).

Niamey is the largest city in Niger, with an extended area of over 552.27 km² and an urbanized area of 255 km^2. It has, in total, a land area estimated at 3,933 hectares (INS, 2012). According to Rossi (2019), it is located between latitude 13°20'-13°35' N and longitude 2°00'-2°15' E in western Niger. The climate is a semi-arid Sahelian region characterized by low rainfalls (540 mm per year) and high temperatures (on average, the temperatures range monthly between 24°C and 36°C). The figure below shows how the climate has varied and changed in the past 30 years.

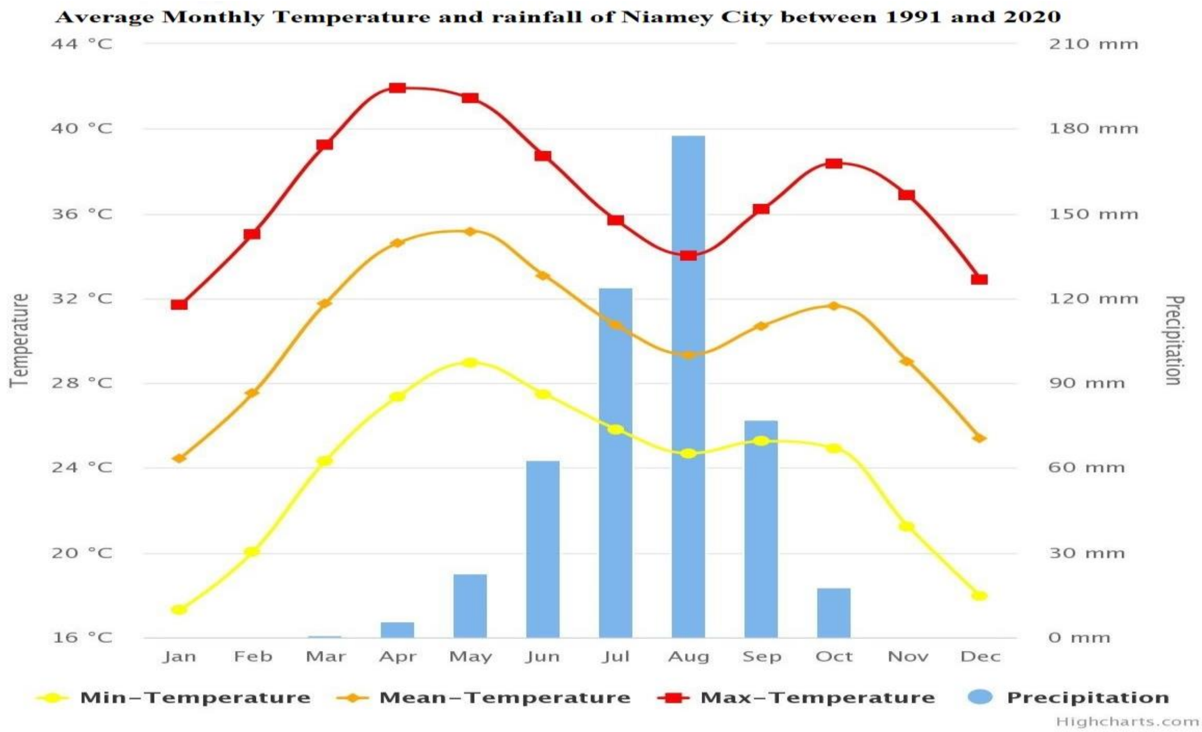


Figure 3: Average Monthly Temperature and Rainfall of Niamey city between 1991 and 2020. Source : World Bank, (2021)

It shows the baseline climate and seasonality by month for the rainfall and the temperature. Therefore, the minimum average monthly temperature was 24.46° C, and the maximum was 35.17° C, with March, April, and May as most hot months. As for rainfall, the average monthly was evaluated at the minimum level of 0.86 mm and the maximum level of 177.96 mm, with the June, July, August and September as months when it rains more.

The city usually observes only one rainy season per year, which occurs between May and September. Niamey Urban Community (CUN) is embedded in the Tillabéri region and divided into two by the River Niger. The most important part of the city is located on the left bank of the river, with many districts divided into municipalities I, II, III, and IV. There are a few districts on the right bank in municipality V. The structure of its urban landscape corresponds to a gradient ranging from highly diversified, fragmented, and both wooded and built-up areas in the city center and along the Niger River to fewer green areas gathering steel-roofed houses whose density diminished towards the periphery (Rossi, 2019). Thus the overview of the landscape structure of Niamey City is described by the following map standing out with paddy fields, green belt, sand, urban and peri-urban build-up, farmland, gardens, wetland grass, bare ground, Niger River, and scrubland.

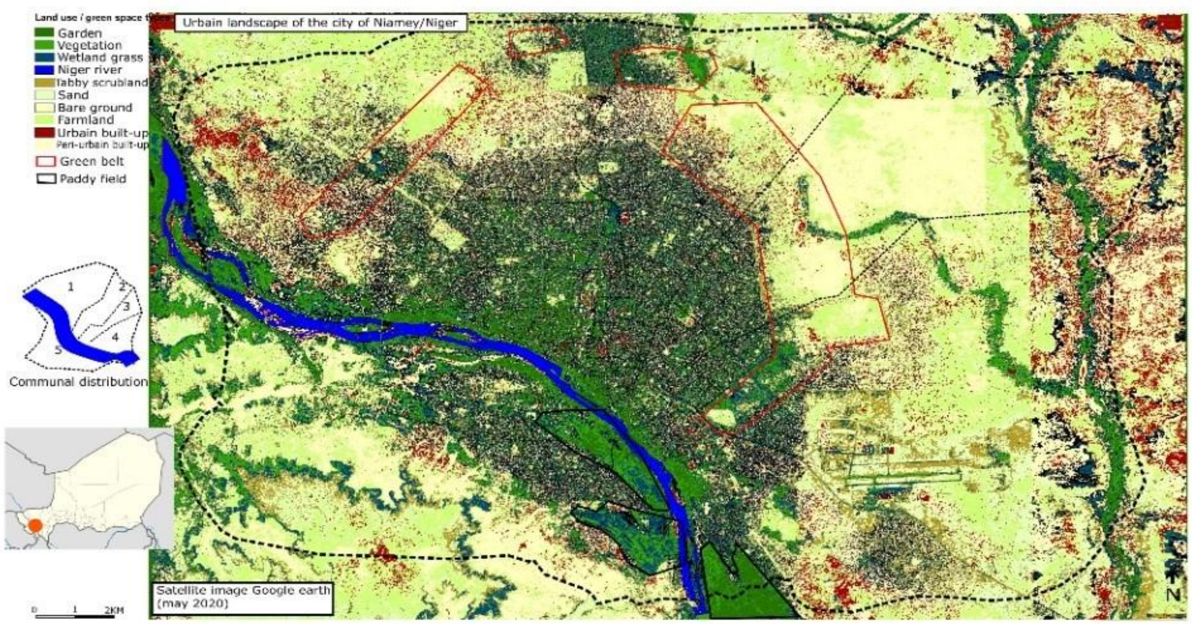


Figure 4: Urban Landscape Structure of Niamey, April (2021)

2.3. Distribution pattern of green cover across Niamey City

The urban vegetation in the City of Niamey essentially consists of the green belt, plantations in concessions or along the main avenues, small tree-lined areas and plantations of fruit trees along the Niger River and the Gounti Yéna valley, and finally, some public gardens and green spaces developed by the municipalities (Banon et al., 2021). This urban vegetation is dominated particularly by trees (Moussa et al., 2019). The predominance of trees dates back to 1924 when the French colonial transformed the City of Niamey into the Capital of Niger with trees as markers of urban identity (Motcho, 2010). In 1935, Niamey City became greener by adopting the models of the European and African neighborhoods that transformed the city into a garden city with tree-lined streets, public green spaces, formal gardens, and household tree spaces. Later during the 1940s, the City of Niamey attended to the development of vast infrastructure as a way for the French to preserve their influence. Therefore, earlier in the 1950s, trees were planted along significant roadways, and after the 1960s, trees were seen as identity, literal, and symbolic urban boundaries for national development (Sidikou, 2010). In 1965, while Niamey was a small city of 34,000 inhabitants, the green belt created and served the city's northeastern border. In the late 1960s, the country faced a series of droughts that led to rapid migration, thereby increasing Niamey's population by 242,000 and threatening the green belt due to the higher demand for land (Motcho, 2010). In 1975, the drought ended, and operation Green Sahel was launched, allowing the City of Niamey to dispose of the broad coverage of trees, especially our fast-growing and drought-resistant so-called neem. Thus, the vegetation was re-established with the abundant rains. The tree coverage has been maintained because the large trees planted yearly on National Tree Day decreed the 3rd of August as Niger's Independence Day. In the second half of the 1980s, the trees across the green belt have been quickly degraded due to the new drought event (Sidikou, 2010). In the 2000s, the Service of Forestry adopted a new forestry code that focused on the participatory methods of forest management in addition to the one which avoids the trees use (Montagne & Amadou, 2012). This new forestry code was financially accompanied by FAO up to $400,000 to facilitate decentralized urban green space management. In 2012, the national forest plan 2012-2021 has created, which suggests agroforestry, public management of tree resources, and the private sector's participation as solutions to environmental degradation, deforestation, desertification, and food insecurity. This plan aims to improve green space management; create the mechanisms of management and evaluation of urban forest resources; and plan and develop urban forestry (Hungerford & Moussa, 2017). In this sense, two planted trees projects have been implemented, the first one planted 20 000 trees between 2018 and 2020 to support the Great Green Wall initiative, and the last one planted 3 million trees during the period 2019-2020 to address heat waves and pollution (Ekamby & Mudu, 2022).

2.4. Sampling Method and Sample Size

The Primary data were collected in July 2021 close to the residents across the five Niamey's municipalities, namely Commune I, II, III, IV, and V. The survey was conducted during the weekdays in order to find the heads of households who are responsible for the most daily expenditures. This idea allows for minimizing the information bias and potential hypothetical biases. The heads of households are considered in this study to ensure the respondents are residents of the specific district. Additionally, the stratified random sampling method was carried out in two steps; first, the districts are randomly selected within the municipality, and second, the residents are chosen randomly within each district selected. Thus, the districts were located across the city: in the downtown district, the urban periphery, or the transition zone between the downtown and periphery. Indeed, the sample was selected based on the projection demographic of Niger 2012-2024, resulting from the fourth census (RGPH) conducted in 2012 by the National Institute of Statistics. According to the INS, (2019), Niamey's population, which was 1,026,849 inhabitants in 2012, is estimated in 2021 at 1,365,927 inhabitant.

Table 2: The distribution of Niamey's population by Commune

Commune	**I**	**II**	**III**	**IV**	**V**	**Total**
Population	276,335	336,292	215,046	363,318	174,936	1,365, 927
Percentage of Niamey's total population	20.43%	24.62%	15.74%	26.61%	12.80%	

Source: (INS, 2019).

In addition, the sample size is determined using the proportion method for the representative sample developed by Cohran (1963, 1975) quoted by Ajay & Micah, (2014). As the population is large, the sample size is given by the formula: $n = \frac{t^2 p(1-p)}{e^2}$ where t is the confidence level (value found in the statistical tables consisting of the area under the normal curve); p is the proportion of citizens that have the attribute of interest i.e., those who perceived at least one ecosystem service in the population and e is the margin of error (the level of precision). However, we do not know the proportion p; so, it is quite common to take 0.5 as a maximum variability in the population to have a more conservative sample size which may be larger than if the variability of the population attribute is truly used (Singh, 2014). Therefore, by using 95% confidence level, the sample size is estimated at $n = \frac{(1.96)^2(0.5)(0.5)}{(0.05)^2} = 385$

Based on the percentage of the population per commune (table 1), this sample size was split out into five (5) communes. Therefore, 79 (20.43%*385) respondents were selected in Commune I, 96 (24.62%*385) in Commune II, 61 (15.74%*385) in Commune III, 103 (26.61%*385) in Commune IV, and 46 (12.80%*385) in Commune V. In the first step, the districts such as Plateau, Koubia, Bobiel, Ryad, and Koira Kano in Commune I; Koira tadji, Lazaret, Banizoumbou, Dar-es-salam, Boukoki , Cite deputé in Commune II; Madina , Kalley Nord, Cité Fayçal, Banifandou in Commune III; Saga, Talladjé, Niamey 2000, Aeroport, Route fillingué, Pays bas, and Gamkalley in Commune IV; and Lamorde, Kirkossey, Nogarey in Commune V were selected using random numbers generator software (RNG)..In the second step, 16 respondents were randomly selected per district based on the method of pace between the households. The pace of 10 was taken from the household of the district chief. Therefore, a total of 400 questionnaires were handled out where 10 were rejected during the data cleaning due either to the typos or the missing values. Thus, 390 questionnaires were used for the analysis.

2.5. Data collection methods

In line with the addressed objectives, quantitative and qualitative data were required from primary and secondary sources. Thus, focus group discussions, semi-structured interviews, personal observation, remote sensing, and survey questionnaire for the structured interviews were conducted among the techniques.

2.5.1. Focus group discussions

Five focus group discussions were conducted in Cité Fayçal, Yantala, Nouveau marché, Zango, and Koira Kano districts purposively selected based on the presence of the largest public green spaces such as place francophonie, place gadafawa, place nouveau marche, petit marche, and bois koira Kano in April 2021. Each focus group discussion consisted of 11 participants 10 were residents and the district chief. The specific topics discussed were the availability of green spaces, their attitudes toward using and managing urban green spaces, and problems related to existing urban green spaces (Appendix C). In total, the sample size was 55 participants. According to (Oxford University Press, 2015), in qualitative analysis, no matter whether the sample size is small, the most important thing is to select meaningful and strategic participants to get important information from the research questions.

2.5.2. Semi-structured interviews

The key informants were solicited to answer some questions based on their knowledge and experience of urban green space management following the participatory approach. Thus, the semi-structured interviews were conducted in February and March 2021, with 12 key informants selected purposively. Therefore, the director of the environment and landscaping office, the director of urban health and improvement of the living environment office, the directors of communal environment services (5), head of production and information division urban of the high commissionership of Niamey Nyala program and the public urban green spaces managers (5) were interviewed based on the questionnaire consisted of the four (4) open-ended questions (Appendix D). Each interview took between 30 and 45 minutes, and the interviewees had the possibility to discuss all the issues of concern. The interviewer could bounce if the interviewees highlighted some critical aspects.

2.5.3. Observation

The direct observation from field so-called firsthand information on the public urban green spaces was used to gain insight into the current urban green spaces management. Some photos (pictures) were used to support the information from the interviews and focus group discussions. This information was analyzed to complete the content analysis.

2.5.4. Remote sensing

The remaining green belt area was obtained via Google earth images from Landsat between 1990 (the year before the green belt’s informal occupation) and 2021. The normalized difference vegetation index (NDVI) was used to classify the images into three land use land cover (LULC) classes: water and buildup areas, bare ground, and vegetated areas according to the value of NDVI ranging from -1 to 1. Thus, the value -1 or near indicates water or buildup areas, 0 indicates the bare ground, and 1 indicates the vegetated areas.

2.5.5. Survey questionnaire

The cross-sectional survey employed a standardized questionnaire composed of socioeconomic, demographic, environmental, and geographical questions, which are closed and open-ended, was conducted. These questions were addressed to the heads of the household in the selected districts and posed in local languages and French because of the Niamey population's heterogeneity. The validity and reliability of the questions were tested through the pilot test survey. The responses are recorded directly by the interviewers. Notably, the respondents were asked for their opinions, perceptions, knowledge, and behaviors on climate change shocks, resilience-related capacities, and the benefits of urban green spaces. In this regard, the respondents were asked to evaluate their capacity to cope with, adapt, and anticipate the climatic shocks they faced during the last five years and the different strategies adopted based on their positive or negative experiences. Likewise, they were asked to report the benefits and services of urban green spaces and whether they participated in management. Therefore, the variables defined from the questions are demographic, socioeconomic, geographical, and environmental variables such as age, gender, education level, household size, income per month, marital status, main activity, housing occupation status, the living period in the neighborhood, distance to the nearest public green spaces, residents' participation in the management of urban green spaces, climate shocks, frequency to visit public green spaces, climate resilience and social, mental, and physical life satisfaction.

2.6. Data analysis methods

The primary and secondary data were analysed using descriptive, content, and econometrical methods according to the research objectives.

- ✓ For the first objective, the green spaces index per capita and the proximity to urban green spaces as the accessibility indicators were estimated by the descriptive analysis to analyse the urban green spaces accessibility in Niamey, according to the WHO. In addition to this quantitative analysis, the qualitative analysis, particularly the content analysis, was employed to assess the indicators such as attractiveness, comfort, safety, and maintenance as recommended by Mensah, (2017) for the state of the urban green spaces, which is intimately related to their accessibility. In fact, by taking into account the two aspects, the researchers analyze broadly the urban green spaces accessibility from a different perspective to make the analysis more comprehensive. Therefore, the focus group discussions and interviews were transcribed manually using the theoretical proposition strategy proposed by Yin (2003). According to this strategy, interviews, focus group discussions, and document information must be analyzed under key themes by ensuring the data are converged to understand the general problem (Baxter & Jack, 2008). Moreover, the direct observation method used by Ali, (2017) via the pictures, and reported tables were solicited to support the content analysis.

- ✓ For the second and third objectives, the econometrical models, notably the multinomial logistic model and partial proportional odds model, were used to analyze the determinants of urban green spaces management practices and assess the contribution of urban green spaces to climate resilience. The choice of these models is due to the nature of the dependent variables, which are all categorical. The urban green spaces' managerial activities are nominal, consisting of watering, putting the fence, and others, while climate resilience ranks from low to high. The latter is defined according to the direct subjective indicator used by Jones et al. (2018) based on the households' perception of the climate shocks and their capacity to prepare for, recover from, and adapt to these climate change shocks. These categorical dependent variable models often depend on the maximum likelihood estimation method which requires assumptions on the probability distribution functions, such as the logistic function (Park, 2005). Thus, the independence of irrelevant alternative (IIA) and parallel regression lines assumptions for respectively multinomial logistic model and partial proportional odds model were tested.

The climate resilience indicator relies on the subjective resilience approach explained by Jones, (2018) in his study “New methods in resilience measurement early insights from a mobile phone panel survey in Myanmar using subjective tools”. For doing so, the author defined the resilience matrix consisted of three components such as anticipatory capacity, absorptive capacity, and adaptive capacity.

- ✓ Anticipatory capacity: the ability of respondent to anticipate or to prepare for the shocks and stresses in order to create a structural change.

- ✓ Absorptive capacity: the ability of the respondent to minimize sensitivity to existing shocks and stresses in the short-term;

- ✓ Adaptive capacity: the ability of the respondent to learn and to adjust to the potential damage after the shocks and stresses.

To appreciate these different components considered as pathways to estimate climate resilience, the author asked these questions according to climate shocks they experience. Therefore, for our study, the individual (dwellers) are asked to self-reveal the main climatic shock that they experienced and then their capacity to prepare for, recover from, and adapt to these climatic shocks. These questions are given in the following table (table 3).

Table 3: Components of the resilience indicator

Climate shocks	Anticipatory capacity	Absorptive capacity	Adaptive capacity
1. Wind **2. Flood** **3. Heat** **4. Drought** **5. Other**	If the main shock occurred, how likely is it that your household would be fully prepared in advance?	If the main shock occurred, how likely is it that your household could fully recover within six months?	If the main shock was to become more frequent, how likely is it that your household could change its source of income or/and livelihood, if needed?

Source: Author from questionnaire of the survey (2021)

Based on these questions, the anticipatory, absorptive, and adaptive capacities were appreciated using Likert scale points such as not at all likely, not very likely, very likely, and extremely likely to adapt, prepare, and recover from the climate shocks. The individuals' answers to each resilience-related capacity question are compiled and converted into a numerical value used to compute the overall resilience score for each respondent. Alternatively, the most straightforward, perhaps appropriate option is to generate each resilience-related capacity with equal average weight through the Principal Component Analysis by assuming that the absorptive capacity is as essential as anticipatory and adaptive capacities in supporting climate resilience.

CHAPTER THREE: URBAN GREEN SPACES ACCESSIBILITY: THE CURRENT STATE IN NIAMEY CITY

3.1. Introduction

Urban green spaces in Niamey City have become increasingly small due to the high rate of urbanization, which exercises the heavyweight on the vegetated areas, particularly the green belt (most significant open green space), with half of its original site diverted for other purposes (Hungerford & Moussa, 2017). The alignment plantings, generally found in the city center, are in the process of degradation and require significant touch-ups. The spaces assimilated to urban parks need to be improved, degraded, and threatened by the waste depository (Banon et al., 2021). While the potential of urban green spaces to boost climate resilience in West African cities depends on their availability which determines their level of accessibility (Anderson, B., J.E. Patiño Quinchia, and R. Preito Curiel, 2022). Thus, a good understanding of the urban green spaces accessibility is critical to increasing the residents' well-being and resilience to climate change for the SDG11 achievement in Niamey. In this chapter, we attempt to analyze the urban green space accessibility related to its current state in Niamey City. To this effect, the green index and proximity indicator was applied as quantitative, accompanied by qualitative ones such as comfort, safety, and attractiveness, to get an insight into the urban green spaces' current state. Therefore, the green index indicator was globally generated based on the urban green spaces available free of cost for the general public and per commune, and proximity indicator to public green spaces was calculated and compared to a benchmark of "15 minutes walking distance" according to WHO from home across the districts.

3.2. Empirical Review

The expansion of the buildup areas in African cities leads to urban green space depletion, making their distribution and access difficult. Thus, the international standards to ensure safe, accessible, and inclusive urban green spaces are far from being reached. For instance, the study of Areola et al. (2020) in Ibadan, Nigeria, showed that the increase in depletion of green spaces by 38.0%, 62.2%, and 61.5%, respectively, between 1972-1984, 1984-2000, and 2000-2015 led to their uneven spatial distribution in the city. Another study from Addis Ababa, Ethiopia, by Azagew & Worku, (2020) demonstrated that the land use for urban green spaces decreased from 2003 to

2016 by 9.2%, causing insufficient accessibility for city residents. Thus, more than 90% of the residents needed access to the existing parks within the minimum walking distance. In Accra city, Ghana, Puplampu & Boafo (2021) revealed that the urban built-up areas increased from 55.1% to 83.79% at the expense of the green spaces declining from 41% to 15% over 27 years, thereby affecting their distribution. In South Africa, due to urban sprawl, many cities have less than 10% of their total green space-occupied land. This situation is characterized by land expropriation for productive purposes at the expense of the urban green spaces, indicating their unequal distribution and low accessibility, especially for disadvantaged people (Mcconnachie & Shackleton, 2010). These disadvantaged people generally live in areas where public green spaces are scarce and poorly maintained, with insufficient private green spaces across their neighborhoods (Liu et al., 2021). As well, the accessibility of urban green spaces is recognized increasingly as an environmental justice issue within the city (Wolch et al., 2014). Considered as an innovative way to achieve sustainable development goal 11, directly and indirectly the goals 2, 3, 11, 13, and 15 by 2030 (Blicharska et al., 2020).

Defined as public parks and other green spaces that are accessible to the public and managed by the local government, urban green spaces, under their functions, provide ecosystem services that improve the quality of life and well-being of the urban population (Fan et al., 2016). Their accessibility can be defined as the ability to reach and access urban green spaces (Kmail, 2020). Reflected by the proximity to urban green spaces, the accessibility has beneficial effects on human health and well-being in terms of physical, mental health and social cohesion (Kabisch, 2019). By contrast, low urban green space accessibility correlates with health problems such as overweight or obese, diabetes, mental stress, and cardiovascular diseases, which likely to reduce the people' resilience (Braubach et al., 2017). The accessibility of green spaces is assessed in terms of the proximity to green spaces and the green index per capita estimated based on the urban green spaces availability. The latter is the most widely used indicator to assess green space accessibility, described as the total area of urban green spaces averaged by the total population within the geographic area (Azagew & Worku, 2020). As a result, World Health Organization recommends a minimum green space size of 0.5 ha to 1 ha within a maximum distance of 300m from home corresponding to approximately 5 min walk, as standard. This maximum distance can be 500m from home approximated to 15 min walk (WHO, 2016). In its original idea, the standard is considered a benchmark among the local authorities to evaluate the urban green spaces state or the progress in supplying the urban green spaces needed for its populations. However, this conception needs to be revised for having left beyond the qualitative aspects of urban green spaces (Maryanti et al., 2016). As a result, Biernacka, (2019) argued that physical access to urban green spaces is sometimes different to access to their services. In this sense, the urban green spaces accessibility evaluation should include the citizen-based opinion about their attractiveness, safety, and comfort for the potential users, even though the aspects to be included are not fixed; it depends on the data availability (Fan et al., 2016). These aspects determine the conditions of the urban green spaces, thereby giving insight into the urban green spaces' current state (Mensah, 2017). As a result, Russo, (2018) argued that these qualitative aspects of urban green spaces influence their accessibility, use, and benefits.

3.3. Methodology

The urban green spaces accessibility assessment is widely conducted using five practical approaches: minimum distance approach, container approach, travel cost approach, spatial interaction approach (gravity model), and covering approach (Kim & Nicholls, 2016). In this study, the minimum distance approach and the coverage approach were used to analyze the urban green space accessibility according to the data available. According to Kim & Nicholls, (2016), the choice of these approaches can be influenced by other factors such as awareness of the facility, perceived or actual level of safety, environmental quality, size, quantity, amenities, and general attractiveness. Through the coverage approach, the public green spaces per capita are calculated for the entire city and per commune at the macro level based on the secondary data from the High commissionership of Niamey Nyala program, and the Institute of National Statistics completed by the geospatial data. This indicator has been used by Azagew & Worku, (2020) in the case of Addis Ababa, Ethiopia and Anguluri & Narayanan, (2017) in Gulbarga city, India. In addition to this per capita green indicator, at the micro level, the minimum distance approach through the urban green spaces’ proximity indicator is used to estimate the time walking for a resident to reach the nearest public green spaces from his home based on primary data. Thus, per capita green index is calculated using the following formula:

$$Green\_index = \frac{\sum_{i=1}^{n} G_i}{\sum_{i=1}^{n} P_i} \text{..(1)}$$

Where G=green space in square meters of the i^th^ commune, Pi= Population of i^th^ unit (commune). According to Anguluri & Narayanan (2017), from this per capita green index, the deficit of the public green spaces in the city was estimated through the following formula:

$Gap = (\text{International\_standard} - \text{Green\_index}) \times P$.............(2) Where P is a total population

$Z_{ij} = \min(d_{ij})$...(3) Where Z_{ij} is the minimum distance from the home i to the nearest public green space j.

For that, the geospatial data from the satellite imagery was used to get the remaining vegetated green belt area calculated using the normalized difference vegetation index (NDVI) by classifying the image from Landsat into three LULC classes: water or buildup areas, bare ground, and vegetated areas. Therefore, these areas were given by ha and classified by commune (table 5). In addition, the map was drawn to represent the distribution of public urban green spaces by using Google earth images with 4800×2803 and 2m pixel resolution and geo-referenced through Arc GIS 10.4. This map was associated with the location plan of Niamey City obtained via Google Maps and the different public green spaces localized using the global positioning system (GPS). According to the availability of the data, other studies use the Gini coefficient (Feng et al., 2019) or the Palma ratio (Liu et al. 2021) to appreciate the urban green spaces’ spatial distribution and accessibility across the city.

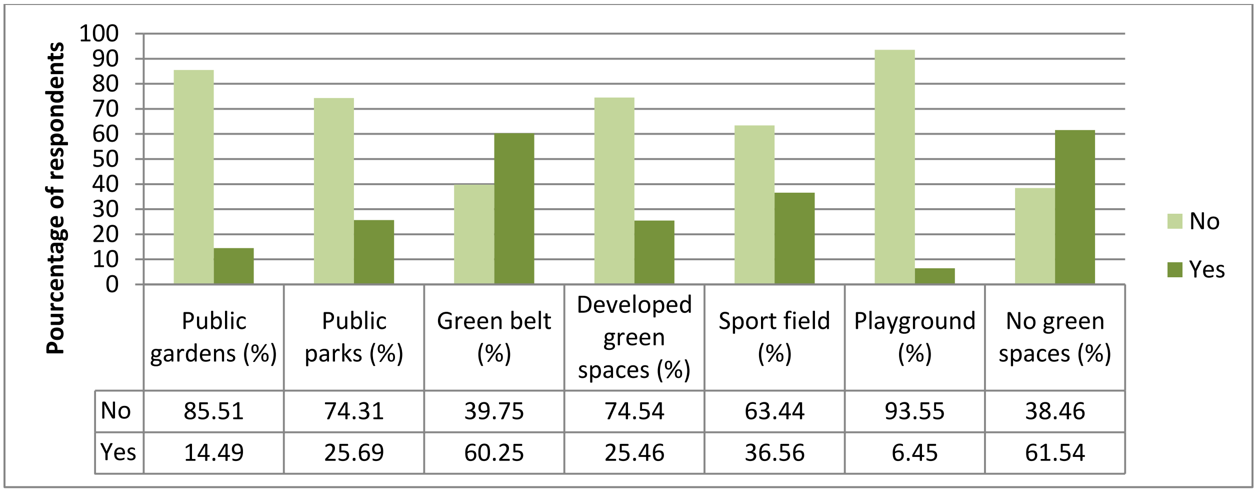
The descriptive analysis used by Girma et al. (2019) and observation method used by Ali (2017) and Djibril et al. (2012) are applied to appreciate the attractiveness of urban green spaces based on safety, comfort, and maintenance aspects. These different aspects have been used by Mensah, (2017) as the criteria of the urban green spaces' current state assessment in addition to the conservation as heritage, public, and community participation. In this regard, he defined safety as the feeling of being free from vandalism and criminal attacks, and availability of first aid, and of lights at night; the attractiveness as the presence of signage, well-grown grasses, walkways, free from litter and animal fouling, availability of dustbins, and absence of unpleasant smell; and comfort as the availability of seats, playing facilities, toilet facilities, and serene environment. To well appreciate these criteria, the focus group discussions and interviews were transcribed using the theoretical strategy proposed by Yin (2003). According to this strategy, the interviews, the focus group discussion, and the information from the document must be analyzed under the key themes by ensuring the data converged to understand the general problem (Baxter & Jack, 2008). Also, personal observation and photographs (pictures) of some large green spaces are used to back the interviews and focus group discussions. The intention behind the photographs was not to take nice and well-arranged pictures but to describe different urban green spaces' qualitative aspects.

3.4. Results and Discussion

The total green spaces area publicly accessible (table 5) allowed estimating the green index per capita for the urban green spaces accessibility. According to the geospatial data from remote sensing, the remaining green belt area is equal to 810 ha i.e. 8,100,000 m^2 and its area per commune were estimated using the spatial classification (Table 4). Also, the primary data from the survey served to estimate the percentage of dwellers near these green spaces within the 15 minutes walking distance across the city (table 6).

3.4.1. Type of Public Green Space

The city of Niamey disposes in terms of public green spaces, public gardens, public parks, green belt, developed green spaces, sport fields, and playgrounds. Therefore, 60.25% of the respondents reported being close to the green belt followed by the sports fields assimilated to green spaces with 36.56%, the public parks with 25.69%, and the developed green spaces with 25.46%. The public gardens and the playgrounds are rare reported with respectively 14.49% and 6.45%. However, 38.46% of the respondents reported no public green spaces near public green spaces, while 61.54% mentioned the presence. The latter percentage decreased by 58.46% at the benchmark of 15 minutes walking distance to have real access to the public green spaces for the respondents’ health and well-being as recommended by WHO against 41.54%.



	Public gardens (%)	Public parks (%)	Green belt (%)	Developed green spaces (%)	Sport field (%)	Playground (%)	No green spaces (%)
No	85.51	74.31	39.75	74.54	63.44	93.55	38.46
Yes	14.49	25.69	60.25	25.46	36.56	6.45	61.54

Figure 5: Type of public green spaces across the districts

3.4.2. Per capita green indicator

By compiling the secondary and primary data (table 5), the minimum standard of urban green spaces per capita (Green index) is calculated for the whole Niamey city and per commune to appreciate the urban green spaces accessibility. Related to that, the urban green spaces deficit is also calculated to identify their current demand. Therefore, the results show that, in Niamey City, the green spaces standard per capita is equal to 6.04 m^2. Based on green spaces gap, the city needs more additional green spaces area, 4,043,143.92 m^2, either 404.314 ha to fulfill the current demand. These results revealed that the urban green spaces are insufficient, by reducing the likelihood of city of Niamey to be resilient and sustainable. This is in line with the results of Mensah. (2017) in Kumasi city, Ghana and Oduwaye (2013) in Lagos city, Nigeria. They found respectively 4.7 m^2 and 2.8 m^2 green spaces per capita. This green index implies the poor access to the urban green spaces. The results also indicate that the green index per capita differs from one commune to another. Thus, commune IV has the highest green per capita i.e., 21 m^2 because the remaining green belt that locates in North-East straddling commune III and commune IV (Banon et al., 2021) (figure 5). However, the highest dense commune (commune II) has 0.242 m^2 overtaken by commune III which has 2.30 m^2. It was noticed that the low densely commune i.e., commune V has 0.019 m^2. This result shows that the accessibility of the urban green spaces is unevenly distributed across Niamey City. This result leads us to think about the probable environmental injustice in the Niamey. The picture four (4) from personal observation and one of the interviews below revealed that this situation is due to the green belt informal occupation, and to the lack of the allotted spaces for public green that often hijack. Indeed, according to Banon et al. (2021), the informal occupation was stated in 2000 when the government had the financial problem to back the salary, it started granting the spaces. This opened the way to the municipalities and indigenous people who detain the land ownership claiming to have the right, start occupying and selling it. This point was confirmed by one of the interviewees who added that this situation is exacerbated by the lack of control from the authorities to stop this operation (see the first interview below). The commune IV has the high green index because the government via presidential decree has declared four (4) sites of green belt as national forest and 3 of them are in the commune IV in 2021 (*Plan d'actions.2020*). This is confirmed by the two interviews below according to the Head of Production and Information Division urban of high commissionership of Niamey Nyala program, and Director of urban health and improvement of the living environment office. However, the low green index of the commune V is due to the spaces constraint for greening related to the lack of planning at the origin (see the second interview below). For the commune III, in addition to have some green areas of green belt, most of its districts are generally among the first well-allotted districts that benefited many green investment projects because they are in the plateau zone where concentrate the administrative and residential activities in the colonial era (Banon et al., 2021).

"…since the green belt creation, the security agents from the environment ministry supervised the space and prevented dwellers to cut the trees. Thus, the trees are preserved until the indigenous people claimed the spaces and started to occupy and sell them. The authorities have no longer enough resources to stop this operation but in 2020 through the action plan, they tried to control the occupation by foreseeing the compensation of these indigenous people by agreement and by declaring the spaces as national forest via the presidential decree" (Director of urban health and improvement of the living environment office, 22/06/2021, translation by author).

"…the green spaces are few in commune V because its districts like Banga bana, Nodirey, and Karadje are among the villages reached and surpassed by the urban dwellings while maintaining their structure intact without adequate allotment which provides spaces for the public green. That's why the government has tried to demolish the districts of commune IV, Saga, and

Gamkalley in return for another place. But, the indigenous people refuse unless the government leaves them the place they always claim in the green belt..” (Head of Production and Information Division urban of high commissionership of Niamey Nyala program, 27/08/2021, translation by author).

3.4.3. Proximity indicator

Moreover, the proximity indicator is calculated in terms of time walking distance at the micro level to examine if the time or distance constitutes a barrier of urban green spaces accessibility. According to the WHO, the accessibility to green spaces is measured via the percentage of the districts’ total population reaching the urban green spaces within 15 minutes walking distance. This study shows that 41.54% of the respondents have access to urban green spaces within the 15 minutes walking distance (table 6). Therefore, more than half of the respondents do not have access to these spaces. This result confirms that distance constitutes a barrier to urban green spaces’ accessibility limiting their use and their potential to be nature based solution to climate change, especially for vulnerable dwellers that are unable to walk a long distance. This is in line with the results of Djibril et al. (2012) in the case of Abidjan city, Cote d’Ivoire, who found that the distance to the urban green spaces and their state reduce their use. Therefore, they revealed that 9.3% of the respondents have access to any urban green spaces within 15 minutes walking distance. By considering 5 minutes walking distance as benchmark for at least 1ha, Anderson, B., J.E. Patiño Quinchia, (2022), found that the cities of Dakar, Accra, and Cotonou have respectively 90%, 84%, and 69% of the persons do not have access to the urban green spaces (Anderson, B., J.E. Patiño Quinchia, and R. Preito Curiel, 2022). This low accessibility of the urban green spaces is synonymous of some health problems such as overweight, diabetes, mental stress, and cardiovascular diseases (Matthias Braubach et al., 2017). Contrariwise, the good access to urban green spaces is associated with higher use, higher physical activity levels, and a lower likelihood of being overweight or obese (Khalil, 2014).

Table 4: Green belt area by commune

Commune	Bare ground (ha)	Vegetation (ha)	Area (ha)
1	158	0	158
2	241	0	241
3	644	47S	691
4	51	763	814
Total	1094	810	1904

Source: Author from remote sensing (2021)

Table 5: Minimum standard for public green spaces per capita in Niamey

Location	Population	Area (km^2)	Density (inch/km^2)	Other green spaces area (m^2)	Green belt (m^2)	Total green (m^2)	Green index (m^2)
Commune I	276,335	116.1	2405.960	43,000	0	43,000	0.155
Commune II	336,292	57.08	5944.218	81,460	0	81,460	0.242
Commune III	215,046	101.41	2140.282	24,500	470,000	494,500	2.30
Commune IV	363,318	109.07	3350.004	0	7,630,000	7,630,000	21
Commune V	174,936	168.60	1043.481	3,400	0	3,400	0.019
Total	**1,365, 927**	**552.26**		**152,360**	**8,100,000**	**8,252,360**	

Source: Author from primary and secondary data (2021)

$$Green\_index = \frac{\sum_{i=1}^{5} G_i}{\sum_{i=1}^{5} P_i} = \frac{8,252,360}{1,365,927} = 6.04$$

$$\text{Gap} = (9 - 6.04) \times 1365927 = 4,043,143.92$$

Table 6: Time to reach the nearest public green spaces

	Effective	Frequency (%)
Less than 5 minutes	74	18.97
6 to 10 minutes	53	13.59
11 to 15 minutes	35	8.97
More than 16 minutes	228	58.46
Proximity according to WHO	**162**	**41.54**

Source: Author from primary data (2021)

3.4.4. Quality of the urban green spaces

The quality of the urban green spaces influences their accessibility via the facilities distribution evaluated in terms of comfort, safety, attractiveness and maintenance (Feng et al. 2019). These qualitative aspects, according to Mensah, (2017) in addition to the conservation of the spaces as heritage, and the community participation in their management give insight of the urban green spaces state/condition. Thus, personal observations from the large urban green spaces have been solicited to support the analysis.

a. Safety/Insecurity

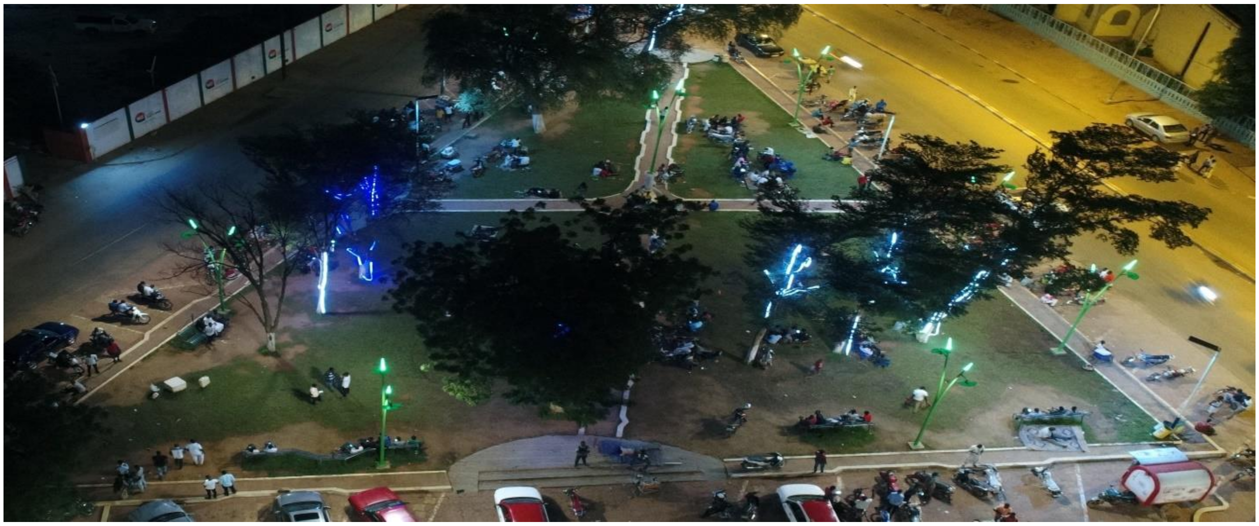
"…we wish that the green belt be completely occupied so that we can cross whenever we want without having feared being attacked. Indeed, it serves as a handout for thieves and criminals who attack people; sometimes, they kill, so we do not know how many people are killed. Within or around, rape and drug use are also common. Also, we observe, sometimes the fires coming from the informal straw hut dwellings" (Focus group discussion, 15/05/2021, translation by author). This situation has been highlighted by Göpfert, (2012), arguing that people see the green belt as a place of vice and crime.

"…the developed public green spaces by the city hall are visited by young people, some of whom are delinquents, transforming them into places of debauchery and preventing certain people to visit and enjoy the spaces." (Focus group discussion, 15/06/2021, translation by author)

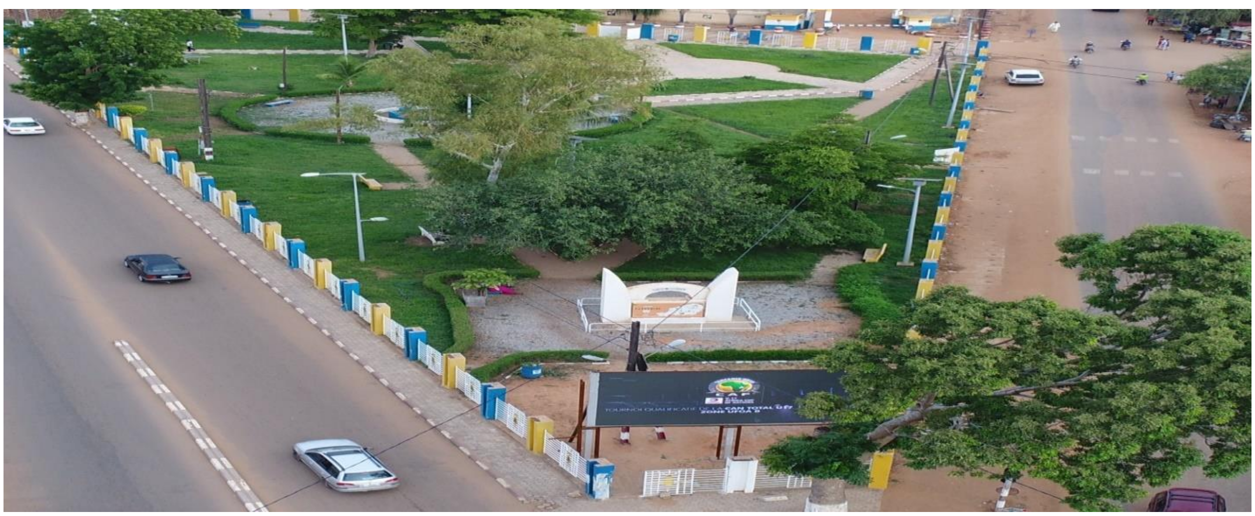
b. Comfort and attractiveness

"…as part of the Niamey Nyala program, which aims to beautify the city and to create recreational places for the people, most of the public green spaces are developed across the city with facilities such as benches, lights, and walkways, and bins for garbage, and also the workmen (managers) hired by City Hall are engaged in taking care of these spaces."(Director of environment and landscaping office, 12/12/2020, translation by author) (See the pictures 1 and 2 below).

"…the facilities, especially the internet in "Niamey Nyala" and Monteil place" make these spaces more attractive and relaxing, where people meet and enjoy their rest. However, most of the visitors are young people, rarely older people “ (one of the managers, 27/06/2021, translation by author) (See the pictures 1 and 2 below).



Picture 1: (Niamey Nyala place), Author from the field, 2021



Picture 2: (Place Monteil) Author from the field, 2021

Moreover, as part of the Niamey green city initiative, the city Hall developed a corridor of 1.4 ha located in the Zango district, well-equipped and maintained with the facilities such as benches, toilets, bins for garbage, and restaurants making the place more attractive. However, the space is less dense in green which limits its potential benefits besides the recreational and esthetical services (picture 3).

Picture 3: (Corridor) Author from the field, (2022)

c. Maintenance

"…about the green belt, its depletion started in 2000 when the government shared some areas with their officials for unpaid salary and built some areas for public institutions such as schools and hospitals. Since this period, the indigenous dwellers who assumed having the right to the sites from their ancestors started to occupy the space while selling some parts to the private companies that, after developing, sold. Again, some parts serve as the depository for waste depository-reducing their ecological services. The trees inside are threatened by the violent wind destroyed their branches generally in the rainy season. Also, trees are threatened by the squatters with dwellings in form of straw built by their wood. As a result, more than two-quarters of the initial area (2500ha) along 25 km^2 is gone. " (Director of urban health and improvement of the living environment office, 22/06/2021, translation by the author). This point has confirmed by Hungerford & Moussa (2017), who highlighted that the green belt is used for informal waste disposal sites, squatters, mosques, gas stations, and car stations with little benefit to the majority of citizens. The following picture stands out this green belt state (picture 4).

Picture 4: (Green belt) Author from the field, (2022)

"…the places that are reserved generally for public green spaces in different districts across the city are sold and occupied by the dwellers with the complicity of the municipalities. Therefore, majority of the districts do not have enough green spaces even absent." (Focus group discussion, 23/07/2021, translated by the author)

"…before the Niamey Nyala program was launched, many public open spaces were not green, they are completely empty, or occupied by small traders, mosques, and car stations. Also, some of the playgrounds did not have light, for example, the Poudrière playground. Now, certain of them are developed even though there is still a lot to do." (Head of Production and Information Division urban of the High commissionership of Niamey Nyala program, 27/08/2021, translated by author)

"…about the streets trees planted following the alignment planting plan generally during the National Independence Day by the Environment Ministry and City Hall are increasingly lost due to the lack of monitoring. Actually, they are left alone and destroyed by the animals in full view of residents. Again, the City Hall in many green spaces' projects do not fully associate the communal environment services" (Director of communal environment services (commune I), 02/07/2021, translation by the author).

"…Although the City Hall conserves permanently the developed urban green spaces and sometimes by certain associations, as the case of the Association "Initiative pour l'arbre, some urban green spaces are overused, leading to their deterioration. Thus, the City Hall lacks the sufficient means to pay the water bill aggravating their state. (Director of the communal environment services (commune III), 02/07/2021, translation by author) For example, the Gadafawa space considered as one of the most prominent green open spaces is degraded due to the dwellers' indifference vis a vis of this space. Another example is from Balafon space, which has been transformed into a waste deposit by the dwellers. This situation has evidenced by the pictures below (personal observation, 2022).

Picture 5 (Gadafawa space): Author from the field, (2021)

Picture 6 (Balafon space): Author from the field, (2022)

From this field observation, fifteen (15) green spaces have been noticed whose certain are in good condition. Six (6) of them were found in commune III followed by commune I, which has five (5), commune II with (3), commune V have only one (1), and none in commune IV but disposes the most part of the remaining green belt (figure 5). It is noticed that commune III has more green spaces, mostly in good condition, than other communes because most of its districts are generally among the first well-allotted districts with the most greening investment projects, as highlighted by Banon et al. (2021). This situation is presented in table (7), revealing that most of the urban green spaces noticed have the essentials to be in good condition. Nevertheless, the toilets need to be included in some green areas, and the grass is degraded or completely disappeared. The map below, drawn by Arc GIS, stands out the different locations of these urban green spaces across the city in addition to the remaining green belt area (figure 5).

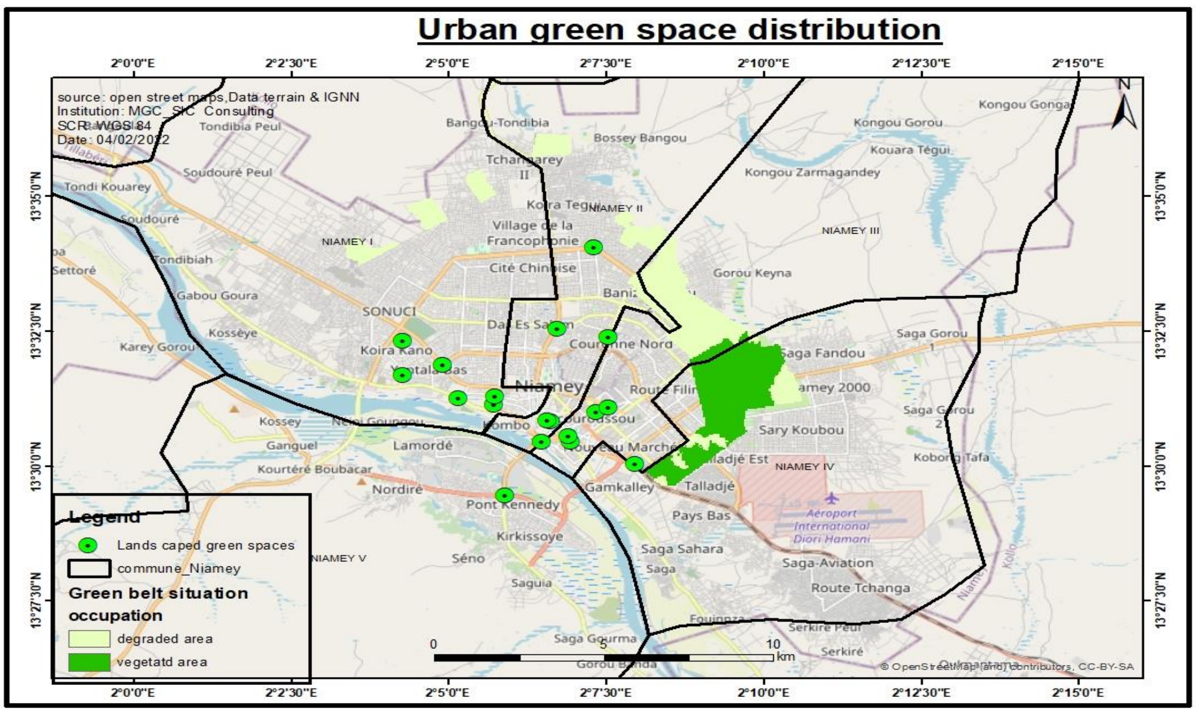


Figure 6: Urban green spaces distribution in Niamey city, February 2022

Table 7: Green spaces state in Niamey city based on field observation

Name of the space	District	Commune	Observation
Bois Koira kano	Koira kano	I	Quality wooded space but neglected and less frequented
Park Koira kano	Koira kano	I	Dense trees space well maintained but less frequented
Square de la présidence	Plateau	I	Developed green space with good facilities but there is no toilet, much frequented by the students.
Place Gadafawa	Yantala haut	I	Developed green space good facilities but there is no toilet and less grasses because of unpaid water bill
Place Château I	Plateau	I	Developed green space with good facilities but there is no toilet
Petit marché	Zongo	II	Developed green space with restaurant and good facilities but less dense in green;
Place Djibo Bakari	Zongo	II	Developed green space much frequented by small traders and served as parking for people's cars
Bosquet des Nations	Koiramé	II	Wooded space well maintained with native species
Place Monteil	Kalley Amirou	III	Developed green space with good facilities, very frequented, degrading the grass
Place Niamey Nyala	Kalley Amirou	III	Developed green space with good facilities, very frequented plus/minus grass
Place Balafon	Lakouroussou	III	Use as waste deposit
Place de francophonie	Cité Fayçal	III	Developed green space with good facilities but there is no toilet, much frequented
Place 1er pont	Terminus	III	Developed green space with restaurants inside
Place Nouveau marche	Nouveau marche	III	Developed green space with benches, bins, toilet, and libraries as facilities
Place Château	Pont kenedy	V	Developed green spaces with benches as facility but less grasses and no toilet.

Author from field observation, (2021)

Definitely, the green belt with more than half of initial spaces disappeared, is far from being the place that provides essential benefits such as improving air quality, heat waves reduction, and wind reduction for people's health, well-being, and resilience. Some developed green spaces are covered by grass with necessary facilities such as benches, bins, lights, and toilets while other are degraded with insufficient sanitation, thereby becoming less attractive for people's recreation and meeting. Al this situation is due to the informal settlements, the lack of funding for greening projects, and the corruption in the parcel allotment (from interviews). Therefore, the current urban green spaces condition in the City of Niamey is not good which likely to compromise their potential benefits.

3.5. Conclusion

Given that urban green spaces are essential for the city's resilience and sustainability, the issue of their accessibility for all citizens should be posed. To this effect, this chapter analyzes the urban green space accessibility related to their current state in Niamey based on the primary (semi direct interviews, and direct observations) and geospatial data. By using the green index per capita; proximity to the green spaces indicator; some qualitative indicators for the urban green spaces state, this chapter found that Niamey city has a green index of 6.04 m^2 per capita, with 41.54% of respondents reaching the spaces within 15 minutes of walking distance. Again, it reveals that the per capita green index is unevenly distributed across the city with $21m^2$ per capita for commune IV, $2.3m^2$ per capita for commune III, $0.242m^2$ per capita for commune II, $0.155m^2$ per capita for commune I, and $0.019m^2$ per capita for commune V. This uneven urban green spaces accessibility related to their current state reduce their potential benefits such as heat waves reduction, noise reduction, violent wind reduction, risk flooding reduction, pollution reduction, air quality improvement for people' health, well-being, and climate resilience. From these findings, the city's authorities should ensure green space management to increase their availability and accessibility for climate resilience of the Niamey's dwellers. Future research could focus on the group of people (rich vs. poor) who are more affected by the uneven urban green space accessibility to stand clearly out whether there is environmental injustice in Niamey city.

CHAPTER FOUR: DETERMINANTS OF THE URBAN GREEN SPACES MANAGEMENT PRACTICES IN NIAMEY CITY

4.1. Introduction

Face the ineffective of the public green spaces to provide sufficient benefits to the dwellers; the latter, as an essential part of greening, produces and protects green spaces through everyday practices on their private property across the city (Hungerford & Moussa, 2017). These urban green spaces management practices support the ecosystem services provided that the dwellers take responsibility for their yards across the city sustainably. They also have the potential to favor environmental connection between private yards and public green spaces thereby reducing the ecosystem disservices (Aronson et al., 2017). In this regard, the dwellers' attitude is essential for the sustainable management of urban green spaces (Ajewole et al., 2019); and individual behavior is a key (Nero et al. 2019). Given that the ability of urban green spaces to provide ecosystem services (benefits) depends on the management actions undertaken by the dwellers and the influencing factors (Nero et al. 2019), this chapter attempts to analyze the determinants of the management of urban green space practiced by the dwellers in the city of Niamey. To achieve this objective, the multinomial logistic regression model was applied to the urban green space management practices variable consisted of three categories corresponding to main activities reported by the respondents. It is about watering (category one), putting the fence (category two), and the others (category three) consisting of pruning/mowing, removing invasive species; and applying fertilizer.

4.2. Empirical Review

Traditionally, the urban green spaces management's responsibility behooves primarily to the municipalities (local authorities). Increasingly the local communities [1]are more involved in this management either independently or in cooperation due to the lack of funding during the process to support its cost (Mattijssen et al., 2018). This responsibility puts them at the core of the decision-making where the other stakeholders take on a distant role or associate with them (Ali, 2017). In this sense, the local communities knowledge and experience make them a masterpiece

[1] The local community refers to a group of interacting people sharing a nationality or culture and living in a common location, a town, city, village, or other areas with a formal government (WHO, 2002)

for effective urban green spaces management (Khirfan & El-shayeb, 2019) which increases the potential gains of green spaces by improving well-being and social cohesion. Consequently, the local communities participation in managing urban green spaces shows how to redress the usually accepted trend of decreasing biodiversity associated with urbanization (Dennis & James, 2016). This participation has multiple socio-ecological benefits and promotes overall urban green space management participation by increasing people's climate change adaptive capacity (Yoong et al., (2017), Clarke et al., (2019)).

Urban green spaces management is a series of actions undertaken to maintain and develop urban green spaces properly. These actions are conducted through applying fertilizer, planting trees, watering, putting the fence, removing the invasive species, maintaining the equipment, and guarding, carried out on more or less a daily basis in the green spaces (Lindgren, 2010). In Manchester city/UK, the management of urban green spaces is mainly carried out by local communities through community gardening, mowing grass, tree planting, invasive species removal, and native habitat restoration. These different activities have led to responsible management evaluated in terms of volunteer hours standardized by area reflected by the civic ecology stewards (Dennis & James, 2016). This civic ecology stewards in the Yokohama city/Japan has been influenced by the age of the citizens, their belief in adequate green, living period in the district, the expected benefits such as social and aesthetic, and their sense of responsibility to maintain the quality of the environment (Sakurai et al., 2015). Also, the commitment of the local communities is perceived by the willingness to create and control their own open spaces according to their needs and the spaces' meaning in their residence (Hassan & Mombo, 2017). The cognitive and emotional variables explain people's motivation and interest in participating in urban green spaces management. Once these variables are observed over the long term, people's perceptions and actions toward green spaces change (Masterson et al. 2017). Thus, the positive cognitive variables lead to the people's sense of ownership and belonging and their willingness to care for urban green spaces, which is limited by the failure of regulatory planning (Hossein et al., 2011). Essentially, people's behavior in managing urban green spaces is motivated by the benefits of the green space perception, the social status of the people associated with their lifestyles and life stages, their discretionary income, and their preference for aesthetics, safety, property values (Aronson et al., 2017). For instance, in Dhaka city/Bangladesh, people's perception of the benefits of urban green spaces and a better understanding of the cultural ecosystem services increase the urban green spaces management initiatives (South, 2021). Moreover, green spaces management activities are influenced by the authorities' seed assistance, the belief in green, and accessibility to green (Fedele et al., 2017). According to Shakeel & Conway, (2014), the household size and the number of years passed by the households in the current home influence the general landscaping activities in the city of Mississauga/ Canada. As to Grove et al., (2014) in New york city/USA, the family's house ownership, the households with more children, and the married family explain the vegetation cover associated with the people's private residential lands management. By looking at the case of San Juan city/ Porto Rico, Meléndez-Ackerman et al., (2014) found that the residential yard green management practices are strongly influenced by the yard area and partially by the respondent's age and their own house.

Empirical studies from African cities showed that managing urban green spaces is driven by socioeconomic, geographical, and environmental factors. In the city of Lagos/Nigeria, Ajewole et al. (2019) showed that the management of urban green spaces is influenced by how the households contribute to either money, materials, and facilities or volunteer hours in management practices. They showed that the volunteer hours in management practices are positively and significantly influenced by gender, marital status, and average monthly income, with 34.16% of the households who were willing to offer volunteer services for urban green spaces management versus 46.67% and 12.50% of the households who were respectively willing to contribute in cash and materials. In the city of Kumasi /Ghana Nero et al. (2019) revealed that urban green spaces management decisions are influenced by a person’s origin, whether urban or rural, their education level, and their short-term interests such as aesthetics, food, fodder, fuel wood, air quality improvement, shade, windbreak, flood mitigation. In the city of Abidjan /Cote d’Ivoire, Kouadio et al., (2018) argued that the money collected from residents for ecosystem services of public green spaces could contribute to the management of public urban green spaces and promote the creation of private urban green spaces through the subsidy. This subsidy could help the residents support the plants' high cost from landscapers or nurserymen (market). In the city of Dar es Salaam/ Tanzania, Hassan & Mombo, (2017) found that the perception of the households to the quality of green spaces and their benefits, the level of education, and the duration of residence positively influenced the households’ willingness to participate in urban green spaces management while the perceived cost, the age, the gender, the marital status and the source of income influenced it negatively. In the case of the city Niamey, Hungerford & Moussa, (2017) found that the trees as sources of food, heat mitigation, and esthetic, are managed via the micro-scale practices influenced by households status. However, they found this management practices are constrained by the households' access to space, water, and money across their neighborhoods. Above all, this chapter attempts to analyze the factors that influence the urban green space management practices in Niamey.

4.3. Methodology

To analyze the determinants of the urban green spaces management practices in Niamey city properly, the multinomial logistic model is applied based on the utility maximisation model from neoclassical theory used to understand the behaviour of the respondents in taking decisions about green spaces management. They are the most commonly used model for analysis of discrete choice options. The multinomial logistic model assumes that the response follows a categorical distribution under the independence of irrelevant alternative assumptions (IIA). This model provides more accurate results than the probit one which is far more computationally. Also, it is more flexible and provides highly interpretable coefficients (Greene, 2012). Previous studies on the urban green spaces management applied econometrical model depending on the nature of the dependent variables and sample size. Therefore, the categorical regression model was applied because of its ability to fit a small sample size (Hassan & Mombo, 2017), multivariate probit regression model because of its flexibility to deal with the correlated multivariate normal distribution of the latent dependent variables (Ajewole et al., 2019), and stepwise multiple regression analysis to identify the best fit model according to the different considered dependent variables (Sakurai et al., 2015).

4.3.1. Theoretical model

The theoretical model adopted in this chapter is grounded by the neoclassical utility maximization theory, in which the individuals' decision is guided by the utility they perceive as the maximum from their decision. Each option choice can be motivated by a random utility. As utility is a random variable, the model gives the probability of each alternative being chosen according to its relative utility (McFadden, 1973). We assume that the respondents' decision to practice an urban green spaces management activity as main activity is based on the relative perceived utility derived from alternative modalities in a decision set. This perceived utility from the alternative decision is more significant than that from other decisions and depends on the respondents' socio-economic and demographic characteristics (Greene 2012). In addition, we assume that the perceived utility depends on city's urban form as argued by the theory of spatial capital underpinned by urban planning theories. Therefore, the respondents' decision to practice an urban green spaces management activity can be also influenced by the factors such as districts status, occupancy status, and living period in the districts.

For the i^{th} respondent faced with J alternative, suppose that the random utility expressed as a function of a set of explanatory variables X is given by the following formula:

$$U_{ij} = x_{ij}\beta_j + \varepsilon_{ij} ...and....U_{ik} = x_{ik}\beta_k + \varepsilon_{ik} ....(\text{eq}: 4.1)$$

Where x_{ij} and x_{ik} are the vectors of explanatory variables, β_j and β_k are the vectors of the unknown parameters to be estimated, and ε_{ij} and ε_{ik} are the random disturbance term, introduced into the equation to capture unobserved or unknown impact factors since it is difficult to measure these factors objectively. If the respondents adopt the j^{th} practice in particular, we assume that U_{ij} is the maximum among the J utilities $U_{ij} \succ U_{ik}$. Hence, the model is driven by the probability that activity j practiced, which is $\text{Prob}(U_{ij} \succ U_{ik})$ for all other $k \neq j$ (Greene 2012).

$$\text{Prob}(U_{ij} \succ U_{ik}) = \Pr ob\left\lfloor (x_{ij}\beta_j + \varepsilon_{ij}) > (x_{ik}\beta_k + \varepsilon_{ik}) \right\rfloor ....(eq: 4.2)$$

Suppose the random disturbance terms ε_{ij} for the different modalities are iid across the alternatives. In that case, the probability of respondent i adopts for $y_i = j^{th}$ practice appears in the form of multinomial logistic distribution expressed as follows (McFadden, 1973).

4.3.2. Empirical model

The Multinomial logistic model is the most frequently model used to explain discrete choices and relies on the independent assumption of irrelevant alternatives (IIA). This assumption states that the odds of the probability of any two alternatives to be chosen by the respondent are independent of any other alternative in the choice set (Greene, 2012). The main advantage of the multinomial logistic model is that it allows the analysis of decisions across more than two categories and the determination of choice probabilities for different categories (Wooldridge, 2002). The empirical model is described via the following equation:

$$Prob(y_i = j / x_i) = \frac{e^{\beta x_i}}{1+\sum_{k=1}^{J} e^{\beta x_k}} \text{...}(\text{eq}: 4.3)$$

Where $i = 1, 2, 3$................N and $j = 1, 2, 3$............J

Therefore, from the estimation of the equation (4.3), j log-odds ratio is inferred which might provide a better summary of the effects of the explanatory variables on the urban green spaces management practices. Indeed, the parameter estimates of the multinomial logistic model provide only the direction of the effect of the independent variables on the dependent. We have the following equation:

$$\ln(\frac{P_{ij}}{P_{ik}}) = x_i^{'}(\beta_j - \beta_k) = x_i^{'}\beta \text{...}(\text{eq}: 4.4)$$

Under null hypothesis according to Hausman and McFadden test, these odds ratios/ coefficients are fixed whether a category is dropped or added. In other words, under this hypothesis, Hausman McFadden test indicates that the constraint and non-constraint models are statistically the same (Greene, 2012). The specified model is given as follow:

$$Y_i = \beta_0 + \beta_1 Age_i + \beta_2 Gen_i + \beta_3 \text{hhd\_size}_i + \beta_4 Mar\_status_i + \beta_5 Edu\_level_i + \beta_6 Work\_status_i + \beta_7 Income_i + \beta_8 Cost\_mana_i + \beta_9 Living\_per\_district_i + \beta_{10} \text{Occupancy\_status}_i + \beta_{11} District\_status_i + \beta_b \text{Benefits\_green}_i + \beta_{12} \text{Plant\_market}_i + \mu_i \text{...}(eq: 4.5)$$

4.3.3. Expected sign of the explanatory variables of the model

The table below gives the code, the label and the expected sign of the different explanatory variables of the above model.

Table 9: Explanatory variables and their expected sign

Variables	Code	Label	Expected sign
Age (Meléndez-Ackerman et al., (2014))	*Age*	Age	-
Gender (Hassan & Mombo, (2017), Ajewole et al. (2019))	*Gen*	Female	+/-
		Male	+/-
Household size (Shakeel & Conway, (2014); Grove et al. (2014))	hhd_size	Household size	+
Marital status (Grove et al. (2014); Hassan & Mombo, (2017))	*Mar _ status*	Unmarried	+/-
		Married	+/-
Education level (Nero et al. 2019)	*Edu _ level*	Unschooled	+/-
		Primary level	+
		Secondary level	+
		University level	+
Work status (Hassan & Mombo, 2017)	*Work _ status*	Unemployed	+/-
		Employed	-
Income (Aronson et al., 2017)	*Income*	<100000	+/-
		100000-200000	+
		200000-300000	+
		>300000	+
Cost of the management (Hassan & Mombo, 2017)	*Cost _ mana*	Cost management	-
Living period in the district (Hassan & Mombo, 2017)	*Living _ per _ district*	Court term	+/-
		Medium tern	+
		Long tern	+
Occupancy status (Meléndez-Ackerman et al., 2014)	Occupancy_status	Tenant	+/-
		Owner	+
District status (Aronson et al., 2017)	*District _ status*	Downtown zone	+
		Transition zone	+/-
		Periphery zone	+/-
Green spaces benefits (Nero et al, 2019)	Benefits_green	Food	+
		Shade	+
		Other	+
Market of the plant (Aronson et al., 2017)	Plant_market	No	+/-
		Yes	+

Source: Author from literature

4.4. Results and Discussion

4.4.1. Description of socio-economic demographic characteristics of households

The descriptive statistics show that the respondents' average age is 45.62564 years, proving the respondents' maturity in making decisions. The majority are male, married, and employed, with 72.05%, 82.82%, and 71.28% of affirmative answers. It is noticed that 27.44%, 14.36%, 46.67%, and 11.53% of the respondents earned respectively below 100000 XOF, between 100000 and 200000 XOF, between 200.000 and 300.000 XOF, and above 300000 XOF per month. Additionally, 31.54% of respondents have a university level, followed by those who have a secondary level 26.92%, a primary level 24.62%, and unschooled 16.92%. This is due to the status of the political capital of the city, whose main economic activity is commerce maintained by clerical work.

Accounting for an average of 7 people per household, 58.21% of the respondents own a house while 41.79% are tenants. The results revealed that 43.08% of the households live in the transition zone compared to those who live in the downtown and periphery zone with respectively 15.38% and 41.54%. In these different zones, 23.59% of the respondents lived for more than five years considered as a long-term, 35.90% for less than one year considered as court term and 40.51% live for the years between 1 and 5 considered as the medium term. Across the districts, the respondents practice their main activities such as watering, putting the fence, removing invasive species, pruning/mowing, and applying fertilizer for urban green spaces management. Thus, 34.62% water, 44.36% put the fence, and 21.02% removed the invasive species, pruned/mowed, and applied fertilizer. As cost of these management practices, the respondents support an average of 3078.718 FCfa per month. According to the results, 52.56% of the respondents reported getting the plants from nurserymen (market) motivated by the shade, food, and other reasons, respectively up to 58.97%, 24.36%, and 16.67%

Table 10: Definitions and summary statistics of qualitative variables

Variables name	Definition	Variable label	Percentage
Urban green spaces management practices	Nominal categorical variable taking 1 if the respondent practices watering as main activity, 2 if putting the fence, and 3 if others such as removing invasive species, pruning/mowing, and applying fertilizer;	Watering	34.62%
		Putting the fence	44.36%
		Others	21.02%
Gender	Dummy variable 1 if respondent is male and 0 otherwise	Female	27.95%
		Male	72.05%
Marital status	Dummy variable taking value 1 if married, 0 if unmarried	Unmarried	17.18%
		Married	82.82%
Education level	Nominal categorical variable taking 1 if the respondent is unschooled, 2 if primary level, 3 if secondary level, 4 if university level.	Unschooled	16.92%
		Primary level	24.62%
		Secondary level	26.92%
		University level	31.54%
Living period in the district	Nominal categorical variable taking 1 if court term, 2 if medium term and 3 if long term. Variable defined based on the residents 'number of years in the district. Thus, referring to the economy and finance theories, court term for less than 1 year, medium term for between 1 to 5 years and long term for above 5 years.	Court term	35.90%
		Medium tern	40.51%
		Long tern	23.59 %
Status of the districts	Nominal categorical variable equals to 1 if the household lives in Downtown zone (districts with complete urban fabrics), 2 if he lives in Transition zone (districts between downtown zone and periphery zone) and 3 if he lives in Periphery zone (districts with incomplete urban fabrics). This variable is defined based on the urban reference plan of Niamey (*PUR* 2009)	Downtown zone	15.38 %
		Transition zone	43.08%
		Periphery zone	41.54%
Occupancy status	Dummy variable taking 1 if the respondent is owner of house where he lives and 0 otherwise (tenant).	Tenant	41.79 %
		Owner	58.21%
Respondents' income per month	Nominal categorical variable representing the amount that household earns per month taking 1 if below to 100000, 2 if from 100000 to 200000, 3 if from 200000 to 300000, and 4 if 300000 to above.	<100000	27.44%
		100000-200000	14.36%
		200000-300000	46.67%
		>300000	11.53%
Work status	Dummy variable taking 1 if the respondent is employed in full or in part and 0 otherwise (retired, jobless, and housewives).	Unemployed	28.72%
		Employed	71.28%
The benefits of green spaces	Nominal categorical variable taking 1 if the respondent green for food, 2 if it is for shade, and 3 for other benefits	Food	24.36%
		Shade	58.97%
		Other	16.67%
Plant market	Dummy variable which equals to 1 if the respondent got plants from nurserymen (market) and 0 otherwise from municipalities or neighbors.	No	47.44%
		Yes	52.56%

Source: Field survey (2021)

Table 11: Definitions and summary statistics of quantitative variables

Variables name	Definition	Mean	Std. dev.
Age	Discrete/numeric variable representing the age of the respondent	45.62564	12.78609
Household size	Discrete/numeric variable: the number of the people living in the household. It is discrete variable	6.933333	3.55575
Cost of urban green spaces management	The amount that the respondent spent for the urban green spaces management per month in CFA defined as discrete/numeric variable.	3078.718	5987.673

Source: Field survey (2021)

4.4.2. Determinants of the urban green spaces management practices

As announced above, the multinomial logistic model has to satisfy the IIA assumption. Therefore, the IIA post estimation test of Hausman-McFadden was performed under null hypothesis which assumes that there is no systematic change in the coefficients/odds ratio if we excluded one of the categories from the model.

Table 12: IIA test

H_0=odds ratio are independent of other alternatives	$\chi^2(18)$	$\Pr ob \succ \chi^2$
	15.42	0.6331

According to the test, the statistic is positive but not statistically significant, even at 10%. We can interpret this result as strong evidence that we cannot reject the null hypothesis. That means that the IIA assumption is satisfied, explaining that the model with all categories or excluding one of the categories, in our case, category 2, does not have any systematic change in coefficients or odds ratio. Furthermore, the likelihood ratio (LR) statistic for this model (LR chi2 (40) = 183.30) shows that there is significance in at least one of the predictor's regression coefficients/odds ratios, which is not equal to zero. McFadden's Pseudo-R2 is equal to 0.2226. This means that the overall model fit is acceptable; thereby, it can provide accurate predictors of the dependent variable. Indeed, as suggested by McFadden (1973), the values of Pseudo R2 between 0.2 and 0.4 provide an excellent model fit. As expected, the variable "**green benefits**" is positive but only statistically significant for the shade category related to food. Likewise, the category "other green benefits," such as improving air quality, reducing heat waves, and infiltrating rainwater, also has the expected sign but is not significant. Therefore, the respondent's interest in shade is among the primary drivers of urban green spaces management practices. This means that the shade from urban green spaces increases the likelihood of managing urban green spaces. Specifically, the relative risk ratio (RRR) shows that respondents interested in the shade are more likely to manage urban green spaces. This result is in line with what Nero et al., (2019) in Kumasi city/Ghana who found that the shade from the trees considered a key factor for the existence and management of urban green spaces. Indeed, the shade generally under trees contributes to coping with the extreme heat via evapotranspiration throughout the hot season, providing an excellent place for relaxing, business, playing, and meeting people. Moreover, in the city of Niamey in particular and other cities of Niger, the shade from trees serves the shelter for people during social events, notably marriage or birth, place of relaxing and playing, and place of trade. The love of people 'shade results from the habits that they have in planting trees each 3rd August of the year decreed as festival day since 1960, thereby the trees planting become cultural (Sidikou, 2010). In this sense, these results are close to that of South (2021) in Dhaka city/Bangladesh who found that the cultural benefits from green spaces increase the urban green spaces management initiatives. In addition, shade from trees allows people to reduce solar radiation penetration and energy consumption, thus saving energy costs and cutting emissions from energy.

The results indicate that the variables such as gender, household size, education level, income, living period in the district, periphery district status, and plant market have a positive impact on the likelihood of managing urban green spaces. In addition to the benefits of green spaces, these variables determine urban green spaces management practices. However, the variables "work status," "the transition district status," and "cost of the urban green spaces management" have a negative impact on the likelihood of the respondents to manage the urban green spaces (table 13).

The gender: the respondent, "male," is more likely to manage urban green spaces than the female. This is expected since green space management activities assuming be hard for the women, are generally practiced by the men. As a result, Hassan & Mombo, (2017) argued that men participate more in green spaces management activities than women since men have easy access to information and are more involved in households' decision-making in developing countries. ***The household size***: the coefficient associated with this variable is positive and significant. This means that household size positively and significantly influences urban green spaces management practices; according to the associating odd ratio, the higher the household size, the higher the likelihood for the respondent to manage urban green spaces. This is highly expected because of the number of people living in the house, which increases the chance of having at least one free person to manage the urban green spaces as highlighted by Shakeel & Conway, (2014) especially when the households have many children. ***The education level***: the positive association between education level and management practices indicates that the higher the level of education of respondents, the higher the likelihood of the respondent for urban green spaces management. Indeed, respondents with primary, secondary, and university education levels are more likely to manage urban green spaces than the unschooled respondent. This is probably due to the capacity of the well-educated respondents to perceive the adverse effects behind the urban green spaces mismanagement compared to the unschooled respondents. This is similar to that found by Nero et al. (2019) in Kumasi city/Ghana. Likewise, Hassan & Mombo, (2017) in the case of Dar es Salam city/Tanzanie, found that under constant conditions, the higher the level of education, the higher the knowledge of the importance of conserving urban green spaces. ***The income per month*****:** the monthly income of respondents positively and significantly affects the likelihood of managing urban green spaces. Indeed, the respondents who reported their income per month between 100000 to 200000 XOF, between 200000 to 300000 XOF, and above 300000 XOF are more likely to manage urban green spaces compared to the respondents whose income per month is below 100000 XOF. This is expected because respondents' income can allow them to bear the management cost and remove the financial constraint, one of many Western African cities' main urban green spaces management problems. This is close to the findings of Kouadio et al. (2018) in Abidjan city/Cote d'Ivoire, highlighting that high-income respondents are more likely to contribute to urban green space management than low-income respondents. ***The living period in the district***: according to the results, the respondents who spent a long time in the district are more likely to manage urban green spaces compared to those who have lived in the district for a short time. This can be explained by the fact that the respondents who have lived for a long time are usually indigenous people or houseowners, thereby they pay more attention to their environment conditions than respondents who recently moved to the area. This is in agreement with the findings of Hassan & Mombo, (2017), who showed that the longer people live in the district, the more committed they are to preserving green spaces in Dar es Salaam City/Tanzania.

The periphery district status: the respondents who live in peripheral districts are more likely to manage urban green spaces than those who live in the downtown area. This can be explained by the fact that many green spaces, especially trees in these districts, will be restored, requiring daily maintenance. This agrees with the results of Nero et al., (2019) who found that people who live in the peripheral areas are more likely to have and maintain green spaces in their compounds than those who live in the city center. This result has been implicitly found by Hungerford & Moussa, (2017) in Niamey city/Niger who highlight that the peripheral districts have higher percentages of fruit trees, needed much more care than most other districts in the city. ***The plant market:*** the variable "plant market" positively and significantly impacts urban green spaces management practices. The results show that the respondents who report buying plants from the nurseries are more likely to manage urban green spaces. This makes sense because people who buy plants for their preference are more likely to take care. This is in line with the results of Aronson et al., (2017) in Munich city/Germany revealed that the ability to buy plants promotes the management of urban green spaces. Nevertheless, Kouadio et al. (2018) in Abidjan city/Cote d'Ivoire found that the dearness of the plants is a barrier for this management.

However, the results show that the factors such as the transition district status, the work status, and the cost of the management practices negatively influence the management of urban green spaces. ***The transition district status***: the respondents living in the transitional districts are less likely to manage urban green spaces by watering than those living in the downtown districts. Indeed, in Niamey, according to Hungerford & Moussa, (2017), water is one of the constraints of managing urban green spaces affecting much more the periphery and transition areas. ***The work status***: employed respondents are less likely to manage urban green spaces compared to the unemployed respondents. This result is counterintuitive since the work status is intimetely linked to the income of respondents, especially the respondents with high income tend to manage urban green spaces. Thus, it is expected that employed respondents be more likely to manage green spaces. It is maybe because the employed respondents do not have sometimes enough time for these activities as found by Hassan & Mombo, (2017). ***The cost of green management***: the increase in management practices cost decreases the likelihood of the respondents to manage urban green spaces. This may be due to the people's financial situation (money) to pay the water bill when the cost increases as indicated by Hungerford & Moussa (2017) in Niamey city. Indeed, this management of urban green spaces practice requires time and money. Therefore, Hassan & Mombo (2017) found that the higher the cost of urban green space conservation, the more people are unwilling to participate.

The results reveal that ***age* and *occupancy status*** have the expected signs but are not significant. Indeed, older people are less likely to manage urban grass spaces than young people, as found by Hassan & Mombo (2017) and by Sakurai et al., (2015). Some urban green space management practices like mowing require a minimum strength. Also, the respondents who live in their own houses are more likely to manage urban green spaces than the tenant since green spaces increase the value of their property, as highlighted by Hungerford & Moussa (2017).

Table 13: Estimation results for the driving factors of urban green spaces management

Categories	Watering			Others		
	Coef	RRR	Std. error (β)	Coef	RRR	Std. error(β)
Intercept	-4.000***	0.018***	1.114	-5.567***	0.004***	1.412
Age	-0.003	0.996	0.014	-0.002	0.997	0.015
Gender						
Female	Reference	Reference	Reference	Reference	Reference	Reference
Male	0.611*	1.842*	0.352	0.488	1.630	0.375
Household size	0.117**	1.124**	0.046	0.028	1.028	0.050
Marital status						
Unmarried	Reference	Reference	Reference	Reference	Reference	Reference
Married	0.478	1.613	0.429	-0.553	0.575	0.397
Education level			.			
Unschooled	Reference	Reference	Reference	Reference	Reference	Reference
Primary level	0.572	1.771	0.444	2.723***	15.234***	0.806
Secondary level	0.391	1.479	0.479	2.388***	10.895***	0.840
University level	0.634	1.886	0.539	3.230***	25.284***	0.856
Work status						
Unemployed	Reference	Reference	Reference	Reference	Reference	Reference
Employed	-0.850***	0.427***	0.320	-0.775**	0.461**	0.346
Income per month						
Below 100000	Reference	Reference	Reference	Reference	Reference	Reference
100000–200000	0.971**	2.642**	0.490	1.164**	3.204**	0.500
200000–300000	0.839**	2.314**	0.390	0.890**	2.433**	0.441
300000 above	0.785	2.192	0.594	1.073*	2.926*	0.567
Cost of management	-0.0001***	1.000***	0.00004	-0.000005	1.000	0.00003
Living period in the district						
Court term	Reference	Reference	Reference	Reference	Reference	Reference
Medium term	0.273	1.315	0.341	0.471	1.602	0.393
Long term	0.656*	1.928*	0.384	1.045**	2.843**	0.417
Occupancy status						
Tenant	Reference	Reference	Reference	Reference	Reference	Reference
Owner	0.499	1.647	0.327	0.054	1.055	0.373
District status						
Downtown	Reference	Reference	Reference	Reference	Reference	Reference
Transition	-0.965**	0.380**	0.424	0.347	1.415	0.504
Periphery	0.348	1.417	0.407	1.085**	2.961**	0.512
Green benefits						
Food	Reference	Reference	Reference	Reference	Reference	Reference
Shade	1.508***	4.519***	0.363	1.139***	3.124***	0.394
Others	0.790	2.204	0.527	0.228	1.256	0.542
Plant market						
No	Reference	Reference	Reference	Reference	Reference	Reference
Yes	1.425***	4.161***	0.331	0.911 **	2.486**	0.357
Number of observations				390		
LR chi2(40)				183.30		
Prob > chi2				0.0000		
Pseudo-R2				0.2226		
Reference category (default)				Putting the fence		
Log likelihood				-320.06712		

Significance levels (P>|z|): * p<0.1; ** p<0.05; *** p<0.01

4.5. Conclusion

The city of Niamey is expanding rapidly leading to the urban green space depletion associated with the weakness and failure of the urban green space management governance. Therefore, the dwellers as essential part of environmental management, green their homes across the neighborhoods through certain micro-scale activities such as fertilizer application, fencing, watering, removal of invasive species and pruning. This study analyses the determinants of urban green space management practices in the city of Niamey. By using the multinomial logistic model from the sample of 390 respondents randomly selected via stratified sampling method, this study revealed that the respondents who benefit shade from urban green spaces are more likely to manage the urban green spaces. In addition to shade from urban green spaces, gender, household size, education level, monthly income, length of time living in the districts, status of peripheral areas, and plant market have the significant positive influence on the urban green space management practices in the city of Niamey. However, the results found that the transition district status, the work status and the cost of management practices have the significant negative influence on the urban green space management practices. In light of these results, the city authorities should facilitate the access to plants to the dwellers by developing the plant market or by providing plants for free that can reduce the cost of the management. They should also sensitize the population about the importance of the greening through the training or an environmental course in school to reinforce people engagement. Finally, they should encourage the environmental association grouping the volunteers by district while financially accompany them in their activities. Future study could investigate whether the yard area and the number of green per residential also influence the management of the green space practices. Also, further study could take into account other parameters of the urban green space management beyond the financial capacity captured here by the dweller’s income, for instance the technical capacity.

CHAPTER FIVE: CONTRIBUTION OF THE URBAN GREEN SPACES TO CLIMATE RESILIENCE OF NIAMEY CITY

5.1. Introduction

Rapid urbanization increases the demand for energy, transport, water, and land, leading to air pollution, informal settlements in flood-prone, increased heat, and loss of biodiversity, thereby making cities more vulnerable to climate change in West African's cities (Anderson, B., J.E. Patiño Quinchia, and R. Preito Curiel, 2022). Thus, building urban resilience is crucial, especially in Niamey city, where low rainfalls and high temperatures characterize the climate; inadequate land use planning is associated with the loss of vegetation and the increase in the prone-flood area's occupation (Hungerford & Moussa, 2017). Although urban green spaces have the potential for climate mitigation and adaptation (Elmqvist et al., (2013), Staddon et al., (2018), Geest et al., (2019), and Francesca et al., (2021)), their contribution to climate resilience needs to be assessed in the city of Niamey. Thus, this chapter attempts to assess the contribution of the urban green spaces to climate resilience through the ecosystem services such as provisioning, regulating, cultural, and supporting services conditioned by urban green spaces management practices. For this purpose, the partial proportional ordered logistic model, which is the least restrictive ordered logistic model, was applied by using the primary data from 390 respondents. Thus, the climate resilience variable was defined according to the subjective approach, categorized into three (3) categories: low resilience, medium, and high resilience. To our knowledge, comprehensive studies have yet to summarize the evidence of the contribution of urban green spaces to climate resilience in the City of Niamey.

5.2. Empirical Review

In the context of climate change, urban green spaces, even small ones, make a significant contribution by yielding ecosystem services that enhance their ability to absorb and respond to disturbances (Jasmani, 2013). Therefore, urban green spaces play a crucial role in providing solutions to the effects of climate change (Geest et al.,2019). They directly increase general health and happiness, indirectly reduce noise, urban heat island effects, and crime rates, and improve air quality (Ma et al., 2019). They provide particularly natural cooling within dense, hot cities (Mathey et al.,2011), significant energy and resource that improves the natural capital and the adaptive capacity of citizens effectively (Kabisch et al., 2017). Thus, ecosystem services improve resilience to climate change and reduce the vulnerability of urban communities (Pauleit et al. (2017), Staddon et al., (2018)). In the case of Charlottetown City/Canada, Khirfan & El-shayeb, (2019) revealed that the ecosystem services from green infrastructure improve urban climate resilience-related persistence, adaptation, and transformation capacities. In the case of Chicago city, New York City, and Baltimore city, Clarke et al. (2019) found that green infrastructure, especially rain gardens, bioswales, and green roofs, improves climate change adaptation and resilience even though they are underutilized and primarily unprotected spaces. In the Coastal Cities/United States, Tauhid, (2018) revealed that green infrastructure, under its potential social, economic, and environmental benefits, can improve climate resilience through flood risk management, drought risk reduction, urban heat island effect reduction, and energy needed reduction at regional, city, neighborhood, and site scales. In the case of European cities, Cabral et al. (2017) found that the ecosystem services, particularly provisioning, regulating, and cultural provided by urban gardens, contribute to water regulation, air circulation, and cooling improvement, microclimate oases for many users, and leisure/ recreation for health and well-being, and promote social cohesion. Thus, Camps-calvet et al. (2016) identified 20 ecosystem services from urban gardens in Barcelona/Spain. The cultural services were the most widely perceived and the most highly valued. They specified that the elderly and people with low, middle income, and migrants are the primary beneficiaries of these services. Likewise, in Rotterdam City/Netherlands, according to Derkzen et al., (2017), people were more willing to adapt and mitigate the climate change impacts, mainly through the cultural services from green infrastructure. However, in Asia, particularly in the City of Guangzhou/China, Zhang, (2019) found that regulating services were the most critical services perceived by the respondents through air quality regulation, temperature regulation, noise control, and biodiversity protection.

The evidence from the African cities has also shown that the urban green spaces have the potential through the ecosystem services to enhance the climate mitigation and adaptation (Mngumi, (2020) ; Anderson, B., J.E. Patiño Quinchia, (2022)). For instance, in the City of Kumasi/Ghana, urban green spaces contribute to climate resilience by reducing urban heat islands, improving air quality, managing flash floods, reducing heat waves, reducing public health hazards, reducing regional mean temperatures, and droughts (Nero et al., 2019). Therefore, Kwadwo, (2013) revealed that the dwellers in Kumasi City were willing to pay for the ecosystem services from green spaces with the regulating services as much more perceived by the dwellers related to the provisioning and cultural services. Considering the green infrastructure as an adaptation strategy to lower the increased temperatures in Bobo-Dioulasso City/Burkina Faso, Faso & Francisco, (2016) found that land surface temperatures were lower in green infrastructure than in urbanized areas. Urban and peri-urban agriculture and forestry were adopted by municipalities to ensure food security and mitigate the flood which frequently hit the city. In Lagos City/ Nigeria, the urban green spaces benefit even the low-income households living in slums and informal settlements by providing food, medicinal herbs, modest monetary gains, social capital, flood regulation, temperature regulation, water form stream, firewood, and aesthetics (Adegun, 2021).

5.3. Methodology

In order to assess the contribution of urban green spaces to climate resilience, first, the climate resilience index was estimated via PCA based on the subjective approach regarding the availability the data at the city level (Jones, 2017). The association between this climate resilience index and the ecosystem services from urban green spaces was checked through the econometric model, mainly the partial odds logistic regression model. This association relies on the spatial capital theory according to which the urban infrastructure for instance green influences the urban life. Previous studies adopted generally the descriptive analysis for this assessment. However, there are many studies on the contribution of the urban green spaces to the human health and human well-being that used the econometrical modeling analysis. For instance, Ma et al. (2019) and Tsurumi & Managi (2015) use the seemingly unrelated regression model (SURE) to assess the effects of urban green spaces on the mental, physical and social life satisfaction separately.

5.3.1. Data modeling

Despite the little and no formalized resilience's theoretical foundation, this study is inspired by the study of Jones et al. (2018) who gave the possibility to analyze the climate resilience on the basis of the households' perceptions of their own capacities in the face climate disturbance. The subjective approach defined by Jones et al. (2018) is applied to estimate the climate resilience indicator based on the anticipation, absorptive, and adoptive capacities of the individual/

households in the face of the climate shocks they experience. Called 3As model, this model is grounded based on the households' perception of the 3As capacities using the four Likert scale points such as not at all likely, not very likely, very likely, and extremely likely (Jones et al., 2018). Finally, the principal component analysis (PCA) is applied for this climate resilience index. The latter as function of these three capacities depends on some factors such as Sociodémographic profile, climate change and variability, income and food access, access to water and health facilities, assets, diversity of income sources, sharing of resources and technology, access to basic services, ecological stability (location) and so on (Asmamaw et al., 2019).

Empirically, Jones, (2018) revealed that the climate resilience is influenced by age, marital status, gender, education, occupation status, status of the area, life satisfaction, climate shocks, and households status. In the context of urban area, the evidence from Sub-Saharan African cities revealed that access to essential services such as water, electricity, health care, education, housing and transportation, social networks, employment, the ownership of productive assets, and the building of flood-barriers influence the urban climate resilience (George, 2019). Likewise, the characteristics such as age, gender, income, and health status of the urban population are the factors that influence the urban climate resilience (IPCC 2015)

Therefore, we assume the climate shocks as the hazards that face the dwellers increase their exposure and reduce their resilience. We assume also that the ecosystem services from green spaces, the life satisfaction and the proximity to urban green spaces influence the climate resilience. As it is about dwellers' capacities to be resilient, so, we assume that the dwellers' socioeconomic and Sociodémographic characteristics such as gender, age, marital status, income, education, and occupancy status influence our model.

The 3As model can be described in the form of linear combination of these three capacities (Anticipatory, Absorptive, and adaptive capacities):

$$\text{Climate\_resilience\_index}_i = \lambda_1 f(Ant\_cap_i) + \lambda_2 f(Abs\_cap_i) + \lambda_3 f(Adap\_cap_i) ....(eq:5.1)$$

Where $\lambda_1, \lambda_2, and \lambda_3$, are respectively the principal components of the Anticipatory capacity (Ant_cap), the Absorptive capacity (Abs_cap), and the Adaptive capacity (Adap_cap).

Thus, the model is presented as follow:

$$Y_i = a + \alpha_1 x_{1i} + \alpha_2 x_{2i} + ... + \alpha_k x_{ki} + \varepsilon_i ....(eq:5.2)$$

Where Y_i is the climate resilience index, x_i is the explanatory variables, and α_i is the associating parameters.

According to the nature of the dependent variable (climate resilience), the ordered logistic regression is a suitable and the most commonly used model for regressing ordinal-scaled outcome variable. Indeed, the ordered logistic model was developed based on proportional odds assumption assuming that all coefficients/odds ratio are similar across the cut points. In the other words, it means that the relationship between the dependent variable and the explanatory variables does not depend on the category j. However, the probabilities of interest differ from the approach follow such as cumulative, stage, and adjacent approach defined respectively by ($\Pr(Y \le j) / \Pr(Y \succ j)$),($\Pr(Y = j) / \Pr(Y \succ j)$), and ($\Pr(Y = j) / \Pr(Y = j+1)$).Thus, if the dependent variable is an ordinal scale (e.g. income), the cumulative approach makes the most sense; if the dependent variable is a series of steps with logical starting and ending points (e.g.: educational level), the stage approach is more appropriate; and if the dependent variable contains the middle category in the ordinal scale, the adjacent approach is the most adaptable (Fullerton, 2009). In this chapter, the cumulative approach is used as the dependent variable "climate resilience" is ordinal scale (low, medium, and high resilience) defined by the scores which are calculated based three (3) resilience related capacities of the respondents. Thus, the probability of interest is the cumulative probability i.e., probability of being less than or equal to a specific category of urban climate resilience giving the vector of covariates x. Traditionally, within this approach, the proportional odds model is the most commonly used model under the proportional odds assumption (Mc.Cullagh 1980).

$$\Pr(Y_i \le j \mid x_i) = \frac{\exp(\lambda_j - x\alpha)}{1 + \exp(\lambda_j - x\alpha)} ....(eq:5.3)$$

Where i=1, 2,….., N (number of sample), j=1, 2,……..,J (number of category) and λ_j denote the cut points associated with j^{th} category. These unknown cut points are assumed to split the tendency into $j-1$ intervals. To ensure the well-defined intervals and natural ordering of the dependent variable, the cut points are assumed to be ascending in order $\lambda_0 \prec \lambda_1 \prec .... \prec \lambda_j$ (Greene 2012).

$$\ln\left(\frac{\Pr(Y_i \le j/x_i)}{\Pr(Y_i \succ j/x_i)}\right) = \lambda_j - x\alpha .... \text{with}(1 \le j \le J) .... (eq:5.4)$$

The probability of the respondents to be low, medium, and high resilient is given by:

$$\Pr(Y_i = j \mid x_i) = F(\lambda_j - x\alpha) .... (eq:5.5)$$

Where, x is a vector of explanatory variables such as the demographic and socio-economic characteristics of the respondent i, and climatic and geographic characteristics of the area of the respondent i, α is a vector of unknown parameters to be estimated, and λ_j denote the cut points associated with the j^{th} category.

The ordered logistic model considers low, medium, and high level of climate resilience to have the same slope except the intercept. For that, the parallel lines assumption[2] must be check following the Brant's Wald test (1990) as a post-estimation test. When the parallel lines assumption is violated, thus, the generalized ordered logistic model or partial proportional odds model relax this assumption across sample. By modifying the equation (eq:5.2) through the partition of α into a subset, the ordered logistic regression model (proportional odds model) becomes the partial proportional odds model by which some coefficients are the same for all the climate resilience level i.e., they respect the parallel lines assumption while some other are allowed to differ by j climate resilience i.e., they violate the assumption (Fullerton, 2009). Thus, the partial proportional model is expressed as follow:

$$\ln\left(\frac{\Pr(Y_i \le j/x_i)}{\Pr(Y_i \succ j/x_i)}\right) = \lambda_j - x\alpha - z\eta_j .... \text{with}(1 \le j \le J) .... (eq:5.6)$$

[2] The parallel lines assumption restricts the coefficients of each explanatory variable to be identical across the set of J–1 cumulative equations. It implies that $\alpha_1 = \alpha_2 = ... = \alpha_{J-1}$ (Greene, 2012)

Where x and z are the vectors of exogenous variables, λ_j is a cutpoint, α is the vector of the coefficients of the variables that meet the parallel lines assumption and η_j is the vector of the coefficients of variables that do not meet the parallel lines assumption.

Thus, the specified model is given by:

$$Y_i = \alpha_0 + \alpha_1 Age_i + \alpha_2 Gen_i + \alpha_3 hhd\_size_i + \alpha_4 Mar\_status_i + \alpha_5 Educ\_level_i + \alpha_6 Income_i + \alpha_7 Work\_status_i + \alpha_8 \text{Occupancy\_status}_i + \alpha_9 \text{District\_status}_i + \alpha_{10} E\cos\text{\_services}_i + \alpha_{11} C\lim ate\_shock_i + \alpha_{12} \Pr ox\_publ\_green_i + \alpha_{13} \text{Life\_satisf}_i + \varepsilon_i \ldots\ldots(eq:5.7)$$

.

5.3.2. Expected sign of the explanatory variables of the model

The table below gives the code, the label and the expected sign of the different explanatory variables of the above model.

Table 14: Explanatory variables and their expected sign

Variables	Code	Label	Expected sign
Age (Jones et al., 2018)	*Age*	Age	-
Gender (George, (2019); Jones et al., (2018))	*Gen*	Female	+/-
		Male	+
Household size (George, (2019)	hhd_size	Household size	-
Marital status (Jones et al. 2018)	*Mar_status*	Unmarried	+/-
		Married	+
Education level (Jones et al., 2018)	*Edu_level*	Unschooled	-
		Primary level	+
		Secondary level	+
		University level	+
Work status (George, 2019)	*Work_status*	Unemployed	-
		Employed	+
Income (George, 2019)	*Income*	<100000	-
		100000-200000	+
		200000-300000	+
		>300000	+
Climate shocks (Jones et al., 2018)	*Climate_shock*	High wind	-
		Flood	-
		Heat	-
Occupancy status (Jones et al. 2018)	Occupancy_status	Tenant	+/-
		Owner	+
District status (Marcus, 2010)	*District_status*	Downtown zone	+
		Transition zone	+/-
		Periphery zone	+/-
Ecosystem services (Nero et al., (2019), Adegun, (2021))	*E*cos_services	Provisioning	+
		Regulating	+
		Cultural	+
Life satisfaction (Jones et al. 2018)	Life_satisf	Low	+/-
		Medium	+
		High	+
Proximity to public green spaces (Braubach et al., 2017).	*Prox_publ_green*	No	+/-
		Yes	+

Source: Author from literature

5.4. Results and Discussion

5.4.1. Description of socio-economic demographic characteristics of households

The descriptive analysis shows that the respondents' average age is 45.62564 years, proving the respondents' maturity in making decisions. The majority are male, married, and employed, with 72.05%, 82.82%, and 71.28% of affirmative answers. It is noticed that 27.44%, 14.36%, 46.67%, and 11.53% of the respondents earned respectively below 100000 XOF, between 100000 and 200000 XOF, between 200.000 and 300.000 XOF, and above 300000 XOF per month. Additionally, 31.54% of respondents have a university level, followed by those who have a secondary level 26.92%, a primary level 24.62%, and unschooled 16.92%. This is due to the status of the political capital of the city, whose main economic activity is commerce maintained by clerical work. Accounting for an average of 7 people per household, 58.21%% of the respondents have their own house while 41.79 are tenants. The results revealed that 43.08% of the households live in the transition zone compared to those who live in the downtown and periphery zone, with 15.38% and 41.54%, respectively. Furthermore, the respondents of the city of Niamey face mainly three (3) climatic shocks during the last five years such as violent wind, flood, and high heat with respectively 37.69%, 32.05% and 30.26%. These shocks cause the livelihood lost, the diseases and even the death sometimes. The ability of the respondents to deal with these shocks is derived from the intertwined absorptive, anticipatory, and adaptive capacities, defined as components of these respondents' climate resilience. Therefore, 33.33% of the respondents are low resilient, 34.87% are medium, and 31.80% are highly resilient. Again, 18.72% of the respondents argued that they are lowly satisfied with their life, where 14.36% are moderately satisfied while 66.92% are highly satisfied. Fortunately, 66.92% of the respondents perceived the cultural services involving the shade, wood, aromatic, and medicine, 17.44% perceived the regulating services containing heat regulation, improving air quality and water interception, and 15.64% perceived the provisioning services containing shade, aesthetic and leisure/recreation.

Table 15: Definitions and summary statistics of qualitative variables

Variables name	Definition	Variable label	Percentage
Gender	Dummy variable 1 if respondent is male and 0 otherwise	Female	27.95%
		Male	72.05%
Marital status	Dummy variable taking value 1 if married, 0 if unmarried	Unmarried	17.18%
		Married	82.82%
Education level	Nominal categorical variable taking 1 if the respondent is unschooled, 2 if primary level, 3 if secondary level, 4 if university level.	Unschooled	16.92%
		Primary level	24.62%
		Secondary level	26.92%
		University level	31.54%
Work status	Dummy variable taking 1 if the respondent is employed in full or in part and 0 otherwise (retired, jobless, and housewives).	Unemployed	28.72%
		Employed	71.28%
Income per month	Nominal categorical variable representing the amount that household earns per month taking 1 if below to 100000, 2 if from 100000 to 200000, 3 if from 200000 to 300000, and 4 if 300000 to above.	<100000	27.44%
		100000-200000	14.36%
		200000-300000	46.67%
		>300000	11.53%
Occupancy status	Dummy variable taking 1 if the respondent is owner of house where he lives and 0 otherwise (tenant).	Tenant	41.79 %
		Owner	58.21%
District status	Nominal categorical variable equals to 1 if the household lives in Downtown zone (districts with complete urban fabrics), 2 if he lives in Transition zone (districts between downtown zone and periphery zone) and 3 if he lives in Periphery zone (districts with incomplete urban fabrics). This variable is defined based on the urban reference plan of Niamey (*PUR* 2009).	Downtown zone	15.38 %
		Transition zone	43.08%
		Periphery zone	41.54%
Climate shock	Nominal categorical variable equals to 1 if household experienced high Wind in the last five years, 2 if he experienced the Flood, and 3 if he experienced Heat.	Wind	37.69%
		Flood	32.05%
		Heat	30.26%
Climate resilience	Ordinal categorical variable taking 1 if low resilience 2 if medium, 3 if high estimated from subjective approach Jones et al. (2018).	Low	33.59%
		Medium	35.64%
		High	30.77%
Proximity to the public green spaces	Dummy variable equals to 1 if the respondent is near to public green spaces and 0 otherwise. This variable is defined based on WHO recommendations i.e., being at 15 min walking distance to green spaces to get the benefits.	No	58.46%
		Yes	41.54%
Ecosystem services	Nominal categorical variable taking 1 if Provisioning 2 if Regulating, 3 if Cultural defined according to the MEA (2005).	Provisioning	15.64%
		Regulating	17.44%
		Cultural	66.92%
Life satisfaction	Ordinal categorical variable taking 1 if low 2 if Medium and 3 if High. It is defined by the social, mental and physical life satisfaction. This variable measures the subjective well-being. It is analyzed alone in order to capture the effects of urban green spaces on the health.	Low	18.72%
		Medium	14.36%
		High	66.92%

Source: Field survey (2021)

Table 16: Definitions and summary statistics of quantitative variables

Variables name	Definition	Mean	Std. dev.
Age	Discrete/numeric variable representing the age of the respondent	45.62564	12.78609
Household size	Discrete/numeric variable: the number of the people living in the household. It is discrete variable	6.933333	3.55575

Source: Field survey (2021)

5.4.2. Classification of ecosystem services

Urban green spaces provide ecosystem services expected to contribute significantly to climate resilience. Widely used to communicate urban green spaces benefits, the ecosystem services must be carefully contextualized about the specific areas and time. Indeed, the ecosystem services and the benefits of urban green spaces can be observed differently from one location to another according to the period, and green spaces state. For example, the trees provide shade for cooling when they reach maturity, which is very helpful in the sunny period but differs from location (Luederitz et al., 2015). Therefore, the classification of the ecosystem services is very complicated due to the multi-functionality of the urban green spaces and the multiplicity of interactions between climate shocks, for example, flood events and pollution (Demuzrer et al., 2014). In the context of this study, ten (10) ecosystem services were identified and classified into three (3) categories, notably provisioning, regulating, and cultural, according to the study's context (figure 6). It is noticed, however, that the respondents did not perceive the supporting/habitat services and the disservices. Figure 6 below indicates that cultural services dominate these ecosystem services with 66.92 %. As the most widely reported, these cultural services consisted of shade, aesthetics, and recreation, with 92.74%, 34.65%, and 19.77% of responses. The shade is considered cultural insofar as it serves as a place where they meet to talk and to play for recreation and leisure, reinforcing social cohesion. The aesthetic is related to the green spaces used to beautify the houses to increase their property values. They are followed by regulating services which represent 17.44 % of services. The respondents assert that the urban green spaces allow them to infiltrate or intercept rainfall water with 5.9% against floods, reduce heat with 75.91%, and improve air quality with 60%. The provisioning services represent 15.64 % of the services explicitly dominated by food (fruits and vegetables), with 42.18% of the affirmative answers. The respondents also mentioned medicine at 35.11%, aromatic at 10.99%, and wood at 5.63%.

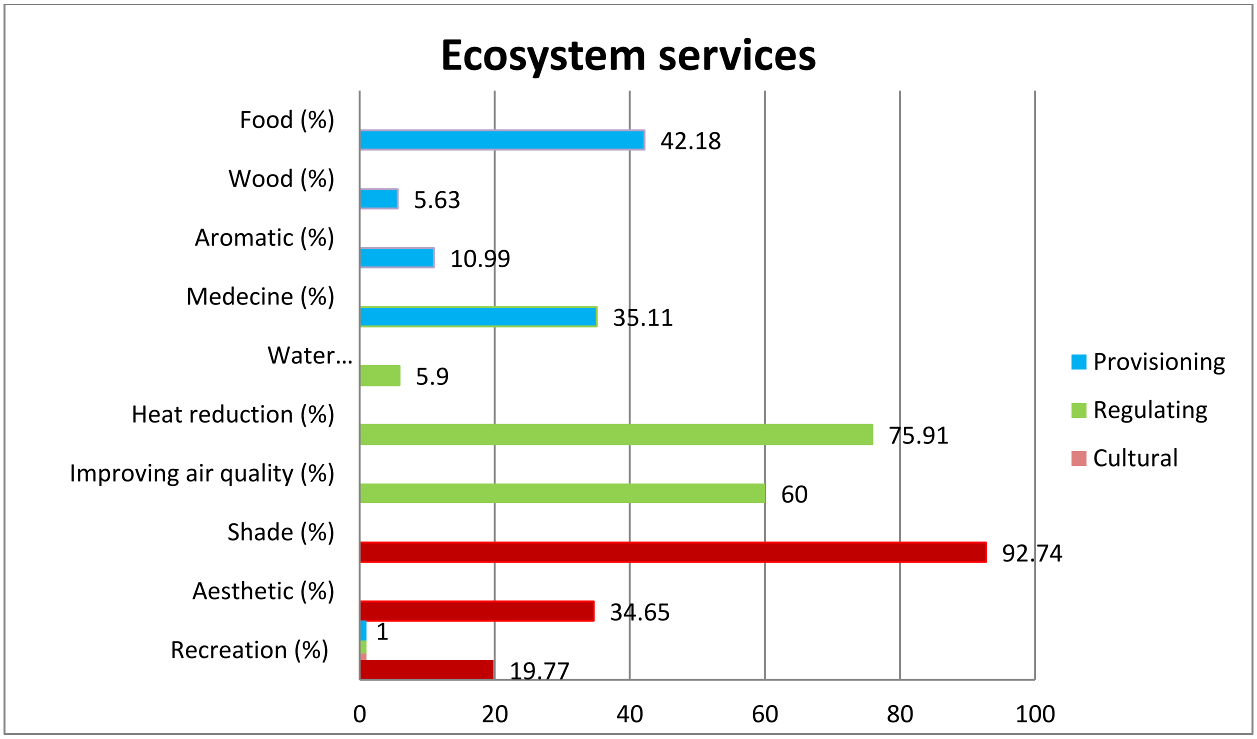


Figure 7: Classification of ecosystem services

5.4.3. Self-assessed resilience related capacities

The households self-assess their ability to prepare, recover, and adapt to the most reported climate shocks, such as high wind, flood, or heat, across the four (4) Likert scale points from not at all likely to extremely likely. Figure 7 indicates that 37.95%, 41.03%, and 27.95% of the respondents perceive themselves as highly likely to prepare, recover, and adapt to the main climate shock they experience. Again, 35.13%, 28.97%, and 37.69% of the respondents perceived themselves as very likely to prepare, recover, and adapt to the main climate shock they experienced. However, compared to 18.46%, 21.28%, and 17.69% of those who are not at all likely, 8.46%, 8.72%, and 16.67% of the respondents are respectively very likely to prepare, recover, and adapt to the main climate shock that they experience. Most respondents perceive themselves as very or extremely likely to prepare, recover, and adapt to the most reported climate shocks. Therefore, as the climate resilience derived from the average of these 3 As capacities, it is expected that most of the respondents be resilient to the climate shocks such as violent wind, flood, or heat.

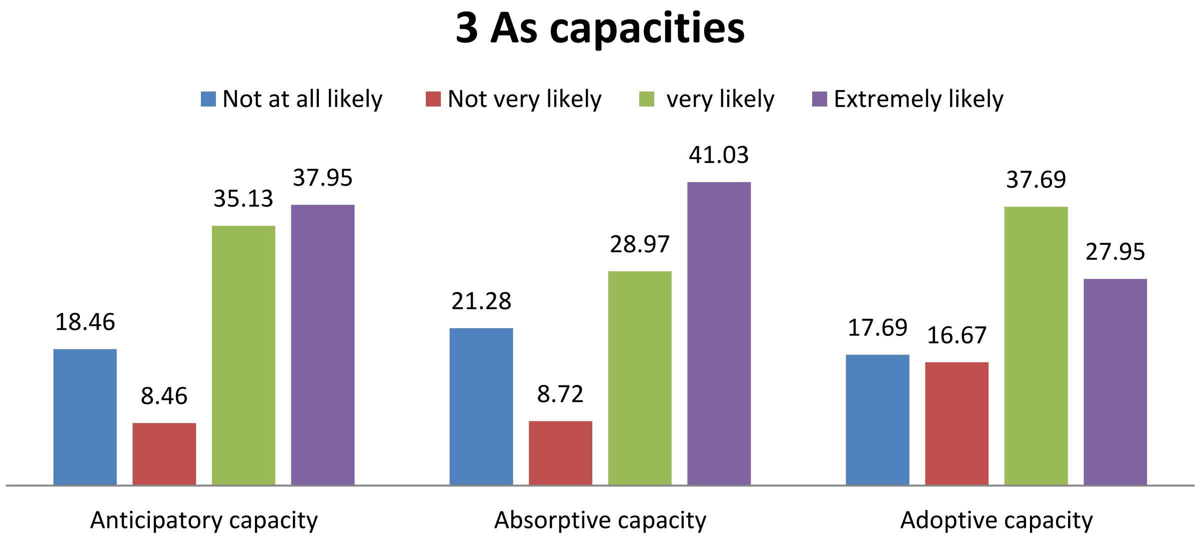


Figure 8: Resilience related capacities

5.4.4. Climate resilience index

From the data survey, the PCA was run, whose results were reported in tables (17) and (18) below. Table (17) indicates that from component 1 to component 3, the proportion of variance explained declines while the cumulative proportion of variance explained increases. Therefore, the three (3) capacities explained respectively 82.8%, 10.6%, and 6.6% of these variations. Also, the proportion of the variance explained by component 1 added to the variance explained by component 2 gives the resulting cumulative proportion of the variance explained. Thus, the three associating components contribute to a cumulative variation of 93.4% using an eigenvalue cutoff of 1.000. The eigenvalues represent the different values that explain the factorial axes, explained respectively up to 2.484, 0.318, and 0.197 by the components 1, 2, and 3.

Table 17: Principal components, eigenvalues, differences between the eigenvalues, proportion of variance explained, and the cumulative.

Component	Eigenvalue	Difference between eigenvalues	Proportion of variance explained	Cumulative
Comp1	2.484	2.166	0.828	0.828
Comp2	0.318	0.120	0.106	0.934
Comp3	0.197	.	0.066	1.000

Source: Field survey (2021)

It is noticed that the first component has the highest eigenvalue equal to 2.35, greater than 1 explaining 82.8% of the variance. Therefore, the variables (capacities) under this first component contribute respectively up to 0.592, 0.572, and 0.568 to the principal component axis, which depicts the first eigenvector. As a result, the overall resilience score is estimated by combining the first eigenvector with the three associated capacities of the leading principal component (table 18).

Table 18: Principal components (eigenvectors/factors scores)

Variable	Comp 1	Compo 2	Compo 3
Anticipatory capacity	0.592	-0.057	-0.804
Adaptive capacity	0.572	-0.673	0.469
Absorptive capacity	0.568	0.737	0.366

Source: Field survey (2021)

According to Jones, (2018), the climate resilience index is generated from overall resilience scores derived from the linear combination of these three capacities by dropping the components that contribute less. Therefore, the first component is considered to generate the overall resilience scores. The quantiles categorized these overall resilience scores into three groups: low score category, medium score category and high score category. The first category, considered low resilience, has scores varying from 1.718 to 4.06, corresponding to 33.59% of the sample. The second category, considered medium resilience has scores varying from 4.06 to 5.215 and correspond to 35.64%. The last one, as high resilience, has scores varying from 5.2157 to 6.9272, corresponding to 30.77%.

5.4.5. Partial proportional odds model results

The application of the ordered logistic model is under the proportional odds assumption/ parallel regression assumption. This assumption is tested via the Brant's Wald test under null hypothesis assuming that there is no difference in coefficients/odds ratio between the categories (table19).

Table 19: Brant's Wald test

H_0=odds ratio are the same between the categories	χ^2	$\Pr ob \succ \chi^2$
	48.79	0.001

χ^2 Statistic was statistically significant at 1%. So, we can reject the null hypothesis meaning that the parallel regression assumption is violated. We conclude that the odds ratio/coefficients are not equal across the categories. Alternatively, we would fit a less restrictive model either the generalized ordered logistic model or the partial proportional odds model. Therefore, according to the following new Brant's Wald test run, the chi2 statistic was not statistically significant indicating that the null hypothesis cannot be rejected; thereby the final model does not violate the parallel lines-assumption (Table 20).

Table 20: Brant's Wald test

H_0=odds ratio are the same between the categories	$\chi^2(18)$	$\Pr ob \succ \chi^2$
	12.84	0.801

As less restrictive model, Wald test shows 18 constraints have been imposed to have ten (10) variables that meet the parallel-lines assumption. For these variables, the sign of coefficients or the odds ratio are the same for all the categories and the interpretation is similar to that of the ordered logistic model. Of the thirteen (13) estimated coefficients, nine (9) associated with the variables gender, marital status, work status, education level, monthly income, climatic shock, life satisfaction, proximity to the public green spaces, and ecosystem services have a significant effect on the climate resilience. Therefore, table (21) below stands out those that meet the parallel lines assumption, such as marital status, education level, income per month, climate shocks, ecosystem services, life satisfaction, proximity to public green spaces, age of the respondents, household size, and occupancy status. According to the results, the chi-square likelihood ratio (24) is equal to 116.05 with a p-value of 0.0000. This indicates, under null hypothesis that the coefficients of the predictors are statistically different from zero. Therefore, the model as a whole is statistically significant compared to the null model without predictors with the value of the pseudo-R-squared which is equal to 0.1356.

The results showed that ***marital status*** is positively and significantly related to climate resilience. This means that the married respondents are more likely to be resilient than the unmarried. It is likely because the married are generally more responsible about making decisions facing any issue (Jones, 2018). According to the results, there is a positive association between the high level of education (***the education level***) and climate resilience (Jones, 2018), and also between high income per month (***the income per month***) and climate resilience. Indeed, the respondents with a high level of education are 2.172 times more likely to be resilient to climate change than the unschooled respondents, given that all the other variables are held constant. This result is expected as highly educated people are well aware of the effects of climate change and more likely to take action against them. Indeed, the ignorance alongside the denial effects is the primary psychological barrier to taking climate change adaptation or mitigation actions (Demuzere et al., 2014). Importantly, the respondents with income per month above 300000 XOF are more likely to be resilient to climate change than those with less than 100000 XOF. This is intuitive because respondents with high monthly incomes are supposed to have the means to take action against the climate change effects; for instance, to acquire solar energy to counter the power cut to reduce the heat. Contrariwise, the low-income respondents would find themselves facing the climate shocks effects with difficulties in taking concrete actions, especially for some who live in the informal settlements.

According to the results, the city of Niamey has mainly experienced three (3) climate shocks, such as wind, flood, and heat, as reported by the respondents. As expected, the sign of ***the climate chocks*** variable is significantly negative. Thus, compared to the respondents who experienced the high wind event, the respondents who experienced heat or flood shock are less likely to be resilient. This is due to the city's climate, which is semi-arid Sahelian, characterized by the high temperature, on average, fluctuating between 22°C and 36°C per month during the year. Also, the city frequently observes flooding during the rainy season, which affects the dwellers' livelihood making them more vulnerable, while violent wind event rarely happens between June and July (figure 3). In this regard, the urban green spaces, through their services, are seen as strategy tools and as a godsend to boost resilience to these climate shocks. This result is line with the results of Jones (2018). Thus, "***Ecosystem services***" provided by the urban green spaces affect climate resilience positively. Indeed, compared to respondents who perceived the provisioning services, those who perceived the regulating and cultural services of green spaces tend to be significantly more resilient to climate change. This result reveals that the role of urban green spaces in reducing the high temperature, the risk of flooding via rainwater infiltration or interception, making the place cooler via evapotranspiration, and improving air quality via the absorption of CO_2 while releasing oxygen in the atmosphere. These results are in line with the findings of Clarke et al., (2019), Cabral et al., (2017), Camps-calvet et al., (2016), Derkzen et al., (2017), and Zhang, (2019). Regarding cultural services, this study demonstrated that urban green spaces contribute significantly to recreation and social activities such as playing and meeting, which affect the respondents' health and well-being by making them less stressed. Also, they increase the property value through the esthetic. This result is much expected since the households in Niamey city plant trees generally for the shade increasing recreation while reinforcing social cohesion, as found by Hungerford and Moussa, (2016) and for heat and air pollution reduction through the carbon stocks' ability to ensure the biomass (Moussa et al. (2019); Illiassou et al. (2016)). Definitely, these results confirm the third hypothesis by which urban green spaces contribute to climate resilience in Niamey city. This agrees with the findings of Nero et al., (2019) in Kumasi City, highlighting that urban green spaces contribute to climate resilience by improving air quality, reducing heat waves and flood risk, and improving health and well-being. These results show that the urban green spaces can act as Nature-based solutions to climate change for the respondents in the City of Niamey. Thus, they allow facing the power cut, especially during summer, and reduce energy consumption and cost when the energy demand exceeds the supply. Also, they provide oxygen by constituting the carbon sink which improves air quality and residents' health rendering the city more livable. To this effect, the respondents' ***life satisfaction*** reflecting their well-being significantly influences climate resilience. Indeed, the respondents who are highly or moderately satisfied with their life are more likely to be resilient to climate change than those who are low satisfied with their life. This is expected as the respondents' happiness should strongly affect their capacity to cope with, adapt, and anticipate climate change, mainly because how people feel about their lives today can help them consolidate the resource to weather the storm tomorrow (Mguni et al. 2010). This positive correlation between life satisfaction and climate resilience has been found by Jones (2018). Interestingly, the positive association between ***the proximity to public green spaces*** and climate resilience showed that the respondents close to public green spaces within 15 minutes of walking distance are 1.753 more likely to be resilient than those far from them. This corroborates the potential of urban green spaces for climate resilience. Indeed, this result is expected since the proximity to the urban green spaces promotes physical activities such as walking, jogging, running, recreational activities, and social cohesion. This makes people near the green spaces more relaxed and less stressed, with a good mood, lower rate of depression, and good health by breathing quality air. This reduces the further cost of illness and thereby increasing their financial capacity. Consequently, they would be more likely to be resilient in the face of perturbations such as environmental extremes, floods, conflicts, or food insecurity (Braubach et al. 2017).

The age of the respondents positively influences climate resilience, but they are not statistically significant. According to the odd ratio, the older respondents are more likely to be resilient to climate resilience. Then, the results show that ***household size*** negatively affects climate resilience but not significantly, meaning households with large sizes are less likely to be resilient. This is expected because of the weight of the family to be supported. Unsurprisingly, the variable "***occupancy status***" has a negative sign even though it is not statistically significant. This is possible, especially in Niamey where the respondents who dwell in the areas with higher risk of flooding like some districts of commune II and V experience frequently the flood events in addition to the heat waves during the summer.

Table 21: Estimation results for the climate resilience

Variables	Coefficients	Odds ratio	Std. error(coef)
Age	0.014	1.014	0.009
Household size	-0.030	0 .970	0.031
Marital status			
Unmarried	Reference	Reference	Reference
Married	0.550*	1.733*	0.289
Education level			
Unschooled	Reference	Reference	Reference
Primary level	0.075	1.078	0.328
Secondary level	0.221	1.234	0.350
University level	0.775**	2.172**	0.382
Income per month			
Below 100000	Reference	Reference	Reference
100000-200000	-0.425	0.654	0.342
200000-300000	0.293	1.341	0.285
300000 above	0.995**	2.704**	0.419
Occupancy status			
Tenant	Reference	Reference	Reference
Owner	-0.103	0.902	0.239
Climate shocks			
Wind	Reference	Reference	Reference
Flood	-0.754***	0.470***	0.262
Heat	-0.580**	0.560**	0.279
Life satisfaction			
Low	Reference	Reference	Reference
Medium	0.770***	2.159***	0.374
High	0..699**	2.012**	0.286
Ecosystem services			
Provisioning	Reference	Reference	Reference
Regulating	1.608***	4.992***	0.394
Cultural	0.886***	2.427***	0.312
Proximity to public green spaces			
Far	Reference	Reference	Reference
Near	0.561***	1.753***	0.214
Number of observations	390		
LR chi2(24)	116.05		
Prob > chi2	0.0000		
Pseudo R2	0.1356		

Significance levels (P>|z|): * p<0.1; ** p<0.05; *** p<0.01

Table (21) draws the variables that do not meet the parallel lines assumption, notably gender, work status, and district status. For these variables, the coefficients or odds ratio differ from the low, medium, and high resilience categories and their interpretation will be similar to those from the multinomial logistic model.

Gender: the gender variable has a negative and significant effect on the low level of climate resilience. Compared to women, men are less likely to be low resilient. This is expected as women are more vulnerable, according to many studies, especially in African countries where traditionally, women have less access to socioeconomic resources (Jones (2018), George, (2019)).

Work status: the results effectively show a positive and significant association between work status and climate resilience, but the coefficients decline across cut-points. Meaningfully, the employed respondents are more likely to be resilient than the unemployed, but the effects become much weaker when the climate resilience level moves from low to high. This is expected since the employed respondents are supposed to have a minimum income to ensure their livelihoods during and after the shocks. This change in the effects is probably due to poor working conditions, such as lack of job security and limited support, which many respondents who operate in the informal sector experience. In fact, according to World bank, (2017), the city of Niamey constitutes the employment opportunities' place for newcomers who generally engage in the informal sector without job security and often settle in the slums, considered the most exposed areas to climate shocks. These informal settlements are found mainly in the periphery and transition districts with unreliable electricity system and insufficient gutters for draining water. Therefore, the results revealed a negative association between the ***district status*** and climate resilience but not statistically significant. This indicates that the respondents who live in the transition zones are less likely to be climate resilient. However, the respondents living in the periphery areas are less likely to be low resilient but more likely to be medium resilient.

Table 21 Estimation results for the climate resilience (Continued)

Categories	Low resilience			Medium resilience		
	Coef	**Odds**	**Std. error (coef)**	**Coef**	**Odds**	**Std. error (coef)**
Intercept	-2.109**	0.121**	0.870	-4.072***	0.017***	0.893
Gender						
Female	Reference	Reference	Reference	Reference	Reference	Reference
Male	-0.537*	0.584*	0.293	0.264	1.303	0.299
Work status						
Unemployed	Reference	Reference	Reference	Reference	Reference	Reference
Employed	1.428***	4.171***	0.264	0.501*	1.650*	0.281
District status						
Downtown	Reference	Reference	Reference	Reference	Reference	Reference
Transition	-0.314	0.730	0.324	-0.314	0.730	0.324
Periphery	-0.263	0.768	0.349	0.304	1.356	0.345
Number of observations			390			
LR chi2(24)			116.05			
Prob > chi2			0.0000			
Pseudo R2			0.1356			
Reference category (default)			High resilience			

Significance levels (P>|z|): * p<0.1; ** p<0.05; *** p<0.01

5.5. Conclusion

The City of Niamey, as most urbanized city of Niger observes the increase in the demand of land for the settlements at the expense of the Agriculture and biodiversity. This situation increases the vulnerability of its population in the face of the climate shocks such as floods, heat, and violent wind. Building for climate resilience of its population is become essential especially with the increase in floods risk and its consequences on livelihood and health these last years. Therefore, the urban green spaces via the provisioning, regulating, cultural, and supporting services are considered a promising solution to tackle these climate shocks. On the basis of these ecosystem services, this study attempts to assess the contribution of the urban green spaces to the climate resilience. For that, the partial proportional odds regression model as particular case of ordered regression model is used on the primary data collected from 385 respondents which are randomly selected via stratified random sampling method. In addition, the dependent variable "climate resilience" is defined through a climate resilience index estimating subjectively by the principal component analysis (PCA). The results show that the respondents who perceived regulating and cultural services from urban green spaces are more likely to be resilient compared to those who perceived the provisioning services. Additionally, the respondents who are near the public green spaces are more likely to be resilient compared to those who are far from these spaces. These results revealed that the ecosystem services from urban green spaces increase significantly the respondents' climate resilience. They also revealed that marital status, work status, education level, monthly income, and life satisfaction increase significantly the likelihood of being climate resilient. In contrast, gender, and climate shock decrease significantly the likelihood of being climate resilient. Further study could attempt to identify the willingness to pay of the respondents for the ecosystem services. Also, the data used in this paper are self-reported and cross-sectional. Thus, there may be a desirability bias or memory effect, especially the climate resilience index is defined based on the subjective approach.

GENERAL CONCLUSION

Face to the rapid urbanization coupled with the climate change, cities in West Africa become increasingly more vulnerable to climate change stimulating the need of enhancing their climate resilience. In this context, the urban green spaces by their ecosystem services are considered as one strategy to enhance the climate resilience. However, the urban green spaces are not well managed leading to their depletion. Thus, this study investigates the way urban green spaces contribute to climate resilience in Niamey City as a case study of West Africa's big cities. Specifically, it is about the analysis of urban green spaces accessibility, the urban green spaces management practices and their contribution to the climate resilience. For that, the chapter one reviews the different theories, concepts, and approaches for the climate resilience. The chapter two provides a methodology framework including research design, data collection, and data analysis methods for each specific objective. The chapter three analyzes the urban green spaces accessibility related to the current state in the city of Niamey based on the green index per capita, proximity to the public green spaces indicator, and qualitative indicators such as safety, attractiveness, and comfort. Thus, the primary and secondary data, semi- structured interviews, focus group discussions, and personal observation are used. The chapter four analyzes the determinants of the urban green space management practices by using the multinomial logistic regression model derived from utility random model. The last chapter assesses the contribution of the urban green spaces to the climate resilience by applying the partial proportional odds regression model. To do so, the subjective approach is used to calculate the climate resilience index based on the anticipative, absorptive and adoptive capacities. Also, the variable ecosystem services used to assess the contribution urban green spaces is classified via the millennium ecosystem assessment (MEA).

We found that, despite the green index per capita of 6.04m^2 less than WHO minimum standard of 9m^2, the respondents who are close to the public green spaces within 15 minutes walking distance are more likely to be resilient to climate change. We found also that the green index per capita is unevenly accessible; thus, commune V, IV, III, II, I has respectively 0.008 m^2, 21m^2, 2.30 m^2, 0.242 m^2, and 0.155 m^2. According to the semi-structured interviews, focus group discussions, personal observations, and some documents analysis, this situation is assigned to the informal settlements, the lack of funding for greening, and corruption in parcels allotment, which in turn reduce not only the quantity but also the quality of green spaces related to their attractiveness, comfort, and safety. Thus, this reduces the public green spaces potential benefits for the city's climate resilience likely to compromise the achievement of SDG 11.7. Regarding the ineffective functions of public green spaces, the dwellers as essential part of environment change, manage urban green spaces around their homes through some practices (Hungerford & Moussa, 2017). According to our findings, these urban green space management practices are positively influenced by shade as benefit from green spaces, gender, household size, education level, monthly income, length of time living in the districts, the status of peripheral areas, and market of the plant. This study concludes that the benefits of urban green spaces are one key driver of the respondents 'commitment vis-a-vis of the urban green spaces management. The benefits from urban green spaces classified into three ecosystem services such as provisioning, regulating, and cultural corroborate the potential of the urban green spaces to contribute to climate resilience of the respondents in Niamey city. Therefore, we found that the respondents who perceived the regulating and cultural services are more likely to be resilient to climate change than those who perceived the provisioning services. This is revealed by Cilliers et al. (2013) and Enu et al. (2022) in the case of Sub Saharan African cities. It is to say that the private green spaces complete the public green spaces in providing ecosystem services for the city, thereby promising the achievement of SDG 11.7. Also, the urban green spaces can act as a nature-based solution to the climate change effects in the City of Niamey.

However, the information from the primary data is cross-sectional and subjected to the desirability bias or memory effect, not least since some interview questions are related to the respondents' income, and respondents' perception of climate change and their capacities to cope with climate change effects. Secondary data could help to apply an objective approach to evaluate the climate resilience of the whole city. Indeed, the subjective approach used to climate resilience index is based on the respondents' perceived capacities to anticipate, to absorb, and to adapt to the climate shocks through the four points likert scale treated as continuous. For future studies, clear attention must be paid to the specific group of people (rich vs. poor) across the city to stand out clearly whether there is environmental injustice in Niamey. Also, it is important to conduct another study for dwellers' perception of public green spaces and their willingness to pay for the related ecosystem services in order to understand the dwellers' ability to value them.

Policy implications

From the key findings, this study presents some policy implications:

- The disparity of green accessibility between the communes should be reduced by fighting against corruption and by increasing environmental stewardship through environmental education program, which can reduce the risk of green spaces being hijacked for other purposes in order to the achievement of SDG 11.7;
- The private green spaces should be encouraged across the city by providing plants and technical assistance to the dwellers, which could reduce the cost of management of green spaces, thereby allowing low-income dwellers access to them and increasing their likelihood of being climate resilience;
- The markets of the plants (nurseries) should be organized, not least since this activity becomes income generating activity; by the way, it can be a source of tax for the local communities and can increase the provision of the open green spaces across the city;
- The allotment of the new parcels should envisage the urban green spaces provision likely to reduce the city's vulnerability to climate change and increase the likelihood of the dwellers to be good health and climate resilient;
- The contingent evaluation especially the willingness to pay for the ecosystem services or the cost-benefits analysis should be conducted to evaluate the real environmental and social impacts of the urban green spaces to each dweller across the city.

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APPENDICES

Appendix A : Research authorization

REPUBLIQUE DU NIGER

FRATERNITE – TRAVAIL - PROGRES

MINISTERE DE L'ENSEIGNEMENT SUPERIEUR ET DE LA RECHERCHE

******

DIRECTION GENERALE DE LA RECHERCHE ET DE L'INNOVATION

****

DIRECTION DE LA RECHERCHE
BP : 628 /Niamey Niger
Tél: (227) 20.75.31.10 /20.75.31.08

N° 00211 /MES/R/SG/DGRI/DR

Niamey, le 03 MAI 2021

Le Ministre

A

M Yahaya Maâzou Moussa
Etudiant à l'Université Cheikh Anta Diop de Dakar, Sénégal

Objet : Autorisation de recherche sur le thème : « *Espaces verts urbains et leur contribution à la résilience des grandes villes ouest africaines : Etudes de cas de la vie de Niamey* »

Réf : V/ D N°00744 du 22 mars 2021

En réponse à votre correspondance citée en référence, j'ai l'honneur de vous faire connaître que votre requête rencontre mon agrément. Toutefois, vous devrez vous conformer aux dispositions ci-après :

1. Cette autorisation est valable un (1) an renouvelable à compter de la date de sa signature et ne peut être utilisée pour une recherche quelconque de financement. Par ailleurs, cette autorisation ne couvre que les recherches sur le terrain cité en objet. Tout autre programme de recherche au-delà de ce qui a été retenu doit faire l'objet d'un accord préalable avec mon département ministériel.

2. Cette autorisation de recherche sur le terrain est accompagnée lors de chaque visite de terrain par une feuille de déplacement sur le terrain fourni par la Direction de la Recherche Scientifique.

3. Vous devez préalablement à vos investigations prendre contact avec les autorités coutumières et administratives locales (Gouverneurs, Préfets, Maires,) des zones concernées et leur présenter votre autorisation. Ces autorités doivent être informées et consultées sur vos opérations scientifiques et vous êtes tenu de respecter les coutumes des populations.

4. À la fin de vos recherches, il vous est requis de déposer :

- *A la Direction de la Recherche* : un rapport de mission, une copie de tout document sonore ou audiovisuel que vous aurez réalisé, deux (2) exemplaires de toutes les publications issues de vos recherches et ceci dans un délai d'un (1) mois à partir de sa date de parution.
- *A l'Institut de Recherche en Sciences Humaines (IRSH)* : tout matériel paléontologique et/ou archéologique que vous aurez collectionné.

En tout état de cause, le non-respect des dispositions ci-dessus constitue une violation de la réglementation en vigueur au Niger qui entraîne par conséquent le non Renouvellement de l'autorisation de recherche et vous expose à des sanctions prévues par la loi.

Veuillez agréer, Monsieur, l'expression de mes encouragements.

REPUBLIQUE DU NIGER – TIMBRE FISCAL 5 000 FRANCS E324433

REPUBLIQUE DU NIGER – Ministère de l'Enseignement Supérieur et de la Recherche – Le Ministre

Mamoudou DJIBO, Ph.D.

B

Appendix B: Survey questionnaire

Cette enquête rentre dans le cadre de nos travaux de thèse portant sur les espaces verts et leur contribution à la résilience de grande ville Ouest Africaine : Cas de la ville de Niamey

Questionnaire ménage

(Ce questionnaire est adressé aux résidents, chefs de ménages de la ville de Niamey)

Nous vous remercions de votre précieux temps accordé pour répondre à nos questions. Nous vous remercions également de votre collaboration.

1. **IDENTIFICATION**

N°	QUESTIONS & REPONSES	CODES/ZONES DE REPONSES
Q1	Code de l'enquêteur	/___/___/___/___/
Q2	Quartier de résidence : ____	
Q3	Date : /_______/_______/_________/	

2. **INFORMATION GENERALE sur le ménage**

N°	QUESTIONS & REPONSES	CODES/ZONES DE REPONSES
Q4	Nombre total de personnes dans le ménage	/___/___/
Q5	Répondant *1=chef de ménage 2=Femme du chef* ***NB: (l'enquête s'intéressera uniquement au chef de ménage ou sa femme)***.	/___/
Q6	Genre : 1=Homme 2= Femme	/___/
Q7	Quel âge avez-vous?	/___/___/
Q8	Statut Matrimonial : *1= Marié (e) 2= Célibataire 3= Divorcé/Séparé (e) 4= Veuf (Ve)*	/___/

N°	QUESTIONS & REPONSES	CODES/ZONES DE REPONSES
Q9	Niveau d'éducation/ Instruction *1=Non scolarisé* *2=Niveau Primaire ;* *3=Niveau Collège ;* *4=Niveau Lycée ;* *5=Bachelier ;* *6=Niveau licence ;* *7=Niveau master et plus*	/___/
Q10	Quelle est votre principale source de revenus ? *1= Agriculture 2= Élevage 3= Commerce/Business 4= fonction publique, 5=Administration privée, 6=Autre (à spécifier)* ____	/___/
Q11	A combien estimez-vous votre revenu par mois ? 1= Moins de 100000; 2= De 100000 à 200000 ; 3= De 200000 à 300000 ; 4= De 300000 à plus	/___/
Q12	En moyenne combien dépensez-vous par jour?	/___/___/___/___/
Q13	Depuis combien de mois vivez-vous dans ce quartier ?	/___/___/
Q14	De quel type est la maison (**Instruction : veuillez observer seulement**) 1=Ciment 2=Banco, 3=Paillote 4=Autre à Spécifier ____	/___/
Q15	Quel est le statut d'occupation de votre logement? *1= Propriétaire 2=Locataire 3=logé gratuitement* *4=Autre à Spécifie)* ____	/___/
Q16	Quel est le nombre d'actifs dont dispose votre ménage ? ***(Instruction : tâchez d'écrire le nombre pour chaque choix)*** 1=Têtes de bétails 2=Volailles 3=Véhicules 4=Motos 5=Télévision 6=Réfrigérateur 7=Climatiseur	 /___/___/ /___/___/ /___/___/ /___/___/ /___/___/ /___/___/ /___/___/

D

N°	QUESTIONS & REPONSES	CODES/ZONES DE REPONSES
Q17	Parmi les phénomènes suivant, lequel subissez-vous principalement au cours de ces 5 dernières années? 1= Vent violent 2= Inondation 3= Chaleur excessive 4= Sècheresse 5= Pollution 6=Autre à préciser	/___/
Q18	Si Q16.1=Oui, parmi les stratégies suivantes, laquelle ou lesquelles avez-vous utilisé pour y faire face : 1=Construire une digue, 2=Créer un caniveau 3=Monter la maison en hauteur 4=Créer des passages d'eau 5=Planter des arbres capable d'absorber l'eau 6=Autre à préciser________________________________	/___/ /___/ /___/ /___/ /___/ /___/
Q19	Si Q16.2=Oui, parmi les stratégies suivantes, laquelle ou lesquelles avez-vous utilisé pour y faire face : 1=Déménager vers une zone moins polluée 2=Planter des arbres 3=Mettre des gazons 4=Autre à préciser_____________________________________	/___/ /___/ /___/ /___/
Q20	Si Q16.3=Oui, parmi les stratégies suivantes, laquelle ou lesquelles avez-vous utilisé pour y faire face : 1=Mettre le climatiseur 2=Utiliser le ventilateur 3=Se mettre sous un hangar 4=Se mettre sous un arbre 5=Se rendre dans un espace vert public 6=Autre à préciser ____	/___/ /___/ /___/ /___/ /___/ /___/
Q21	Si Q16.4=Oui, parmi les stratégies suivantes, laquelle ou lesquelles avez-vous utilisé pour y faire face : 1=Rester à la maison 2=Arroser la devanture de la maison 3=Planter des arbres 4=Mettre des gazons 5=Autres à préciser____	/___/ /___/ /___/ /___/ /___/

N°	QUESTIONS & REPONSES	CODES/ZONES DE REPONSES
Q22	Si Q16.5, quelle stratégie avez-vous utilisé principalement pour y faire face? ____ ____	
Q23	Si le phénomène que vous subissez principalement est observé et se produirait dans un avenir proche, quelle est la probabilité que votre ménage soit entièrement préparé à l'avance ? 1=Pas du tout probable, 2=Peu probable, 3=Très probable, 4=Extrêmement probable	/___/
Q24	Si le phénomène que vous subissez principalement est observé et devait devenir plus fréquent et plus grave à l'avenir, quelle est la probabilité que votre ménage puisse faire face aux nouvelles menaces présentées ? 1=Pas du tout probable, 2=Peu probable, 3=Très probable, 4=Extrêmement probable	/___/
Q25	Si le phénomène que vous subissez principalement est observé et s'était récemment terminé, quelle est la probabilité que votre ménage se rétablisse complètement dans les six mois ? 1=Pas du tout probable, 2=Peu probable, 3=Très probable, 4=Extrêmement probable	/___/

3 INFORMATION SUR LES ESPACES VERTS, LEUR GESTION ET LEURS BENEFICES

N°	Questions & Réponses	Codes
Q26	1. Existe-t-il un espace vert au sein ou aux alentours de votre ménage ? Oui 2. Non ***(un espace vert : « tout espace, quel que soit sa superficie, recouvert de végétation naturelle ou boisée. », (St-Arnaud, 2008))*** ***(Veuillez observer l'existence de l'espace vert pour répondre. Si vous n'apercevez pas d'espace vert, veuillez poser la question)***	/___/
Q27	Si Q26=Oui, de quel type d'espace vert s'agit-il ? ***(Instruction : choix multiple 1=Oui 2=Non)*** 1=Arbre ; 2=Gazon; 3=Arbuste ; 4=Toit vert ; 5=Mur vert ;	 /___/ /___/ /___/ /___/ /___/

	6=Jardin; 7=Autres (à préciser) ____	/___/ /___/
Q28	Si Q26=Oui, avez-vous participé à sa mise en place ? 1. Oui 2. Non	/___/
Q29	Si Q28=Oui, qu'est-ce qui vous a motivé à le ou les mettre en place? **(Instruction : choix multiple 1=Oui 2=Non)** 1=Loisir (sports et jeux) ; 2=Esthétique ; 3=Aromatique ; 4=Ombre ; 5=Bois de chauffe ; 6=Commerce (fruits et légumes); 7=Alimentation (fruits et légumes); 8=Amélioration de la qualité de l'air; 9=Médecine ; 10=Réduction de la chaleur; 11=Interception/infiltration d'eau ; 12=Autres à préciser____	/___/ /___/ /___/ /___/ /___/ /___/ /___/ /___/ /___/ /___/ /___/ /___/
Q30	Si Q28=Oui, d'où les aviez-vous procurés ? 1=Autorités; 2=Pépiniéristes; 3=Naturel; 4=Voisins/Connaissances	/___/
Q31	Si Q26=Oui, quelle activité principale faites-vous régulièrement pour cet espace vert? ***(Instruction : choix multiple 1=Oui 2=Non)*** 1=Arroser; 2= Mettre de la clôture; 3=Tondre/tailler; 4=Mettre l'engrais ; 5=Éliminer des espèces envahissantes ; 6=Autre (à préciser) ____	/___/ /___/ /___/ /___/ /___/ /___/
Q32	A combien s'élève approximativement le cout de cet entretien par mois?	/___//___//___//___/
Q33	Si Q26=Oui, quels bénéfices tirez-vous de cet (s) espace (s) vert (s) ? ***(Instruction : choix multiple 1=Oui 2=Non)*** 1=Loisir (sports et jeux) ; 2=Esthétique ; 3=Aromatique ; 4=Ombre ; 5=Bois de chauffe ; 6=Fruits et légumes pour commerce;	/___/ /___/ /___/ /___/ /___/ /___/ /___/

	7= Fruits et légumes pour alimentation 8=Amélioration de la qualité de l'air; 9=Médecine ; 10=Réduction du bruit ; 11=Réduction de la chaleur ; 12=Interception/infiltration d'eau ; 13=Autres à préciser____	/___/ /___/ /___/ /___/ /___/
Q34	Si Q26=Oui, êtes-vous satisfaits mentalement, physiquement et socialement de cet espace vert ? 1. Oui 2. Non	/___/
Q35	Si Q34=Oui, comment estimez-vous le degré de votre satisfaction sur votre santé actuelle? 1=Très faible ; 2= Faible ; 3=Moyen ; 4=Élevé ; 5=Très élevé	/___/
Q36	Si Q26=Non, pourquoi vous ne l'avez pas dans votre ménage ? (***Instruction : choix multiple 1=Oui 2=Non)*** 1=Ça ne nous intéresse pas ; 2=Manque de moyens financiers ; 3=Manque de temps ; 4=Manque d'espace ; 5=J'ai mis mais ça n'a pas tenu ; 6=Je ne suis pas le propriétaire de la maison ; 7= Autre (à préciser) ____	/___/ /___/ /___/ /___/ /___/ /___/ /___/
Q37	Avez-vous connaissance d'un espace ou des espaces verts publics dans votre voisinage? 1. Oui 2. Non	/___/
Q38	Si Q37=Oui, de quel(s) type (s) d'espace vert s'agit-il ? ***(Instruction : choix multiple 1=Oui 2=Non)*** 1=Jardins publics ; 2=Parc public, 3=Ceinture verte ; 4=Espaces verts aménagés ; 5=lieux de sports ; 6=lieux de jeux ; 7=Autres (à préciser) _______________________________________	/___/ /___/ /___/ /___/ /___/ /___/ /___/ /___/

Q39	Si Q37=Oui, souhaiteriez-vous avoir plus dans votre quartier ? 1. Oui 2. Non	/___/
Q40	Si Q37=Oui, Combien de temps faites-vous pour se rendre à l'espace vert public le plus proche (en minutes)?	/___/
Q41	Si Q37=Oui, Dans quel état est-il? *1=Délaissé aux ordures 2=Préservé et entretenu 3=Menacé par les habitations 4=Autres (à préciser)* ____	/___/
Q42	SI cet espace est préservé et entretenu, quels sont les acteurs qui interviennent pour cet entretien ? ***(Instruction : choix multiple 1=Oui 2=Non)*** 1=Municipalités 2=Chefs du quartier 3=Résidents 4=Autres (à préciser) _____________________________________	 /___/ /___/ /___/ /___/
Q43	Si Q37=Oui, est ce que vous avez l'habitude de le visiter ? 1=Oui 2=Non	/___/
Q44	Si Q43=Oui, Pour quelle (s) raison (s) le visitez-vous? ***(Instruction : choix multiple 1=Oui 2=Non)*** 1=Loisir (sports et jeux) ; 2=Alimentation (fruits) ; 3=Bois de chauffe ; 4=Randonnée ; 5=Etude 6=Autres (à préciser) ____________________________________	 /___/ /___/ /___/ /___/ /___/ /___/
Q45	Si Q43=Oui, combien de fois le visitez-vous par mois ?	/___/___/
Q46	Si Q43=Non, Pourquoi vous ne le visitez pas? ***(Instruction : choix multiple 1=Oui 2=Non)*** 1=Trop de moustiques ; 2=Insécurité 3=Trop de bruit 4=Distance 5=Autres (à préciser)__________________________________	 /___/ /___/ /___/ /___/ /___/
Q47	Si Q37=Oui, avez-vous participé à sa mise en place ? 1. Oui 2.Non	/___/

Q48	Si Q37=Oui, avez-vous participé à des activités d'entretien de cet espace vert ? 1. Oui 2. Non	/___/
Q49	Si Q48=Oui, combien de fois avez-vous participé	/___/___/
Q50	Si Q48=Oui, A quels types d'activités avez-vous participé ? ***(Instruction : choix multiple 1=Oui 2=Non)*** 1=Arroser 2=Mettre de la clôture; 3=Tondre/Tailler; 4=Mettre de l'engrais ; 5=Eliminer des espèces envahissantes ; 6=Autre (à préciser) ___________________________________	 /___/ /___/ /___/ /___/ /___/ /___/
Q51	Si Q48=Non, êtes-vous prêt à y participer ? 1. Oui 2.Non	/___/
Q52	Si Q51=Oui, de quelle manière souhaiteriez-vous y être associé(e)? ***(Instruction : choix multiple 1=Oui 2=Non)*** 1=Arroser 2= Mettre de la clôture; 3=Tondre/Tailler ; 4=Mettre l'engrais ; 5=Eliminer des espèces envahissantes ; 6= Autre (à préciser) ____	 /___/ /___/ /___/ /___/ /___/ /___/
Q53	Préfériez-vous un immeuble en lieu et place de cet espace vert public? 1=Oui, 2=Non	/___/

<u>Observations de l'enquêteur :</u>

Merci de votre collaboration !!!!

Appendix C: Focus group discussions

DEBRIEFING DU FOCUS GROUPE

Nom de facilitateur : ______________ **Nom de Co-facilitateur** ____________	**Date** : /______/_______/_______/		
Nom du quartier : ____			
Nombre de personnes présentes : ______ **Homme** : _______ **Femme** : _______	**Age :** ___________ ______________	**Education level** ____________ ____________	**Work status** ____________ ____________

Questions de recherche	**Idées fortes**
1. Comment voyez-vous la disponibilité des espaces verts urbains dans votre quartier?	
2. Comment voyez-vous l'attitude des résidents concernant l'utilisation et la gestion des espaces verts ?	
3. Selon vous, quels sont les principaux problèmes qui affectent les espaces verts urbains ?	

Merci pour votre participation !!!

Appendix D : Interview guide

Débriefing de l'entretien

Recherche sur la problématique des espaces verts urbains dans la ville de Niamey

Nom Facilitateur:_____________________ **Nom Co-facilitateur** :___________________	**Date** :
Nom de l'institution : _________________________________	

Nom de l’intervieweur : ______________________________

1. **Questions de recherche**

Questions de recherche	**Idées fortes**	**Explications**
1. Comment voyez-vous la disponibilité des espaces verts urbains dans votre quartier?		
2. Quels sont les parties prenantes qui interviennent dans la gestion des espaces verts urbains dans la ville de Niamey ?		
3. Que pensez-vous de leur collaboration dans la gestion de ces espaces verts urbains ?		
4. Selon vous, quels sont les principaux problèmes qui affectent les espaces verts urbains ?		

1. **Défis liés à l’organisation de l’entretien**

2. **Recommandations de l’intervieweur:**

Merci pour votre participation !!!

Appendix E: Estimation results

```
. mlogit Managerial_activities Age Gen hhd_size Mar_status i.Educ_level Work_stat i.Income Cost_mana i.Living_per_district Occu
> pancy_status i.District_status i.Benefits_green Plant_market

Iteration 0:   log likelihood = -411.71471
Iteration 1:   log likelihood = -323.71412
Iteration 2:   log likelihood = -320.13729
Iteration 3:   log likelihood = -320.06736
Iteration 4:   log likelihood = -320.06712
Iteration 5:   log likelihood = -320.06712

Multinomial logistic regression                 Number of obs     =        390
                                                LR chi2(40)       =     183.30
                                                Prob > chi2       =     0.0000
Log likelihood = -320.06712                     Pseudo R2         =     0.2226
```

Managerial_activi~s	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Watering						
Age	-.0035333	.0142393	-0.25	0.804	-.0314418	.0243753
Gen	.6111737	.351996	1.74	0.083	-.0787258	1.301073
hhd_size	.1169372	.0466353	2.51	0.012	.0255336	.2083407
Mar_status	.4782477	.4293969	1.11	0.265	-.3633548	1.31985
Educ_level						
Primary level	.5719138	.4439905	1.29	0.198	-.2982916	1.442119
Secondary level	.3912967	.4791356	0.82	0.414	-.5477918	1.330385
University level	.6343254	.5392534	1.18	0.239	-.4225918	1.691243
Work_status	-.8498172	.3205893	-2.65	0.008	-1.478161	-.2214737
Income						
100000-200000	.9715318	.4902925	1.98	0.048	.0105762	1.932487
200000-300000	.8390803	.3904419	2.15	0.032	.0738282	1.604332
300000 and above	.7850249	.5940577	1.32	0.186	-.3793068	1.949357
Cost_mana	-.0001295	.0000477	-2.72	0.007	-.0002229	-.0000361
Living_per_district						
Medium term	.2737106	.3414218	0.80	0.423	-.3954638	.942885
Long term	.6566024	.3840304	1.71	0.087	-.0960834	1.409288
Occupancy_status	.4992074	.3279439	1.52	0.128	-.1435509	1.141966
District_status						
Transition	-.9658683	.4242557	-2.28	0.023	-1.797394	-.1343425
Periphery	.3485119	.4079783	0.85	0.393	-.4511109	1.148135
Benefits_green						
Shade	1.508321	.3633137	4.15	0.000	.7962388	2.220402
Others	.7906497	.5275173	1.50	0.134	-.2432652	1.824565
Plant_market	1.425834	.3309153	4.31	0.000	.7772523	2.074416
_cons	-3.999252	1.114187	-3.59	0.000	-6.183019	-1.815485
Putting_the_fence	(base outcome)					
Others						
Age	-.0025481	.014885	-0.17	0.864	-.0317222	.0266259
Gen	.4886839	.3745506	1.30	0.192	-.2454218	1.22279
hhd_size	.0278319	.0491423	0.57	0.571	-.0684853	.1241491
Mar_status	-.5535518	.3976769	-1.39	0.164	-1.332984	.2258806
Educ_level						
Primary level	2.723525	.8059806	3.38	0.001	1.143832	4.303218
Secondary level	2.388337	.8400046	2.84	0.004	.7419578	4.034715
University level	3.230165	.8562677	3.77	0.000	1.551911	4.908418
Work_status	-.7750362	.3466022	-2.24	0.025	-1.454364	-.0957084
Income						
100000-200000	1.164574	.5002523	2.33	0.020	.1840977	2.145051
200000-300000	.8892022	.4410276	2.02	0.044	.0248041	1.7536
300000 and above	1.073744	.5675347	1.89	0.058	-.0386031	2.186092
Cost_mana	-5.01e-06	.0000301	-0.17	0.868	-.0000639	.0000539
Living_per_district						
Medium term	.4712069	.3933425	1.20	0.231	-.2997302	1.242144
Long term	1.04502	.4172795	2.50	0.012	.2271668	1.862872
Occupancy_status	.0538654	.3736377	0.14	0.885	-.678451	.7861819
District_status						
Transition	.3470889	.5040266	0.69	0.491	-.6407851	1.334963
Periphery	1.085673	.5123627	2.12	0.034	.0814605	2.089885
Benefits_green						
Shade	1.139025	.3943749	2.89	0.004	.3660648	1.911986
Others	.2281168	.5424081	0.42	0.674	-.8349834	1.291217
Plant_market	.9108042	.3571387	2.55	0.011	.2108251	1.610783
_cons	-5.567339	1.412106	-3.94	0.000	-8.335015	-2.799662

```
. hausman partial all, alleqs constant

Note: the rank of the differenced variance matrix (18) does not equal the number of coefficients being tested (19); be sure
        this is what you expect, or there may be problems computing the test.  Examine the output of your estimators for
        anything unexpected and possibly consider scaling your variables so that the coefficients are on a similar scale.
```

	—— Coefficients ——			
	(b) partial	(B) all	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Age	.0232466	-.0025481	.0257948	.0107501
Gen	-.2942344	.4886839	-.7829183	.1797792
hhd_size	-.0717369	.0278319	-.0995688	.0305643
Mar_status	-1.2189	-.5535518	-.6653481	.2330648
Educ_level				
2	2.420173	2.723525	-.303352	.2289778
3	2.504123	2.388337	.1157864	.2821422
4	2.843133	3.230165	-.3870312	.3103409
Work_status	.0311022	-.7750362	.8061385	.
Income				
2	.2214858	1.164574	-.9430884	.1728185
3	.2513418	.8892022	-.6378604	.
4	.0227855	1.073744	-1.050959	.3360859
Cost_mana	.0001111	-5.01e-06	.0001161	.0000445
Living_per~t				
2	.232744	.4712069	-.238463	.1142989
3	.6193193	1.04502	-.4257003	.1204614
Occupancy_~s	-.6417675	.0538654	-.6956329	.0923122
Benefits_g~n				
2	-.6681437	1.139025	-1.807169	.2971735
3	-.6552568	.2281168	-.8833736	.445466
Plant_market	-.4526393	.9108042	-1.363443	.2652039
_cons	-1.661943	-5.567339	3.905396	.

```
                          b = consistent under Ho and Ha; obtained from mlogit
           B = inconsistent under Ha, efficient under Ho; obtained from mlogit

    Test:  Ho:  difference in coefficients not systematic

                 chi2(18) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       15.42
                Prob>chi2 =      0.6331
                (V_b-V_B is not positive definite)
```

```
. ologit Climate_resilience Age Gen hhd_size Mar_status i.Educ_level i.Income Work_status Occupancy_status i.District_status i.
> Eco_services i.Climate_shock Prox_publ_green i.Life_satisf, or

Iteration 0:   log likelihood = -427.75549
Iteration 1:   log likelihood = -384.41522
Iteration 2:   log likelihood = -383.90335
Iteration 3:   log likelihood = -383.90259
Iteration 4:   log likelihood = -383.90259

Ordered logistic regression                     Number of obs     =        390
                                                LR chi2(21)       =      87.71
                                                Prob > chi2       =     0.0000
Log likelihood = -383.90259                     Pseudo R2         =     0.1025

------------------------------------------------------------------------------------
Climate_resilience | Odds Ratio   Std. Err.      z    P>|z|      [95% Conf. Interval]
-------------------+----------------------------------------------------------------
               Age |   1.015187   .0094436     1.62   0.105      .996846    1.033866
               Gen |   .8529683   .2060233    -0.66   0.510     .5312957    1.369397
          hhd_size |   .9694341   .0299065    -1.01   0.314     .9125554    1.029858
        Mar_status |    1.63119   .4583521     1.74   0.082     .9404236    2.829344
                   |
        Educ_level |
    Primary level  |   1.115317   .3586807     0.34   0.734     .5938216    2.094791
  Secondary level  |   1.234222   .4244776     0.61   0.541     .6289922    2.421816
 University level  |   2.061805   .7721834     1.93   0.053     .9895946     4.29574
                   |
            Income |
    100000-200000  |   .6302072   .2093565    -1.39   0.165     .3286335    1.208523
    200000-300000  |   1.219625   .3409983     0.71   0.478     .7050766    2.109677
300000 and above   |   2.713833   1.136995     2.38   0.017     1.193882    6.168858
                   |
       Work_status |   2.991087   .7209824     4.55   0.000     1.864886    4.797398
  Occupancy_status |   .8584429   .2018036    -0.65   0.516     .5415146    1.360858
                   |
   District_status |
       Transition  |   .7404574   .2350153    -0.95   0.344     .3974984    1.379319
        Periphery  |   .9978565   .3185865    -0.01   0.995     .5337086    1.865658
                   |
      Eco_services |
       Regulating  |   4.819459   1.854534     4.09   0.000     2.267018     10.2457
         Cultural  |   2.308376   .7077218     2.73   0.006      1.26572    4.209933
                   |
     Climate_shock |
            Flood  |   .5023278   .1273498    -2.72   0.007     .3056267    .8256257
             Heat  |   .5665981   .1557673    -2.07   0.039     .3305716    .9711463
                   |
   Prox_publ_green |   1.695277   .3568562     2.51   0.012      1.12218    2.561055
                   |
       Life_satisf |
           Medium  |   2.047462   .7544967     1.94   0.052     .9943635    4.215863
             High  |   1.924736   .5414088     2.33   0.020     1.109013    3.340454
-------------------+----------------------------------------------------------------
             /cut1 |   2.151261    .843471                       .4980886    3.804434
             /cut2 |    3.93813   .8618298                       2.248975    5.627286
------------------------------------------------------------------------------------
Note: Estimates are transformed only in the first equation.
```

```
. oparallel

Tests of the parallel regression assumption

                 |   Chi2     df  P>Chi2
-----------------+----------------------
     Wolfe Gould |  50.32     21   0.000
          Brant  |  48.79     21   0.001
          score  |  43.99     21   0.002
likelihood ratio |  41.11     21   0.005
            Wald |  45.57     21   0.001
```

Wald test of parallel lines assumption for the final model:

```
. gologit2 Climate_resilience Age Gen hhd_size Mar_status i.Educ_level i.Income Work_status Occupancy_status i.District_status
> i.Eco_services i.Climate_shock Prox_publ_green i.Life_satisf, autofit


         chi2( 18) =   12.84
       Prob > chi2 =    0.8013

pl(1b.Eco_services 2.Eco_services 3.Eco_services 1b.Educ_level 2.Educ_level 3.Educ_level 4.Educ_level 1b.Income 2.Income 3.Inco
> me 4.Income 1b.District_status 2.District_status 1b.Climate_shock 2.Climate_shock 3.Climate_shock 1b.Life_satisf 2.Life_satis
> f 3.Life_satisf Age Occupancy_status Mar_status hhd_size Prox_publ_green)
```

Climate_resilience	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
low_resilience						
Age	.0141643	.0095237	1.49	0.137	-.0045019	.0328304
Gen	-.5373163	.2932858	-1.83	0.067	-1.112146	.0375133
hhd_size	-.0300669	.031525	-0.95	0.340	-.0918547	.0317208
Mar_status	.5498611	.2891011	1.90	0.057	-.0167666	1.116489
Educ_level						
Primary level	.0753621	.3282783	0.23	0.818	-.5680516	.7187758
Secondary level	.210816	.3500063	0.60	0.547	-.4751836	.8968157
University level	.7755625	.3817123	2.03	0.042	.0274202	1.523705
Income						
100000-200000	-.4246205	.3416336	-1.24	0.214	-1.09421	.244969
200000-300000	.2939409	.2850507	1.03	0.302	-.2647483	.85263
300000 and above	.9948317	.4190598	2.37	0.018	.1734896	1.816174
Work_status	1.428374	.263989	5.41	0.000	.9109649	1.945783
Occupancy_status	-.1033907	.2387369	-0.43	0.665	-.5713063	.364525
District_status						
Transition	-.3141162	.3237334	-0.97	0.332	-.9486221	.3203897
Periphery	-.2627949	.349472	-0.75	0.452	-.9477474	.4221577
Eco_services						
Regulating	1.607781	.3940208	4.08	0.000	.8355148	2.380048
Cultural	.8866138	.3124803	2.84	0.005	.2741638	1.499064
Climate_shock						
Flood	-.7542892	.2616238	-2.88	0.004	-1.267062	-.2415159
Heat	-.5800954	.2792546	-2.08	0.038	-1.127424	-.0327665
Prox_publ_green	.5613344	.2142035	2.62	0.009	.1415033	.9811655
Life_satisf						
Medium	.769923	.3744512	2.06	0.040	.036012	1.503834
High	.6993579	.2862562	2.44	0.015	.1383062	1.26041
_cons	-2.109199	.8701949	-2.42	0.015	-3.81475	-.4036486

Medium_resilience						
Age	.0141643	.0095237	1.49	0.137	-.0045019	.0328304
Gen	.264579	.2993931	0.88	0.377	-.3222208	.8513788
hhd_size	-.0300669	.031525	-0.95	0.340	-.0918547	.0317208
Mar_status	.5498611	.2891011	1.90	0.057	-.0167666	1.116489
Educ_level						
Primary level	.0753621	.3282783	0.23	0.818	-.5680516	.7187758
Secondary level	.210816	.3500063	0.60	0.547	-.4751836	.8968157
University level	.7755625	.3817123	2.03	0.042	.0274202	1.523705
Income						
100000-200000	-.4246205	.3416336	-1.24	0.214	-1.09421	.244969
200000-300000	.2939409	.2850507	1.03	0.302	-.2647483	.85263
300000 and above	.9948317	.4190598	2.37	0.018	.1734896	1.816174
Work_status	.5007286	.2807784	1.78	0.075	-.049587	1.051044
Occupancy_status	-.1033907	.2387369	-0.43	0.665	-.5713063	.364525
District_status						
Transition	-.3141162	.3237334	-0.97	0.332	-.9486221	.3203897
Periphery	.3045406	.3451752	0.88	0.378	-.3719905	.9810716
Eco_services						
Regulating	1.607781	.3940208	4.08	0.000	.8355148	2.380048
Cultural	.8866138	.3124803	2.84	0.005	.2741638	1.499064
Climate_shock						
Flood	-.7542892	.2616238	-2.88	0.004	-1.267062	-.2415159
Heat	-.5800954	.2792546	-2.08	0.038	-1.127424	-.0327665
Prox_publ_green	.5613344	.2142035	2.62	0.009	.1415033	.9811655
Life_satisf						
Medium	.769923	.3744512	2.06	0.040	.036012	1.503834
High	.6993579	.2862562	2.44	0.015	.1383062	1.26041
_cons	-4.071699	.8933233	-4.56	0.000	-5.822581	-2.320818