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**Demographic Patterns of Socio-Economic Needs in Kenya:
Informing Public Resource Allocation Criteria in Kenya**

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Abstract

Purpose: This paper analyzes multi-dimensional deprivation in Kenya.

Methodology: The analyses is carried out within a principal component analysis framework. This analysis is based on data drawn from the 2019 Population and Housing Census and employs counties in Kenya as the unit of analysis.

Findings: Multi-dimensional deprivation in Kenya is high with 53 per cent of the population being multi-dimensionally deprived. There is widespread cross-county variation in deprivation with 29 (out of 47) counties facing major to extreme forms of deprivation. Counties experiencing the worst deprivations are within the arid and semi-arid lands. Observed heterogeneity in cross-county deprivations is largely driven by deprivations related to access to safe drinking water, electricity, garbage collection, and human waste collection which jointly account for 93 per cent of the total variance. Variation in deprivation to formal education explains less than 1 per cent of the total variance, reflecting near-universal access to education in Kenya.

Unique Contribution to Theory, Practice, and Policy: These results have important ramifications for policy on resource allocation. In particular, resource allocation formula which enhances social welfare in Kenya has to attach great importance to water, energy, garbage collection, and human waste collection while maintaining the current levels of access to education.

Keywords: *Deprivation, Resource Allocation, Social Welfare Criterion, Kenya*

INTRODUCTION

Resource allocation, as a concept in applied economics, emanates from the scarcity of resources required to meet unlimited population needs and wants. Various means are used in allocating resources; these include markets in free economies and planning through political processes in mixed economies. Modern macroeconomic theory and policy rest on the assertion of John Keynes' mixed economic system on the role of government in solving market problems and promoting welfare. Harvey (1981), through an analysis of the relationship between public sector growth and labor force expansion, acknowledges economies embracing the case for public sector spending in providing adequate interventions to access public goods.

The government in a mixed economy is constantly under pressure to quench the ever-growing demand for public goods and services to improve society's welfare level (Montibeller & Franco, 2011). The challenge of efficiently allocating public resources rests on fiscal budgets as a tool for public sector spending and determining the services' value for money across different financial expenditure avenues (Barroy & Gupta, 2020).

The unique nature of a government in mixed economies is in its combination of markets and planning considerations in allocating resources to public goods and services such as healthcare, education, defense, and fire emergency services. According to (Nafziger, 2021), sufficient food, entrance to primary education, basic healthcare services, adequate and consistent water supply, proper sanitation, and safe and affordable housing are the set of basic needs of a population fulfilled through public service in mixed economies. However, the considerations and deliberations that inform public resource allocation and distribution decisions vary from different factors that come into play to the weights attached to the mandatory and essential variables (Kakungu, 2013).

This delicate balancing act forms the cornerstone of studies around the world, which aim at generating and improving existing resource allocation avenues towards more effective and efficient public spending within the government. These studies include Allain et al (2015), Kakungu (2013), and Dolan, Layard, & Metcalfe (2011). These studies highlight governments exploring different approaches to allocate resources efficiently (Allain et al., 2015). The standard cost approach in resource allocation utilized in Australia is anchored on total expenditure broken down by function and jurisdiction; calculations on the average cost per capita of providing a particular service across different locations form the public resource allocation basis. Modifications of this approach have been applied in Japan and Sweden which apply Horizontal Fiscal Equalization.

Local authorities in the United Kingdom apply a regression-based approach, which is an improved standard cost approach in resource allocation. A model of public resource allocation is determined by performing a regression analysis on explanatory variables e.g., population size among deprivation, among others which portray regional differences, which are viewed as needs indicators to explain past public spending variations (Dolan, Layard, & Metcalfe, 2011). Most utilized approaches are the *Outcome-based method* that is applied by Wales and the *Bottom-Up cost approach* for the Netherlands.

Despite these deliberate efforts, no unanimous concession has been reached on how governments can efficiently allocate resources to maximize societal welfare.

Public Resource Allocation in Kenya

Kenya's 2010 Constitution is touted as a well-sought-after solution to attaining equity in public resource distribution (Kinuthia & Lakin, 2016). It appeared to debunk the proposal of allocating public resources to areas with a comparative advantage as proposed by the 1965 Sessional Paper 10 "*African Socialism and its Application to Planning in Kenya*". Although those mentioned above diverged in the approach, they both pointed to addressing some socioeconomic inequities for "less developed areas in the country" and "for marginalized groups and areas."

Deliberate efforts have been made towards shaping public resource allocation in Kenya. These efforts are evident in the Development Fund allocated to constituencies, various active schemes for cash transfers, Equalization Fund disbursed to counties to address marginalization, and conditional grants channeled to water and health sectors at the county level.

The allocation of public resources in Kenya conforms to the 2010 Constitution. The Commission on Revenue Allocation (CRA) recommends the basis for horizontal public resource sharing of national government revenue to the national and county governments as spelled out in Article 216 of Kenya's 2010 Constitution. Under this constitutional provision, the national government, through National Treasury, allocates financial resources annually to counties in Kenya.

Citizens in Kenya are entitled to the same level of public services, and relative needs should inform public resource allocation. The CRA formulas were generated and have evolved to facilitate equitable resource sharing and to ensure inclusivity in attaining economic growth and development. These formulas transitioned from the first to the third generation, with the changes seeking to incorporate socioeconomic variables considered vital in bolstering economic growth and improving human welfare in the country. These details are shown in Table 1.

Table 1: Commission for Revenue Allocation formulas since Devolution

Index	1 st Generation	2 nd Generation	3 rd Generation	Deviation of 2 nd from 1 st Generation	Deviation of 3 rd from 1 st Generation
Population	0.45	0.45	0.18	-0.27	-0.27
Equal Share	0.25	0.26	0.19	-0.06	-0.07
Poverty Gap	0.2	0.18	0.14	-0.06	-0.04
Land Area	0.08	0.08	0.08	0	0
Fiscal	0.02	0.02		-0.02	-0.02
Responsibility Development Factor		0.01			-0.01
Health			0.17		
Agriculture			0.1		
Public Administration			0.01		
Urban Services			0.05		
Rural Access			0.08		
Aggregate	1	1	1	-0.41	-0.41

Data Source: Commission for Revenue Allocation

The basis for the allocation of public resources considers the size of the population, land area occupied by counties, and poverty gap, among other variables which indicate need. Over time, the population proportion has been a significant factor in all the generational formulas despite its 60 per cent¹ decline in the weight attached to it in the 3rd generation. The population index is inferred from the county's population relative to the country's. This definition biases these allocations towards counties with larger populations since the index is given by:

$$population\ index_i = \frac{population\ in\ county\ i}{\sum_{i=1}^{47} population\ in\ county\ i}$$

The Context

The resource allocation criteria in Kenya have evolved slowly and seem to take baby steps at fulfilling global and regional principles and practices that define resource allocation and distribution (Kinuthia & Lakin, 2016). Devolution marked a major change which was ushered in by the Constitution of Kenya 2010. Although the people attached great expectations to the era of Devolution, the socioeconomic aspirations seem to be out of their reach with the slow transfer of resources to the counties (Ngigi & Busolo, 2019). The flow of public resources through budgets has been slow and disbursements less. The current trends in inflation and cost of living (KNBS monthly inflation reports) seem to be quickly deteriorating the welfare levels of the population. Whereas the Civil Society Groups and local and international donors have united with the government in their complementary role of attaining the SDG 2030 dream of promoting welfare and enhancing livelihoods, deliberate allocations by the government to needful and socioeconomically deprived counties are yet to be seen (Kayode, Muhammad, & Bello, 2021).

The undesirable microeconomic outcome of Kenya's resource allocation criteria through the increasingly wide discrepancy between the rich and the poor and the deprived and privileged households cannot be overlooked. More Kenyans daily are increasingly unable to afford their

basic needs and sustain themselves in the unprecedented harsh macroeconomic environment (see Kenya Food Security Outlook 2022) (Kumar, 2021). Poor access to basic needs hinders welfare improvement (Chamboko & Guvuriro, 2021). In the wake of these developments and socially undesirable outcomes, this study seeks to develop a resource allocation framework to address the needs and gaps of the socioeconomically deprived in Kenya.

Specifically, the paper analyzes public resource sharing model for counties in Kenya informed by their populations' socioeconomic characteristics and establishes a county deprivation index based on socio-economic characteristics. In so doing, this paper lays the groundwork for a debate on utilizing socioeconomic characteristics in determining a deprivation index that biases more allocations towards socioeconomically deprived counties. Specifically, the paper derives a multiple/ multi-dimensional deprivation index which combines various indicators of resource misallocation across Kenya's counties (Townsend, 1987). These indicators capture essential services that cannot be afforded by the residents of a given county or are lacking (Fabrizi et al, 2023; Saunders & Naidoo, 2009; Townsend, 1987).

Literature Review

The Theory

One of the first attempts at looking at deprivation was made in Malthus (1798). The author links aggregate population to food yield whereby the amount of food yielded per head exhibits an inverse relationship with aggregate population. This was attributed to the *Law of Reducing Yields*. As population grows faster than food supply, food yield per head declines; this induces population growth slowdown via vice and misery. As the population falls, food yield per head rises; thereby, encouraging rapid population growth. Chowdhury & Hossain (2018) and Rahman (2019) indicate that following Malthus (1798) leads one to inevitably conclude that growth in food production is a limiting factor to an increasing population. An implication of Malthus (1798) to the present paper is that counties receiving more resources per person would experience explosive population growth; this in turn puts a strain on available resources which, if not raised further, would translate into vice and misery.

Ehrlich & Kim (2015) indicate that Malthus (1798) is founded on a wide range of household (microeconomic) factors relating to fertility levels and death rates and macroeconomic production. These factors present the circumstances under which a population automatically balances itself given zero changes in technology or agricultural land. Galor & Weil (2006) observe that an increase in available resources in an economy may not translate to a change in the level of per capita income if one were to follow the logic of Malthus (1798).

Malthus appreciated the consistent efforts needed by the people to facilitate the process of economic development, as opposed to an automatic process, and observed that an economy slumps severally before accomplishing an exceptional level of development (Varian, 2018). Hence, the economic development process is a rough one on economic activity (Rahman, 2019). He emphasized maximizing production activities and optimally allocating resources to increase a country's opulence in the short run.

Malthus (1798) supports the present study in promoting economic development as it favors a more unbiased dispensation of landed possessions that would increase effectual demand and production. The theory proponent notes that if the land divided into small possessors is carried to an extreme,

it would negatively affect production. This justifies the utilization of aggregate land area occupied by counties as opposed to land distribution within counties.

A related theory is the optimum theory of population developed in Cannan (1924) but popularized in Robbins (2021). This theory links the population's size and the production of wealth. Cannan (1924) argues that societies have optimal population sizes which vary with changes in the methods and techniques of production. Population growth raises the size of the labour force, which pushes the optimal level upwards. This theory is relevant to the present paper in that it avails the basis for revising population weights in the resource allocation formula to reflect relative changes in population across counties. Recent political discourse in Kenya pities the one man- one vote- one shilling narrative against a needs-based assessment in the sharing of revenues raised nationally (Ndii, 2020; Ngunjiri, 2024). The former ignores the level of deprivation in a constituency or county while emphasizing greater resource allocation to populous counties. The latter recognizes the need to remedy economic disparities which exist within and among counties in Kenya (The Constitution of Kenya, 2010; Githaiga & Bett, 2020).

Carrington (2018) describes the optimal population as the perfect population, which, merged with the other resources availed to them or the country's production means, will capitulate maximum returns or income per head. Dasgupta (2018) notes that the optimum population is a postulation in which the human population can stabilize, sustaining a maximum population size with optimal living standards for everyone. According to Coale & Hoover (2019), a rise in the population size above or below the optimal level will lower income per person.

Related strand of literature builds on first- and second-generation theories of fiscal federalism (Oates, 1985). Both strands emphasize decentralization of fiscal resources as vital in enhancing public sector's performance (Oates, 1999). In the first generation (Samuelson, 1954), governments at the national and county level are assumed to endeavor to raise the social welfare of their constituents as much as possible. Each county government then avails local public goods which are aligned with demands of the respective constituents. Thus, when constituents demand, say, clean markets, clean public ablution facilities, and functional street lighting, the relevant county government avails precisely these outputs. However, governments face political constraints and incomplete knowledge which undermines public goods provisioning that would otherwise maximize the welfare of the society. The second-generation theory builds on public choice, and considers public servants/ decisionmakers as self-interested individuals who inevitably pursue their own objective functions (Oates, 1985). As such, public servants endeavor to maximize respective budget sizes (Brennan & Buchanan, 1980). This then implies that allocation of resources will not be uniform across county governments, and the public services and goods availed will differ across the counties based on the strategic priorities taken up by public servants at the county and national levels. As a consequence, multidimensional deprivation will differ across counties based on budget sizes and county/ national priorities.

Nevertheless, the link between population and resource allocation is best understood at the household level. Becker (1965) and Varian (2018) considered the household as both a producing and consuming unit rather than a purely consuming unit. The starting point is that the household or the family is the most fundamental institution in society (Chiappori, 2018). The household's output is consumed firsthand without being sold on the market (Muth, 2020). The central idea is that total income is split among household members based on a sharing rule, and each maximizes

its use on its own. The sharing rules are the foundation behind decisional processes (Chiappori, 2019; Fulop, 2019). Extending the Beckerian framework, Hamermesh (2019) argues that improving household members' well-being does not rely on the exclusive application of the market economy's principles. Non-market behavior, including security, closeness, humanity, and social connections, is just as important. The relevance of this theory is that resource allocation by the government is justified by the understanding that markets may not adequately address deprivation and need.

Economists have long focused their attention on the consumption and labor supply choices of one-person families, as this is the most basic unit of analysis in the economic theory of the household. Also, the household's choices may be characterized by a utility function whose maximization is constrained by the available funds. Intriguingly, this approach produces observable limits on domestic conduct. For instance, according to the unitary model of the household, zero-heterogeneity, symmetry, and semi-negativity are necessary properties of household needs. If these conditions are met, the econometrician can investigate how economic policies affect people's well-being by retracing their preferences from data collected on the whole spectrum of household needs. However, it is essential to note that recent developments in family economics, following in the footsteps of Gary Becker's seminal writings, have adopted a more holistic perspective of household behavior, encompassing non-market activities like reproduction, education, and time allocation. Consequently, the family is shown as a production unit that combines the agent's time with market commodities to generate the outputs, and this agent eventually seeks to address these concerns.

Previous Studies

Land & Michalos (2018) acknowledge the deliberate mass efforts made in arriving at a social and economic index which was the basis of the quality of life conversation in the 1990s. Discussions around the quality of life have also been shaped by publications such as: "Assessing Quality of Life and Living Conditions to Guide National Policy," "Barometers of Quality of Life Around the World," and "Millennium Development Goals (MDGs) in Retrospect," respectively featured in Hagerty, Vogel, and Møller (eds, 2002), Møller et al. (eds, 2008), and Andrews et al. (eds, 2015). The Social Indicators Movement identified six components that defined the level of living. The concept of the level of living was one that "directs and restricts information to the areas where the political mechanism is by some degree of consensus used to influence the living conditions through social policy", "organizes the information into areas or levels of living components, by the sector divisions used in social policy", "a unitary measure of welfare, Gross Welfare Product (GWP), is rejected in favor of separate indicators to be assigned relative weights through the political process", "it is primarily concerned with the individual's command over resources with which he can act rather than with individual need for satisfaction", "political resources are included as a level of living component", and "We would not attempt to specify 'a model for the good life', thus summarizing and making explicit all value premises in some neat formula from which we could then go on to specific indicators. The authors further recognized absence of unanimity on what countries considered the quality of life in government manipulations. A list of nine components was developed to capture the level of living, which entailed work and working conditions, economic resources, political resources, schooling, health and the use of medical care, family origin and family relations (social resources), housing, nutrition, leisure time and pursuits.

Kakungu (2013) presents a resource allocation model for constituencies in Zambia. The author employs principal component analysis on a dataset drawn from the Census conducted in 2010. The author indicates relative disadvantages existing among constituencies. These relative disadvantages informed consolidation of deprivations into a composite deprivation which would then form the basis for Constituency Development Fund Allocation. The composite deprivation index utilized socioeconomic variables as inputs. These variables included: access to clean water, improved energy sources, environment-friendly solid and human waste disposal methods, Internet connectivity, knowledge deprivation, quality of housing, and ownership of lifestyle assets such as mobile phones, radio, television, refrigerator, motorcycles, vehicle, and computer. Findings revealed that 60 per cent of the Zambia population was most deprived, 15 per cent moderately deprived, and 25 per cent not deprived.

Variables relating to Access Deprivation

Previous studies considered various factors as measures of deprivation. We begin with access deprivation with a particular focus on the following:

1. The proportion of households without access to improved sources of water supply
2. The proportion of households without access to improved sources of energy for lighting, heating, and cooking Maurya & Pandey (2010) examined deprivation from a decent standard of living in India using the UNDP Human Development Index. Deprivation was based on the percentage of the population without access to safe drinking water, energy supply per 100,000 people, and number of electrified villages, among other variables. The authors reveal a decent standard of living across all the states in India despite one-half of the population being exposed to decent housing deprivation exceeding 40 per cent. The next set of factors focus on the following:
3. The proportion of households without access to solid waste collection
4. The proportion of households without access to human waste collection
5. The proportion of households without a toilet

Akoteyon & Soladoye (2021) analyze slum deprivation index in Nigeria. The analysis utilized a dataset covering 1,398 households in 16 informal settlements. This enabled the authors to utilize the water, sanitation, and hygiene (WaSH) framework in analyzing the quality of dwellings and the physical environment. Key indicators included: presence of stagnant or sewage water and solid waste piles near the dwelling, the availability of waste bins in the household, the type of waste bin, and method of waste disposal. It was established that 18.7 per cent of the sampled slums were highly deprived. Deprivations in water, sanitation, and hygiene indicators showed slum deprivations levels of 37.5, 12.5, and 56.3 per cent, respectively. 50, 37.5, 43.75, and 31.3 per cent of the slum dwellers were highly deprived in terms of dwelling, waste disposal, waste pile, and stagnant water, respectively. 57.5 per cent of slum dwellers employed proper waste disposal methods although 47.5 per cent of the households had solid waste piles around their dwellings.

Access to the Internet is an essential component of connectivity and interconnectivity. Its deprivation could affect the material well-being of individuals. We therefore consider a 6th element:

The Proportion of Households without Access to the Internet

The World Health Organization (WHO, 2021) attach great importance to access to clean water, adequate sanitation, and hygiene. Lack of basic drinking water services, especially in rural areas, open defecation, and other forms of poorly managed sanitation show the global need to address such socioeconomic attributes of populations.

Shandler & Canetti (2019) utilize a randomized controlled trial on a 60-person sample—students and community members to test the consistent effectiveness of individuals to politically express themselves, associate with others, and seek for political information in the presence or absence of Internet access. Findings reveal Internet deprivation negatively affecting individuals' ability to exercise basic political rights. With Internet access, 61, 93, and 71 per cent of participants were able to express themselves politically, exercise civic association, and access political information, respectively. These estimates contrast with 29, 47, and 44 per cent among individuals who lacked internet access.

Kumar (2021) observes that poor households in India faced high deprivation levels compared to the non-poor, especially in the rural areas. The author utilized the modified Sopher's Disparity Index to explain the stark differences in access to basic public goods between the poor and non-poor households as well as in contrasting across livelihood categories, religious groups, caste, and ethics groups. Results from the probit model highlighted high deprivation patterns among poor households, agricultural laborers, households historically influenced by caste and ethnic-based organizations, and those in minority religions. There was a similar pattern in accessing basic amenities across social groups.

Variables relating to Knowledge Deprivation

Knowledge plays a vital role in human development since it is the engine of technological progress that allows societies to raise productivity and expand economic possibilities for progress. On this note, therefore, we consider another critical element of deprivation:

The Proportion of Persons without any Formal Education

Maurya & Pandey (2010) relied on State-level data from the 2009 Economic Survey in explaining deprivation from access to knowledge in India. Knowledge access was measured in terms of the literacy rate and gross enrollment ratio in classes 1 to 8 (elementary school) for children aged 6-14 years. A key finding was that all the States in India experienced significant deprivations related to knowledge access. 24 out of 27 States reported deprivation scores exceeding 30 per cent.

Variables Relating to Housing Deterioration

Having a roof over one's head matters a lot. However, shelter remains a challenge to many people in Kenya and around the world. This necessitates looking at the following forms of deprivation:

1. The proportion of households whose roofs are made of poor-quality material.
2. The proportion of households whose dwelling's wall is made poor quality material.
3. The proportion of households whose dwelling's floor is made poor quality material.

Akoteyon & Soladoye (2021) defined dwelling type by housing unit types and the total number of residents per dwelling. Findings hinted at 80 per cent of slum residents occupying a one-room apartment, 16.5 per cent a room-parlor apartments, and 3.9 per cent flat dwelling units. Less than 1 per cent lived in duplex dwelling units. Environmental conditions were also wanting with 55 per cent of slum households having stagnant water around their dwellings.

The Kenya National Bureau of Statistics (KNBS, 2017) utilized the 2014 Kenya Demographic and Health Survey (KDHS) dataset in analyzing child poverty in Kenya. The analysis relied on multiple overlapping deprivation analysis (MODA) method. Deprivation rates were 29 per cent higher for children aged 12-59 months than 12 per cent for children aged 0-11 months. Between 12 and 59 months, 37 per cent of children were undernourished, but between 0 and 11 months, that number dropped to 17 per cent. Children between the ages of 0 and 11 months were most likely to be without basic sanitary facilities (54 per cent), as well as inadequate shelter (53 per cent). Among 5-14-year-olds, the largest deprivation rate related to housing (62 per cent), and sanitation (58 per cent). Deprivations in access to healthcare, schools, and knowledge were 38, 37 and 27 per cent, respectively. Child poverty was evaluated solely using the 2014 KDHS data. The present study uses the normative method and globally acknowledged characteristics of child well-being to analyze child deprivations over five waves of the KDHS from 1993 to 2014.

Overview of Literature

It is without a doubt that various socioeconomic characteristics have been used to explain non-monetary deprivation from literature. Even though the conversation on composing an appropriate deprivation index is far from over, any deprivation measure should flexibly accommodate the varied views on welfare. This paper deliberately constructs a robust deprivation index that integrates the mass effort made by earlier research on welfare patterns. While most of these socioeconomic characteristics seem to be fundamental in influencing a deprivation index and, ultimately, a public resource allocation criterion, the relative scale in the magnitude of influence is unequal (Bocquet-Appel, & Naji). Different models, including profit, multivariate analysis, controlled randomized experiments, and component analysis, have been used to predict the influence of single socioeconomic characteristics and jointly analyze socioeconomic patterns on welfare levels, deprivation trends, and public resource allocation.

In Kenya, a single component index, the population index, has been used to inform public resource allocation. People may be counted in one or more of the domains, depending on the number of types of deprivation that they experience (Karadimitriou et al., 2021). It is doubtful that a single component can sufficiently predict deprivation and ultimately influence resource allocation. In light of this observation, this paper utilizes a robust dataset drawn from the 2019 Kenya Population Census Report.

Methodology

Conceptual Framework

The central idea behind public resource allocation is the effective maximization of the welfare of a population in a given society while conforming to the global principles and good practices attached to sharing resources. The option chosen by a government or State depends on the level of welfare it intends to achieve for its population. Explaining public resource allocation, therefore, requires making several assumptions about a society's social welfare function or assuming that the decision is anchored on a government's relative financial position (Kabubo-Mariara, Wambugu, & Musau, 2011). In either case, a government that is keen on maximizing social welfare while minimizing costs will pick a public resource allocation criterion that yields better social welfare.

Public resource allocation offers a government multiple options for maximizing social welfare. A population's socioeconomic characteristics then offer a tangible basis for resource allocation. These characteristics enable the portrayal of population proportions that have access to essential public goods as privileged, whereas groups within populations lacking access to the same are characterized as deprived. A deprivation index is then obtained. It follows that a sound government will channel the flow of more public resources to deprived populations compared to those with access. This paper's conceptual framework is presented in **Error! Reference source not found.**, whereby allocation of public resources is based on an index comprising 9 items.

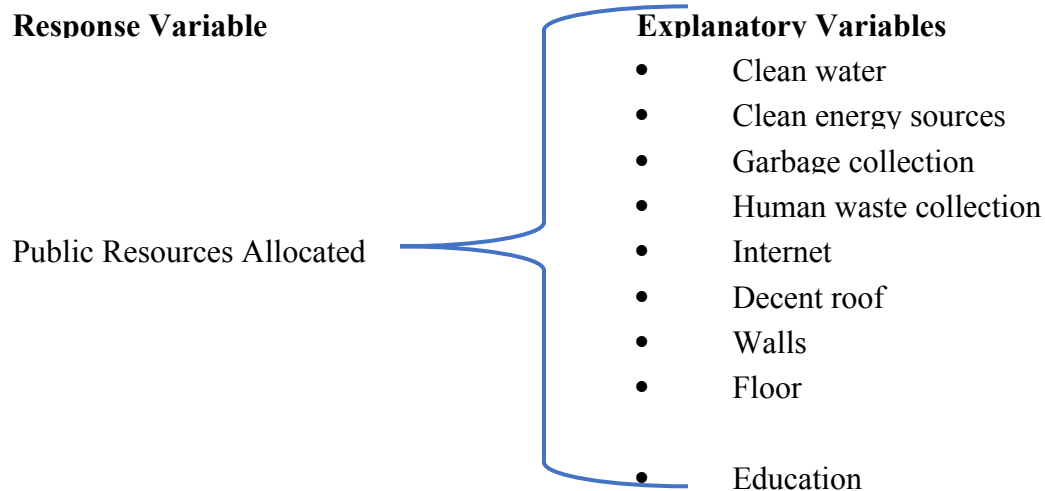


Figure 1: Conceptual Framework

The Theoretical Model

In making a societal welfare choice, a government picks an alternative that makes its population better off with minimal possible costs. A public resource allocation criterion which encompasses variations in socioeconomic characteristics and addresses societal deprivation issues is preferred if it takes society to a higher level of social welfare while minimizing associated expenditures. The demand for public goods and services reflects both the direct and indirect benefits perceived by individual households and society (Carrington, 2017). The decision maker in the allocation of public goods is a social planner, either the government or a government agency. This social planner then establishes an efficient and effective public resource allocation criterion that is beneficial to society. We then develop a public resource allocation criterion based on the social and economic characteristics of a population.

Let X be a vector of social and economic characteristics of a population residing in the k th county or region. Denote these characteristics by i such that $i = 1, \dots, n$ is characteristic 1, ..., n th. Let composite deprivation index and deprivation of the i th characteristic be denoted by D^c and d_{X_i} , respectively. The composite deprivation index is an additive function of characteristics of the population. Thus, we have:

$$D_k^c = f_k(d_{X_1}, \dots, d_{X_n})$$

Since population characteristics are not uniform across counties, and within the same county, the population is not equally deprived across all characteristics, $d_{-}X_i$ varies across characteristics. This allows for introduction of weights attached to characteristics. Heterogeneities across counties further implies heterogeneous allocation of public resources. Thus, the share of public resources, p_k , allocated to the k th county depends on the deprivation level. That is,

$$p_k = D_k^c = f_k(d_{-}X_1, \dots, d_{-}X_n) \Rightarrow p_k = f(D_k^c)$$

The Empirical Model

The analytical model builds on the specification $p_k = f(D_k^c)$. We employ principal component analysis (PCA) whereby the composite deprivation index for the k th county is given by:

$$D_k^c = \sum_{i=1}^N \beta_i^2 d_{-}X_{i,k}, \sum_{i=1}^N \beta_i^2 = 1$$

Where β is the factor loading corresponding to i th variable. The intuition behind PCA is that some characteristics could be highly correlated (Alkire et al., 2015), thereby necessitating the need for weighting. We consider nine variables. These are summarized in Table 2. The national deprivation index is given by averaging composite county deprivation indexes. That is,

$$D^c = \frac{\sum_{k=1}^K D_k^c}{K}, k = 1, \dots, K, K = 47$$

Our analysis utilizes data retrieved from the 2019 Population and Housing Census report.

Table 2: Variables and Measurement

Serial	Variable	Description
1	Water	The proportion of households without access to safe drinking water.
2	Energy	The proportion of households without access to electricity
3	Garbage	The proportion of households without access to solid waste collection
4	Human waste	The proportion of households without access to human waste collection
5	Internet	The proportion of households without access to the Internet
6	Education	The proportion of persons without any formal education
7	Roof	The proportion of households whose dwelling's roof is made of poor-quality material.
8	Walls	The proportion of households whose dwelling's walls is made of poor-quality material.
9	Floor	The proportion of households whose dwelling's floor is made poor quality material.

These proportions measured as percentages are important because counties differ in their population sizes and give a simple measure with which to make reference on deprivation. Our measure, however, does not indicate the depth of deprivation with respect to particular characteristics.

Results and Discussion

Identification of Principal Components

There are significant associations between various variables. Pairwise correlations in Table 3, for instance, suggest high correlations between accessing electricity and accessing the Internet. This then hints at energy deprivation being correlated with Internet access deprivation.

Table 3: Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9
1. water	1.00								
2. energy	0.67***	1.00							
3. garbage	0.40**	0.74***	1.00						
4. human waste	0.60***	0.62***	0.32*	1.00					
5. Internet	0.60***	0.90***	0.87***	0.67***	1.00				
6. roof material	0.53***	0.50***	0.17	0.92***	0.52***	1.00			
7. wall material	0.36*	0.59***	0.63***	0.47***	0.65***	0.47***	1.00		
8. floor	0.56***	0.84***	0.74***	0.74***	0.92***	0.64***	0.80***	1.00	
9. formal education	0.19	0.24	0.01	0.53***	0.25	0.54***	0.12	0.34*	1.00

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Variables are measured in terms of percentage of the population with access, not without, at the county level. The sample has a size of 47.

We then employ PCA. The variance decomposition in Table 4 suggests that the first three principal components explain 87per cent of the total variance. Together with the fourth component, 93per cent of the total variance is explained. The first principal component explains 62per cent of the variance whereas principal components 2 and 3 explain 17per cent and 8per cent of the total variance, respectively.

Table 4: Variance Decomposition

Component	Eigenvalue	Difference	Proportion	Cumulative
1	5.56397	4.00972	0.6182	0.6182
2	1.55425	0.84584	0.1727	0.7909
3	0.708415	0.144907	0.0787	0.8696
4	0.563508	0.259695	0.0626	0.9322
5	0.303813	0.149445	0.0338	0.966
6	0.154367	0.066685	0.0172	0.9831
7	0.087682	0.039584	0.0097	0.9929
8	0.048098	0.032206	0.0053	0.9982
9	0.015892	.	0.0018	1

Variable labels are given in Table 3

Variance decomposition suggests that greater importance ought to be attached to access to safe drinking water, electricity, garbage collection, and human waste collection. Items 1, 3, and 4 constitute the WaSH framework. Water, garbage collection, and the collection of human waste are important in the following respects. One, accessing water that is safe for drinking is important both household consumption as well as in supporting agricultural activities such as livestock feeding. Garbage and human waste collection matters because the presence of garbage and human waste could render water unsafe for drinking alongside raising incidences of diarrhea and water-borne infections. Formal education appears to explain very little of the total variance. The intuition is straightforward. Gaps in education access have almost been bridged, and hence less weight can be attached to education which is almost universal in Kenya.

We apply our discretion in ignoring the other 6 principal components. In any case, the last 3 principal components explain about 1.7 per cent of the total variance. We therefore narrow down to the first three principal components and report their respective factor loadings in Table 5. We conducted two tests which we do not report here. The first test analyzed independence between principal components. Test results indicated that component 1 was unrelated to components 2 and 3, and components 2 and 3 were unrelated. The second test considered equality of the factor loadings with respect to each principal component. This test indicated that factor loadings were not equal.

Table 5: Factor Loadings

Variable	Component 1	Component 2	Component 3	Variance share unexplained
1	0.2983	0.0539	-0.7567	0.09467
2	0.3785	-0.1658	-0.1661	0.1406
3	0.3085	-0.4719	0.1487	0.1086
4	0.351	0.3719	-0.0826	0.09468
5	0.3963	-0.2007	0.0154	0.06324
6	0.3135	0.4602	-0.0305	0.1233
7	0.3162	-0.2036	0.4046	0.2632
8	0.4056	-0.0836	0.1881	0.04882
9	0.1717	0.5551	0.4132	0.2362

Variable labels are given in Table 3.

Independence of principal components indicates that we can compute a composite index using either of the three components. Since component 1 explained more than one-half of the total variance, we compute a composite index using it. This composite non-deprivation index is given by:

$$ND_k^c = (0.2983^2) d_{X_{1,k}} + (0.3785^2) d_{X_{2,k}} + \dots + (0.1717^2) d_{X_{9,k}}$$

And the composite deprivation index is given by:

$$D_k^c = 100 - ND_k^c$$

Regional Variation in Deprivation

Counties in Kenya experience varied exposure to deprivation. Twenty-five counties have deprivation index exceeding the 53 per cent national average. We reveal in Table 6 that most of the worst performers are within the arid and semi-arid lands (ASALs). Deprivation is particularly pronounced in Mandera, Wajir, West Pokot, Samburu, and Turkana counties with more than 75 per cent of the population experiencing deprivation. Although Nairobi, Kiambu, and Mombasa counties have the lowest levels of deprivation 16.4, 23.0, and 24.1 per cent, respectively with these estimates call for urgent attention.

Table 6: Deprivation across Counties in Kenya

Percentage of the Population not Deprived										
County	Water	Energy	Garbage	Human waste	Internet	Roof	Wall	Floor	Education	Deprivation Index
NAIROBI CITY	84.20	96.7	80.80	96.40	52.40	94.20	70.10	92.50	99.37	16.44
KIAMBU	86.00	91.9	40.70	96.20	42.70	97.70	66.00	89.00	99.60	22.97
MOMBASA	56.60	86.3	61.80	91.10	39.20	96.90	86.40	86.20	99.19	24.07
KAJIADO	66.40	67.9	38.00	80.10	33.10	86.70	48.40	76.50	99.41	36.80
NAKURU	71.60	64.3	29.60	89.10	26.80	96.10	55.40	63.90	99.65	37.98
UASIN GISHU	82.00	63.9	22.80	90.60	28.00	96.60	46.80	64.90	99.65	38.03
KISUMU	72.90	94.5	10.00	85.30	23.90	98.10	44.10	57.80	99.69	38.26
MACHAKOS	56.60	48.2	18.70	88.80	25.80	98.00	77.70	73.80	99.50	38.81
NYERI	82.10	72.0	13.10	94.40	29.90	98.90	33.30	59.30	99.58	39.07
KIRINYAGA	67.90	66.0	11.50	95.70	24.10	99.40	48.20	57.40	99.63	40.86
MURANG'A	66.10	60.5	6.10	94.20	20.70	99.10	49.50	59.60	99.66	42.58
TAITA/TAVETA	68.70	48.0	7.40	85.10	23.90	98.00	53.50	60.90	99.61	44.13
EMBU	67.90	47.3	8.00	90.40	22.10	99.00	49.70	59.50	99.64	44.39
NYANDARUA	77.60	41.6	6.40	93.10	20.60	99.10	28.30	48.20	99.75	48.38
MAKUENI	44.40	20.4	4.40	85.30	16.10	98.80	72.70	62.90	99.49	49.41
MERU	63.40	40.6	5.40	89.80	19.30	98.30	26.10	52.60	99.51	50.08
KILIFI	71.00	38.6	12.90	72.00	15.10	96.80	56.40	45.10	99.52	50.18
LAIKIPIA	65.10	42.7	16.10	82.10	22.60	90.50	28.70	46.50	99.58	50.54
LAMU	68.80	43.6	7.10	66.60	19.40	89.60	48.30	47.90	98.23	51.29
TRANSNZOIA	75.70	38.1	6.10	84.50	16.90	95.90	35.30	39.50	99.66	51.77
THARA-NITHI	59.10	35.3	4.70	86.70	18.80	98.40	31.40	47.90	99.43	51.98
KERICHO	46.70	45.1	10.90	84.30	19.00	96.70	29.60	45.50	99.70	52.09
VIHIGA	68.30	38.6	1.20	90.20	14.10	98.50	25.30	31.90	99.60	54.56
KITUI	38.50	17.2	4.20	78.50	13.60	96.40	68.80	47.10	99.37	54.87
NANDI	45.80	30.7	3.10	86.70	17.10	96.80	29.10	42.80	99.62	55.46
BUNGOMA	80.50	21.8	2.10	83.60	13.80	96.40	35.00	32.40	99.64	55.81
BUSIA	73.80	26.2	2.80	82.20	13.50	88.30	33.70	38.40	99.69	55.86
NYAMIRA	51.50	43.2	3.60	76.00	15.90	97.90	33.80	30.70	99.66	56.04
KISII	52.10	39.5	6.10	74.90	16.00	97.80	33.90	32.80	99.71	56.05
SIAYA	55.10	19.6	0.60	81.50	14.90	94.70	33.50	45.00	99.63	56.85
KWALE	56.20	31.1	7.50	57.20	12.40	95.50	49.10	40.80	99.48	56.90
KAKAMEGA	72.30	25.2	1.50	89.00	14.50	94.80	25.00	28.40	99.64	57.15
MIGORI	46.10	23.5	2.90	75.00	14.30	96.20	34.40	40.50	99.67	58.27
ISIOLO	65.10	40.6	12.40	62.10	14.20	74.60	28.50	35.70	98.90	58.36
HOMA BAY	51.90	18.5	1.80	74.50	15.20	98.00	26.90	41.70	99.70	58.87
BOMET	39.30	22.1	4.70	85.90	16.60	92.10	20.50	35.90	99.70	59.75
ELGEYO/MARAKET	43.10	24.7	1.80	67.90	14.20	81.80	29.40	30.60	99.63	62.91
BARINGO	34.70	28.7	2.10	60.70	15.30	75.90	17.10	35.90	99.53	64.71
GARISSA	53.70	24.0	10.60	44.30	12.20	59.60	32.20	24.70	89.28	67.63
NAROK	30.00	19.9	5.10	60.60	12.00	76.60	16.80	25.10	99.60	68.37
TANA RIVER	55.00	26.1	1.80	41.80	8.90	62.80	32.70	23.30	98.63	68.47
MARSABIT	46.40	21.2	5.60	43.00	8.30	55.50	28.50	27.90	98.92	69.89
MANDERA	36.00	15.8	9.80	34.70	7.80	50.00	28.90	15.40	94.18	74.99
WAJIR	49.20	14.6	7.80	29.80	8.30	42.80	26.40	16.50	93.62	75.49
WEST POKOT	31.20	11.9	2.70	48.50	8.10	46.50	17.60	18.80	99.54	75.66
SAMBURU	36.70	14.6	3.70	29.60	9.70	39.20	21.30	22.30	99.49	76.54
TURKANA	48.20	8.8	2.30	24.30	6.90	53.40	12.70	13.10	98.74	78.57

Source: Author's Computation

We then look at deprivation across the 9 characteristics. In terms of access to formal education, all counties seem to perform well. However, there are widespread disparities regarding the other eight characteristics. Kernel density plots in **Error! Reference source not found.** indicate that many

counties report fewer than 10 and 20 per cent of the population, respectively, accessing solid waste/garbage disposal services and the internet. Whereas some counties have over three quarters of the population accessing garbage collection, none of the counties had over 60 per cent of the population accessing the internet. A bulk of the counties had over 80 per cent of the population having access to a good roof and human waste disposal whereas few counties reported extremely small shares. Overall, there are widespread variations across counties in terms of the characteristics considered except for access to formal education.

We present two measures of central tendency median and the mean alongside measures of spread in Table 7. The quartile deviation, which ignores extreme values, indicates that variation in access to education was negligible relative to the other characteristics. There are widespread variations in terms of the proportion of the population accessing a good floor, human waste disposal, electricity, safe drinking water, and a good wall. Skewness suggests that the distribution of access to safe drinking water, human waste collection, a good roof, and formal education is left-skewed, i.e., there are few extremely small values and a large concentration of many high values with respect to these characteristics. Other characteristics exhibit positive skewness. Kurtosis indicates only the distribution of access to safe drinking water and a good floor as not having heavy tails. The median calls for a strategic rethink. More than one-half of the counties have 38, 6, 16, 33, and 43 per cent of their population accessing electricity, garbage collection, internet, a good wall, and a good floor, respectively.

Table 7: Summary Statistics

Statistic	Water	Energy	Garbage	Human Waste	Internet	Roof	Wall	Floor	Education
N	47	47	47	47	47	47	47	47	47
Mean	58.75532	39.60851	11.28298	74.55957	18.68511	86.91277	38.87234	45.00213	99.02577
Standard error	2.218215	3.320577	2.27761	2.918154	1.349177	2.581276	2.518354	2.812386	0.273068
Kurtosis	2.018031	3.24178	11.72493	3.091296	5.986944	3.863741	3.209783	2.912918	18.861
Skewness	-0.077554	0.994532	2.907006	-1.105141	1.598345	-1.517065	0.94144	0.592052	-3.987567
Median	56.6	38.1	6.1	82.2	16	96.2	33.5	42.8	99.59606
1 st quartile	46.4	21.8	2.9	62.1	13.6	81.8	28.3	30.7	99.40847
3 rd quartile	71	48	11.5	89.1	22.6	98	49.1	59.3	99.65092
Quartile deviation	12.3	13.1	4.3	13.5	4.5	8.1	10.4	14.3	0.121225

Statistics, other than N (number of observations) indicate the percentage of the population with access to a given characteristic.

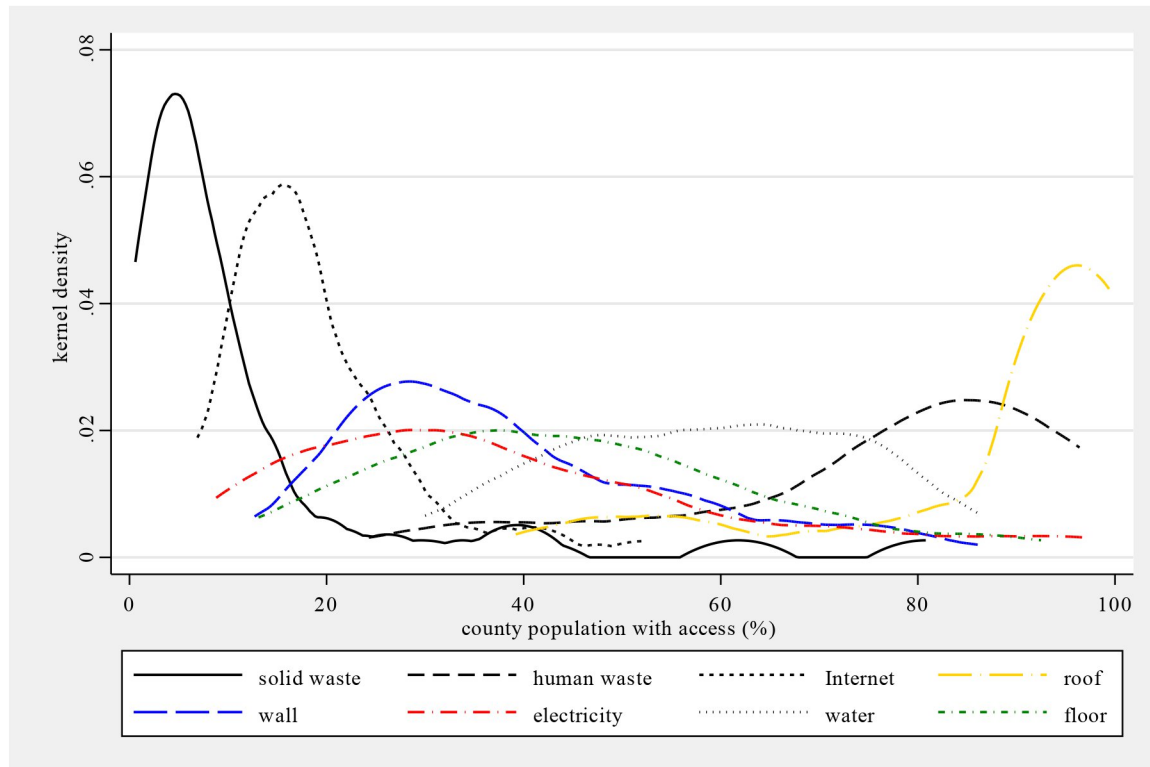


Figure 2: Distribution of Access

Source: Author's Computation

Last, we classify counties into quintiles of deprivation. Quintiles are based on the distribution of the deprivation index. We show in Table 8 that 29 counties (62 per cent) faced overall deprivations ranging from major to extreme.

Table 8: Deprivation Severity

Deprivation rank	Deprivation index	Number	Counties	Percentage	Cum.
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		of counties			
Minor deprivations	< 40.86	9	Nairobi, Kiambu, Mombasa, Kajiado, Nakuru, Uasin Gishu, Kisumu, Machakos, Nyeri	19.15	19.15
Moderate deprivations	$40.86 \leq D_k^c < 51.29$	9	Kirinyaga, Muranga, Taita Taveta, Embu, Nyandarua, Makueni, Meru, Kilifi, Laikipia	19.15	38.30
Major deprivations	$51.29 \leq D_k^c < 56.04$	10	Lamu, Trans Nzoia, Tharaka Nithi, Kericho, Vihiga, Kitui, Nandi, Bungoma, Busia, Nyamira	21.28	59.57
Large deprivations	$56.04 \leq D_k^c < 64.70$	9	Kisii, Siaya, Kwale, Kakamega, Migori, Isiolo, Homa bay, Bomet, Elgeyo Marakwet	19.15	78.72
Extreme deprivations	$64.70 \leq D_k^c \leq 100$	10	Baringo, Garissa, Narok, Tana River, Marsabit, Mandera, Wajir, West Pokot, Samburu, Turkana	21.28	100.00

Source: Author's Computation

Linking Deprivation to Resource Allocation

Analysis of deprivation in Kenya indicates cross-county differences in overall deprivation are largely driven by deprivations in access to safe drinking water, electricity, garbage collection, and human waste collection. A resource allocation criterion which enhances social welfare has to, therefore, attach greater importance to these four factors, and less emphasis on the other five factors. This does not mean undermining other factors, e.g., by discouraging access to formal education. It only implies that formal education and Internet access could be maintained at their current proportions while channeling additional resources towards enhancing access to the four issues identified.

Conclusion

This paper analyzed deprivation across counties in Kenya via principal component analysis on a dataset drawn from the 2019 Population and Housing Census report. Findings highlight a national deprivation index of 53 per cent, suggesting that one in every two Kenyans faces overall deprivation. Subnational analysis reveals 62 per cent of the counties having at least one in every two persons being overall deprived. Deprivation is entrenched across ASAL counties with Turkana, Samburu, West Pokot, Wajir, and Marsabit counties reporting alarmingly high levels of overall deprivation. A synthesis of the analysis indicates 93 per cent of the total variance in deprivation among counties being explained by deprivation in terms of water, energy, garbage collection, and human waste collection. The research findings have potential uses in providing decision makers with information on resource allocation, planning, and budgeting. Specifically, designers of resource allocation criterion ought to lay greater emphasis on water, energy, garbage collection, and human waste collection.

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