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## Toward SDG-11: How Social Resilience Affects Urban Settlement in South Africa?

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### ABSTRACT

The re-engineering of urban city planning and transformation of land spaces should be guided by the vision of creating liveable, secure spaces and resourcefully efficient cities and towns. The study's objective was to assess the social resilience of Khayalitjha in-situ informal settlement in the Free State Province of South Africa based on service delivery. The household survey sample size consisted of 295 randomly selected dwelling units, and a Multinomial Logit Regression model was applied. The security of land tenure, no secure dwelling unit tenure, and dwelling unit tenure were the indicators used to measure the concept of social resilience as an outcome variable. The model revealed that the essential service delivery (access to electricity, refuse dump/removal, a pit latrine/toilet without a ventilation pipe, and clean water) positively and significantly associated with dwelling unit tenure social resilience status were all statistically significant with secure dwelling unit tenure, in-secure dwelling unit tenure, and no secure dwelling unit tenure. Regarding urban social resilience, 20% of households had a secure tenure, 38% had an insecure tenure, and 42% had no tenure status. Insecure tenure and no tenure participants were thus vulnerable and their urban resilience was threatened. The study recommends that developing an urban resilience framework aligned with a disaster risk reduction and management framework will contribute to guidelines for resilience strategies in both metropolitan and non-metropolitan cities.

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**KEYWORDS:** disaster risk reduction; urban resilience; land tenure; peri-urban; human settlement; basic service delivery

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### INTRODUCTION

The United Nations General Assembly convened the third United Nations Conference on Housing and Sustainable Urban Development, also known as HABITAT III, to strengthen global agreements for sustainable urbanization, which focus on the implementation of the New Urban Agenda (NUA) for cities [1]. To explore this new urban paradigm, there is

a need to develop an urban resilience disaster risk reduction and management (DRRM) framework within sustainable human settlement and informal settlement upgrading in the Free State province of South Africa. Urban resilience is critical to achieving the post-2015 globally agreed frameworks and vision 2030 targets. The frameworks are the Sendai Framework of Disaster Risk Reduction (SFDRR), Sustainable Developmental Goals (SDGs), the Paris Agreement on Climate Change, also known as the United Nations Framework Convention on Climate Change (UNFCCC), and the NUA. The four frameworks serve as foundations for building urban resilience within sustainable human settlement and informal settlement upgrading [2].

According to Peters et al. [3], “delivering this global vision by 2030 in a sustainable and inclusive manner requires that all major frameworks be negotiated and agreed upon throughout 2015 and 2016”. Given that the term ‘resilience’ is addressed consistently across the SFDRR, SDGs, and HABITAT III frameworks, the action plan is developed in a variety of scenarios and sizes. This necessitates coordinated monitoring to make progress on the reporting process and keep a check on enhancing resilience [4].

The present global catastrophe resilience initiative aims to reduce catastrophic consequences while strengthening communities [5,6]. The third United Nations Conference on Human Settlements adopted the NUA, which outlined a number of development goals, targets, and objectives. The NUA preparation document (HABITAT III—Urban Resilience) produced in 2015 acknowledged that the HABITAT Urban System Model Approach enhances urban resilience for the built environment. This is defined as a system, community, or society’s ability to resist, absorb, accommodate, adapt to, transform, and recover from the consequences of a danger in a timely and effective manner, including through the preservation and restoration of basic structures and functions through risk reduction management [4,7].

Urban cities can accelerate economic growth, attract investment, spur innovations, and enhance productivity. However, poorly managed urbanization can exacerbate existing challenges such as environmental degradation, poor housing, inadequate transport mobility, poor essential service delivery, lack of urban-health care or adequate care for the aged, inequalities, and social segregation, which leave cities vulnerable and prone to natural and man-made disaster risks [8]. Following SDG 11, “to make urban cities and spatial settlement types inclusive of the marginalized, secure, disaster risk resilient and develop sustainability while ensuring access to adequate, safe and affordable housing”, the provision of municipal essential services talks directly to sustainable human settlement and informal settlement upgrading [9].

Despite the buzzword ‘Urban Resilience’, a significant gap exists between the debate on urban resilience and the capacity to build and develop an urban resilience DRRM framework in practice [2]. The

attention and urgency given to urban resilience is due to the diverse challenges of natural and fabricated disasters facing urban cities. Challenges include vulnerability to climate change, rapid urbanization, migration to urban cities, inadequate housing and basic social service infrastructure, and insecurities [10]. As a result, urban resilience should be considered more than a disaster risk reduction instrument, but also as a comprehensive plan for sustainable urban development making cities welcome places with opportunities, with disaster risk reduction measures interwoven into city systems [11]. The International Institute for Environment and Development (IIED) [12] highlighted that the SFDRR does not address the threats brought about by lack of security of tenure and possible eviction, which negatively influences informal settlement residence. The SFDRR does not address how upgrading informal settlements can reduce disaster risks by using existing developmental practices and programs. Concerns of eviction and lack of security of tenure are characterized as chronic stresses rather than acute shocks such as intermittent disturbances of floods, fire, droughts, pandemics, and the collapse of key infrastructure [13].

Tenure is usually established through the legal systems, customary laws, and informal or hybrid occupation arrangements. The definition emphasizes people's relationship between housing ownership and the land. This illustrates that tenure is not only about the law and legal forms to the land or house but is broader in its application. It is about relationships that people have with the land.

Tenure was defined in 2012 when the Global Tools Network differentiated passive and active tenure security. Passive tenure security infers to be free of the risk of land eviction. In contrast, active tenure security means performing transactions such as buying, selling, or leasing arrangements acquired by the owner. Security of tenure simply means protection from evictions. It is possible to improve informal settlers' tenure security in an incremental way. However, it requires innovative thinking from the multi-stakeholders, and the will to do things differently [14].

Rising inequality can endanger social cohesion and weaken social resilience in an urban city, community, or household, which impedes economic resilience [15]. Firstly, there is the conceptual barrier of the word 'resilience' with the challenge of what should be measured. Secondly, the methodological barrier of measuring resilience due to a lack of reliable data [16].

This study's social resilience concept is related to urban and regional systems. The social resilience approach acknowledges that human-social systems depend on settlement habitat, which ultimately depends on natural resources and the stability of the ecosystem [1]. Weakley [17] recognized vulnerability and resilience in informal settlements using Kya Sands informal settlement in Johannesburg, South Africa, as a case study. The idea of resilience in conjunction with informal settlements is that informal settlements bring residents near jobs, provide livelihood

opportunities, cheaper dwelling units, and access to essential services. Melore and Nel [18] conducted a similar study on the resilience of two rural settlements in mountainous areas, namely Konso in Ethiopia and Qwaqwa in South Africa with regards to the influence of climate change on assets available to the communities. This comparative case study used a mixed-method research approach from primary household and secondary climate data. The concept of urban resilience was measured in terms of economic resilience. However, resilience was purely based on a qualitative data collection method. The current study advocates for a household-based quantitative analysis using the multinomial logistic regression (MLR) model to predict the outcome of social resilience at an informal settlement level and using social resilience instead of economic resilience concepts.

More specifically, there is paucity of low level geographical place name data, which are quantitative and evidence-based for in-situ informal settlement upgrading of Mangaung Metropolitan Municipality cities. This data would assist planning for adequate housing and disaster risk reduction, while building urban cities' social resilience at in-situ informal settlements. As such, this study advocates for a household survey while using MLR analysis model to predict the outcome of social resilience at an informal settlement level and using the concepts of social resilience instead of economic resilience. Although African urban cities are considered vibrant urban areas that generate almost 60% of economic regional growth, increasing population and transformation puts pressure on local municipalities to provide basic service delivery and to build social resilience. Thus, the chronic crisis of sustainable human settlement and in-situ informal settlement upgrading is not addressed. Therefore, this study explored the association between basic service delivery and social resilience. Even though Khayalitjha has been an in-situ settlement for 15 years with incremental development, the reality is that little has been achieved in providing basic service delivery and adequate housing.

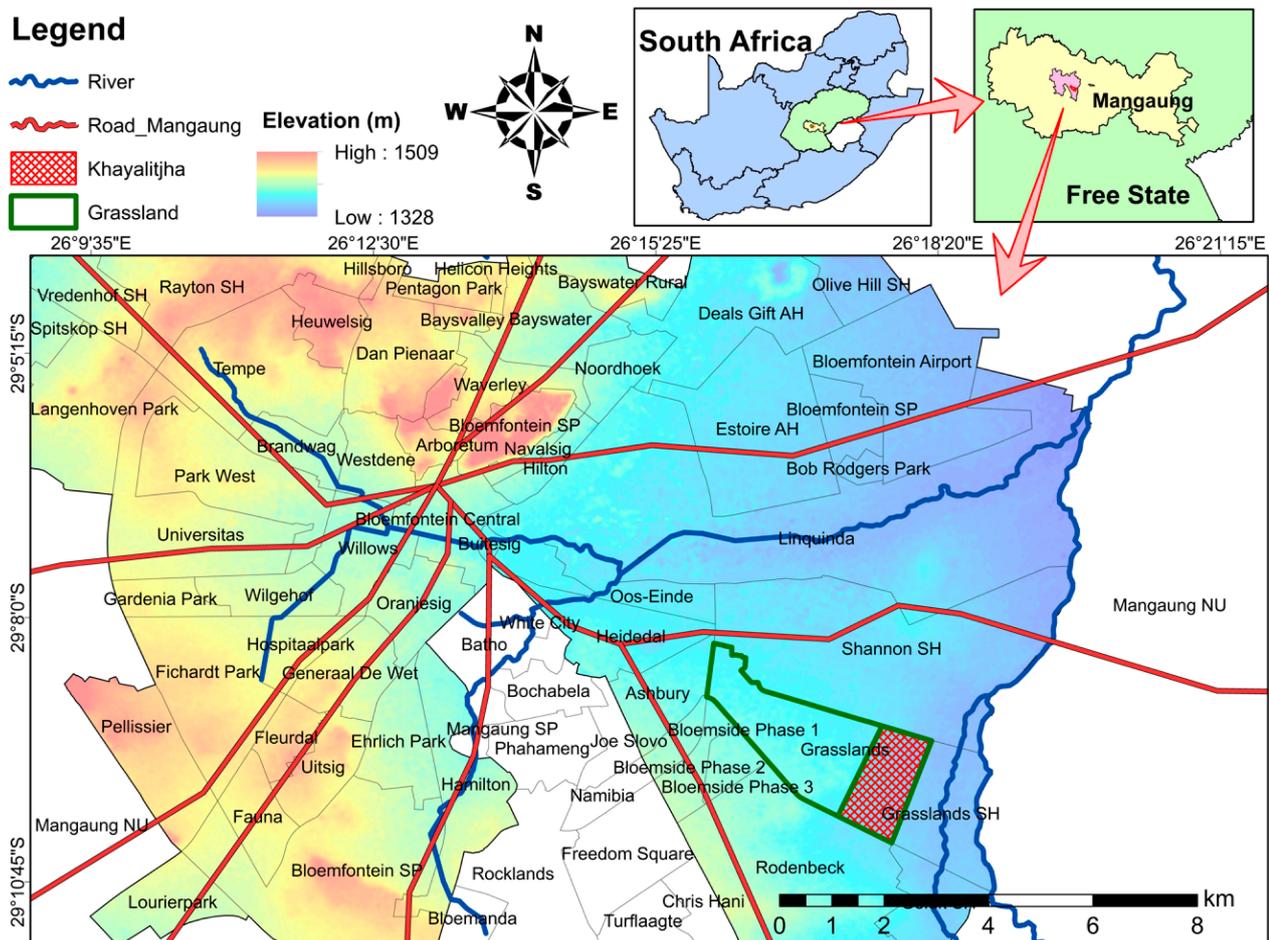
The study assessed the social resilience of Khayalitjha (Free State Province of South Africa) in-situ informal settlement based on service delivery. The findings can assist policymakers to develop appropriate policies and mitigation methods, which enhance social resilience through improvement of basic service delivery of Khayalitjha in-situ informal settlement.

#### **DEMOGRAPHIC PROFILE OF KHAYALITJHA IN-SITU INFORMAL SETTLEMENT**

Khayalitjha in-situ informal settlement is geographically located in Bloemfontein city of Mangaung Metropolitan Municipality of the Free State Province, South Africa. Khayalitjha in-situ informal settlement (Figure 1) was chosen because it is located in an urban metropolitan city. People settled in Khayalitjha around 2004 and underwent incremental development for about 2000 surveyed erf/erven (RSA MMM (h), 2021).

According to Statistics South Africa (Stats SA) [19] and Mangaung Metropolitan Municipality [20], the demographic profile of Khayalitjha informal settlement in Ward 17 under the current municipal demarcation is as follows:

1. Total population: 8319, of which 7973 are Black, 323 are Coloured, 20 are Indian, and 4 are White.
2. Total Households: 8305, of which 7923 reside in informal dwellings, 321 in formal dwellings, 60 in other types of dwellings and 2 in traditional dwellings.
3. Mainly comprises “one-person-headed households”, just like any other informal settlement in South Africa.



**Figure 1.** Khayalitjha in-situ informal settlement study area within Bloemfontein. Sources: Authors' with assistance of GIS expert.

## MATERIALS AND METHODS

A cross-sectional household-based survey was used with mixed data collection due to COVID-19 pandemic. Data were collected using Computer Telephone Interviews (CATI) and Paper Assisted Personal Interview (PAPI). The overall sample size was fixed at 5% of the total sample frame (i.e., 8305 household estimates) with a total sample size of about 415 household heads. However, only 295 responded.

The enumeration areas (EAs) created for Census 2011 implementation served as appropriate sampling units for the 12 clusters created for this study. An EA was the smallest geographical unit used to demarcate the country for census enumeration. A geographical map of Khayalitjha with 12 EAs and households per EA was obtained from Stats SA. Each EA represented a cluster and the unit of observation was the persons within the households and the household itself.

Quantitative data collection followed the following sampling approach. Firstly, a sample of 5% of dwelling units was selected by systematic random sampling for each of the 12 clusters. The scope of the study excluded dwelling units or businesses with no household occupants living in those structures. At each cluster level, the sample was done by probability proportion to population (PPP) size. For instance, the large sample size allocation in Cluster F, as depicted in Table 1, achieved better precision in calculating the standard error. The proportional allocation of the sample in each cluster, as outlined in Table 1, was given as a reference to show how the sample distribution deviated from a proportional allocation of the overall 5% of the total sample of 8305 households. The sample was allocated at a cluster level to minimise the expected coefficient variations (CVs). As a result, the total sample size was 415 households from a total dwelling units.

**Table 1.** Household-based survey sample distribution by cluster segmentation.

Number	Cluster	Households estimates (sample frame)	5% sample	sample size	sample interval	Actual respondents
1	A	372	4%	19	20	11
2	B	412	5%	21	20	14
3	C	293	4%	15	20	11
4	D	376	5%	19	20	12
5	E	562	7%	28	20	16
6	F	2421	29%	121	20	112
7	G	659	8%	33	20	13
8	H	604	7%	30	20	13
9	I	501	6%	25	20	11
10	J	886	6%	44	20	32
11	K	573	7%	29	20	18
12	L	646	8%	32	20	32
		8305	5%	415		295

Note: The first and second column indicates that the enumeration areas (EAs) (12EAs) created for Census 2011 implementation served as appropriate sampling units for the 12 clusters created for this study. The third column, 8305—indicates the population (the total sample frame). The fourth column indicated that 5% of the sample frame (8305) intended to interview as a sample size or respondents (415). In the last column, 295 respondents were willing to respond. Source: Authors' compilations.

The minimum acceptable response rate for the household-based survey at Khayalitjha was set at 71% out of a total sample size of 415 households. A total of 295 households completed the questionnaire. The response rate was 71% and calculated as  $(295/415) \times 100$ . A total of 415 households were then selected from the total population of 8305 households. The sample size for the qualitative self-assessment study was increased to 100 entities relevant to sustainable human settlement and informal settlement upgrading. Fifty entities were associations from non-governmental organisations ( $n = 38$ ) and the private sector ( $n = 12$ ).

The MLR model was applied to analyse the predicted independent variables of essential service delivery in forecasting the categorical dependent variables' outcomes regarding security of tenure to measure urban social resilience. The MLR model is used to predict a response or outcome variable using continuous or categorical explanatory variables as independent variables [21]. The study outcome variable was social resilience, which was constructed from security of dwelling unit tenure. The dwelling unit security of tenure to indicate social resilience was classified into three dependent variables: secure dwelling unit tenure, insecure/partly secure dwelling unit tenure, and no security of dwelling unit tenure. Table 2 depicts the outcome variables with explanations.

**Table 2.** Security of dwelling unit dependent variables classified into three categories.

Outcome variable description	Variable explanation
(1) Security of dwelling unit tenure	Household head is assigned the plot stand and plot number by the local municipality and occupies the dwelling unit free from paying rent.
(2) Insecurity of dwelling unit tenure	Household head rents the dwelling unit from a landlord within a plot assigned by the local municipality.
(3) No security of dwelling unit tenure	Household head occupies a dwelling unit not located within the demarcated local municipal assigned plot or stand, irrespective of paying or not paying rent to a landlord.

Source: Author's compilations.

For the explanatory/ independent variable, consider a random variable "Y<sub>i</sub>" that may take several discrete or indiscrete values, which will be indexed as 1, 2, 3, ..., *j*. The outcome response/ dependent variable for measuring social resilience takes the values to denote the three categorical dependent variables as it explained in Table 2, which we index 1, 2, and 3. Multinomial distribution as denoted Equation 1:

$$\Pr\{Y_{i1}=y_{i1}, \dots, Y_{ij} = y_{ij}\} = (n_i/y_{i1}, \dots, y_{ij}) \pi_{i1}^{y_{i1}}, \dots, \pi_{ij}^{y_{ij}} \quad (1)$$

Where " $\pi_{i1}$ " is the probability that the "i-th" response outcome for measuring the dependent variable of social resilience is of a household with secure security of tenure. For the explanatory/independent variable

grouped data, such as household head age cohort, auxiliary random variables representing counts of responses in the explanatory/independent variable categories were introduced. The index “ $ni$ ” denotes the number of cases in the “ $i$ -th” group and lets “ $Y_{ij}$ ” represent the number of responses from the “ $i$ -th” group that fall into the “ $j$ -th” category of the dependent/ outcome response variable for measuring social resilience, with observed value “ $Y_{ij}$ ”.

In the MLR model, “ $i$ ” represents age groups, “ $ni$ ” is the number is the number of household heads in the “ $i$ ” age group, and “ $Y_{i1}$ ,  $Y_{i2}$ , and  $Y_{i3}$ ” are the number of households among the three classified categories for measuring social resilience, using a proxy indirect indicator of secure security of dwelling unit tenure, insecure security of dwelling unit tenure and no secure security of dwelling unit tenure, respectively.

It should be noted that “ $\sum_j Y_{ij} = ni$ ” denotes the counts in the various outcome response categories for measuring social resilience, adding to the number of auxiliary age cohort categories. For individual explanatory variables, such as gender of the household head, the index “ $ni$ ” becomes an indicator variable or dummy variable, which takes the value “1” if the “ $i$ -th” response falls in the ‘ $j$ -th’ category and ‘0’ otherwise. As a result, “ $\sum_j Y_{ij} = 1$ ”, since one and only one of the individual explanatory predictor variables ‘ $y_{ij}$ ’ can be on for each case. This was done by letting “ $y_{i1}$ ” be one of the “ $i$ -th” household heads with secure security of dwelling unit tenure and ‘0’ if otherwise.

One social resilience indicator category, namely of a household with secure security of dwelling unit tenure, was nominated as a baseline indicator. The log-odds for the two remaining indicator categories, insecure security of dwelling unit tenure and having no secure security of dwelling unit tenure at all, were calculated and became the linear function of outcome variable. Then the odds that a household within Khayalitjha-denoted as ‘ $i$ ’ falls in the group category ‘ $j$ ’ instead of the baseline indicator of having no security of dwelling tenure at all of ‘ $\pi_{i1}/\pi_{ij}$ ’ was calculated. Thus, the study determined the odds of a household having secure security of dwelling unit tenure rather than having insecure security of dwelling unit tenure, and the odds of a household having insecure security of dwelling unit tenure rather than a household having no secure security of tenure at all. Equation 2 depicts that in the MLR model, there is an assumption that the log odds of each response follow a linear model.

$$\ln \frac{\pi_{ij}}{\pi_{i1}} = \alpha_j + X_j \beta_j \quad (2)$$

Where “ $\alpha_j$ ” is a constant, and “ $\beta_j$ ” is a vector of regression coefficients, for “ $j = 1, 2, \dots, j - 1$ ”. The constant is written explicitly; subsequently, we assume that the model matrix “ $X$ ” does not include a column of ones. This is classified as an analogous logistics regression model with the exception that the probability distribution of the response is multinomial instead of binomial, and we have “ $j = 1$ ” instead of one. The “ $j = 1$ ” multinomial logit equations contrast each of categories “1, 2, ...,  $j - 1$ ” with category “ $j$ ”,

whereas the single logistics regression equation is a contrast between successes and failures, which is usually dichotomous. Note that if  $j = 2$ , the multinomial logit model would reduce to the usual logistic regression model.

To describe a variable with “ $j$ ” response categories, only “ $j - 1$ ” categories are needed; the applied MLR model with  $j = 3$  categories with category 1 versus 3 and category 2 versus 3. The missing contrast of categories 1 and 2 can easily be obtained in terms of the other two as depicted in Equation 3:

$$\log \frac{\pi_{i1}}{\pi_{i2}} = \log \frac{\pi_{i1}}{\pi_{i3}} - \log \frac{\pi_{i2}}{\pi_{i3}} \quad (3)$$

## RESULTS AND DISCUSSIONS

### Descriptive Analysis and Multinomial Logit Regression

Table 3 and Figure 2 summarises the research findings from the MLR model and descriptive analysis. Access to electricity was positively and statistically significant 1% level. Few households had legitimate access to electricity with ownership of the plot stand making inhabitants eligible for such service. The policy of the Mangaung Metropolitan Municipality, electrification of dwelling units, allows only officially awarded dwelling units and erf/erven to receive electricity from the main grid. As a result, only 24% of households were legally connected to the electrical grid in Khayalitjha in-situ informal settlement. However, 40% of households with insecure tenure security, and one-third (33%) of households with no security of tenure at all, had electricity. This discrepancy was due to illegal or unsafe electrical connection for a monthly fee of R200, equivalent to US\$10 by July 2021. The households referred to this as a straight connection. The implication for Mangaung Metropolitan Municipality is that the electrification policy must be reviewed to include dwelling units or erf/erven with insecure dwelling unit tenure or no dwelling unit tenure. This will benefit local municipal cities by collecting revenue tax from electricity. These findings are similar to the study on the economic conditions leading to illegal connections at Quarry Road informal settlement in South Africa. The results revealed that illegal electricity connections are common in informal settlements. Most residents of the Quarry Road informal settlement bought their houses with an existing illegal electrical connection, with most residents accustomed to this illegal act [22]. Poorly managed urbanization systems such as electricity only exacerbate the vulnerability status and poor social resilience due to man-made stresses at an in-situ informal settlement. Furthermore, the findings support the implementation of the New Urban Agenda (NUA) for cities, the development of an urban resilience Disaster Risk Reduction and Management (DRRM) framework within sustainable human settlement, and in-situ informal settlement upgrading in South Africa’s Free State Province to meet the post-2015 globally agreed frameworks and global

vision 2030 targets. The global frameworks serve as the foundation for constructing urban resilience within the context of sustainable human settlement and in-situ informal settlement upgrading [1,2].

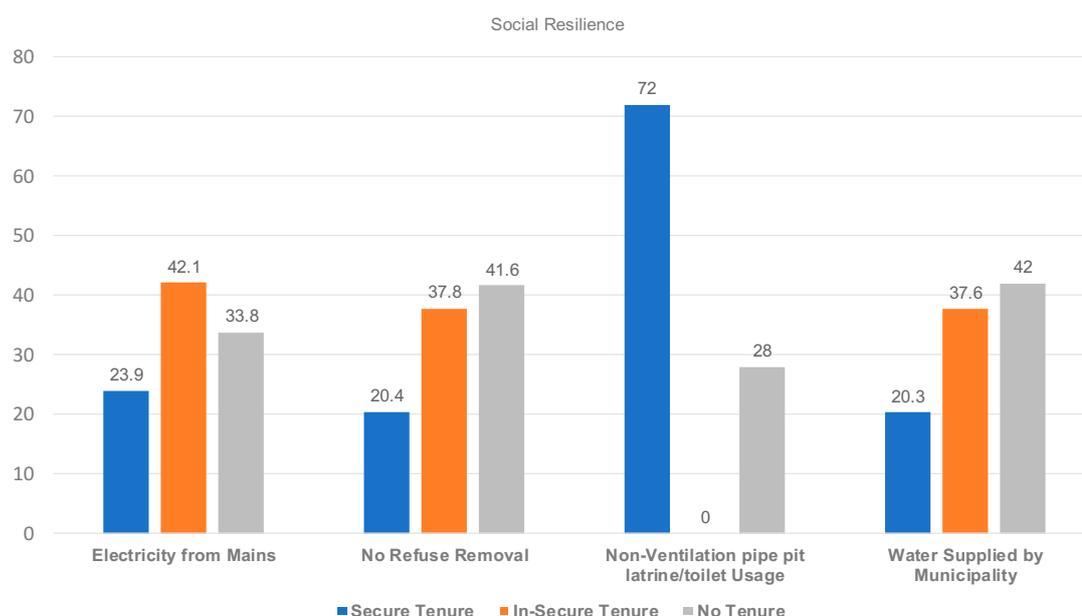
**Table 3.** Household essential service delivery as predictors of social resilience.

Explanatory variables	Coefficient	P-Value	Social Resilience		
			Secure Tenure	Insecure Tenure	No Tenure
Access to electricity for lighting from the mains	0.051	0.000*	58 (23.9%)	102 (42.1%)	82 (33.98%)
No access to own refuse dump/removal	0.041	0.331**	60 (20.4%)	111 (37.8%)	122 (41.6%)
Access to a pit latrine/toilet without a ventilation pipe	0.381	0.000*	54 (72%)	0 (0%)	21 (28%)
Access to clean water supplied by the municipality	0.012	0.000*	60 (20.3%)	111 (37.6%)	124 (42%)
Duration of settlement in Khayalitjha, measured by the year the household first moved into the informal settlement	0.016	0.009*	170 (58.2%)	109 (37.3%)	13 (4.5%)
Male household head by age in years	0.128	0.000*			
18–35			22 (7.4%)	41 (13.9)	43 (14.6%)
36–40			15 (5.1%)	34 (11.5%)	41 (13.9%)
41–55			15 (5.1%)	15 (5.1%)	29 (9.8%)
56–60			1 (0.3%)	9 (3.1%)	1 (0.3%)
60+			7 (2.4%)	12 (4.1%)	10 (3.4%)
Female household head by age in years	0.235	0.000*			
18–35			22 (7.4%)	37 (12.5)	46 (15.6%)
36–40			25 (8.5%)	47 (15.9%)	38 (12.9%)
41–55			10 (3.4%)	19 (6.4%)	12 (4.1%)
56–60			0 (0%)	5(1.7%)	4 (1.4%)
60+			3 (1%)	3 (1%)	24 (8.1%)
Number of observation	295				
LR chi <sup>2</sup>	96.06				
Prob > chi <sup>2</sup>	0.000				
Log likelihood	—469.542				
Pseudo R <sup>2</sup>	0.076				
Variance Inflation	4.9				
Factor (VIF)					

Note: \*, \*\* significant—1%, and 5% respectively. Source: Author's computation.

Access to refuse removal was positive and statistically significant at 5% level. About 20% of households with secure tenure had no refuse removal, compared to 37.8% of households with insecure dwelling unit security and 42% with insecure tenure security or households with no security of tenure. Households with secure security of tenure were probably more likely to take care of their environment. The Mangaung Metropolitan Municipality refuse removal policy only provides services to deed-registered residential areas by the Surveyor General. The by-law policy implications need to be reformed to align with the right to a clean

environment stipulated by the South African constitution. A similar study was conducted at Khayelitsha site C informal settlement in Cape Town. The residents indicated that dumping rubbish in the open was their solution to dealing with a lack of service delivery by the City of Cape Town metropolitan municipality [23]. The act of taking care of one's environment by cleaning and providing access to refuse removal demonstrates that security of tenure is more than just protection from eviction, but contributes to social resilience and toward achieving the SDG-11 goal. Poorly managed urbanization can exacerbate existing challenges such as environmental degradation, poor essential service delivery, lack of access to urban-health care, adequate care for the elderly, inequalities, and social segregation, making cities more vulnerable to both natural and man-made disaster risks [8].



**Figure 2.** Key findings of essential service delivery in relation to urban social resilience. Source: Author's compilations.

Proper toilet facilities were positive and statistically significant at 1% level. The questionnaire included various options for decent toilet facilities. Most households (72%) with secure tenure had access to toilet facilities since they had a reason to improve their dwellings. No households (0%) with insecure dwelling unit tenure, and 28% with no security of dwelling unit tenure had access to proper toilet facilities. The insecure tenure households usually rent and are less likely to dig holes for a pit-latrine. The no-tenure households typically do not have the land space to build such a toilet since they dwellings encroach on the road and foot pathways among the informal settlement. For policy implications, this will require fast-tracking infrastructure development for proper sanitation facilities within the in-situ informal settlement of Khayalitjha. Besides, provision of municipal essential services (SDG-11) is related to

sustainable human settlement and informal settlement upgrading [9]. Similarly, a study on waste management in South Africa argued that more than 5000 people living in the informal settlements of Langrug in Cape Town are expected to share one toilet facility with five other households [24]. Due to poor service delivery by local municipalities, the absence of access to a functional toilet facility is a health risk, which not only undermines the city's social resilience but also the fundamental right to live in a clean environment.

Access to clean water was positive and statistically significant at 5% level. A fifth of households (20%) with secure dwelling unit tenure, 38% with insecure dwelling unit tenure, and 42% with no secure dwelling unit tenure had access to water. A measure of clean drinking water was provided to in-situ informal settlements of Khayalitjha. Water emergency grants for in-situ informal settlements are available, which have policy implications. The Water Hub study led to interesting results that demonstrated how much the value of nature-based processes was underestimated. For instance, the concept of developing the Urban Living Labs (ULL) arose due to contaminated water, which affected people's health and the natural environment. The ULL bio-filtration system treated between 50,000 to 100,000 litres of water per week without adding chemicals or using non-renewable energy. It was then proven that natural filters removed 100% of bacteria and 90% of the phosphate and reduced nitrogen by 75% to 85%. As a result, the Water Hub reused the water for vegetable gardening, generating energy, and making compost [24].

Due to incremental informal settlement upgrading, piped tap water was installed at 2000 serviced stands. The households are not expected to pay for services, property rates, and taxes. Only properties with a market value above R70,000.00, equivalent to US\$4666.66 (July 2021) are expected to pay for services. As a result, the insecure tenure and no-tenure households opted for illegal piped water connections for a straight connection fee of R150.00 (US\$10 at July 2021). The households used local unregistered plumbers, and a once-off payment for illegal water pipe installation and connection to household taps. An official South African identification document or being legally documented by Home Affairs immigration policies is one of the requirements to be eligible for a serviced plot stand with incremental upgrading. Most informal settlement residents of Khayalitjha are, however, Lesotho Nationals with expired legal documents or low-income urban economic migrants not interested in owning dwelling units. This implies that informal settlement communities should strengthen and intensify the advocacy and publicity campaigns regarding the Breaking New Ground policy and the housing programme options. These findings align with The Socio-Economic Rights Institute of South Africa (SERI), which highlighted that profound inequalities in access to basic municipal household services like clean water, proper sanitation facilities, and electricity characterize South African informal settlements. According to Tun [10] and IIED [12], the

increased focus and urgency on urban resilience is owing to urban cities experiencing natural and artificial calamities. These difficulties include people's vulnerability to climate change, growing urbanization, a lack of tenure security, migration to metropolitan areas, inadequate infrastructure, housing, basic social services, and insecurity.

The settlement duration in Khayalitjha is positive and statistically significant at 1% level. Duration was measured by the year the household first moved into Khayalitjha informal settlement and included 58% of households with secure dwelling unit tenure, 37% of households with insecure dwelling unit tenure, and 5% of households with no secure dwelling unit tenure. This implies that the Department of Human Settlement and local municipality should focus stakeholder engagement and publicity campaigns of the Breaking New Ground housing programme towards in-situ informal settlement household segmentation. The Department of Human Settlement indicated that innovative thinking and engagement is needed to enhance active tenure security [14].

Male and female household heads were positive and statistically significant at 1% level. Male-headed households between the two age cohorts of 18–35/36–40 years old comprised 7% of households with secure dwelling unit tenure together with 14% of households with insecure dwelling unit tenure and 15% with no secure security of tenure. This implies that policies should concentrate on the lack of adequate housing for youth and young adults. The same policy transformation should be addressed to female-headed households within the same two age cohorts of 18–35 and 36–40 years old. The female-headed household of 18–35 years old also had 7% of households with secure dwelling unit tenure, together with 13% of households with insecure dwelling unit tenure and 16% with no secure dwelling unit tenure. The General Household Survey indicated a similar household head age trend. Those aged 45 years and older were less likely to occupy informal dwellings and more likely to occupy formal dwellings in 2014 than in 2002. Thus, the data show that the situation regarding the formalization of dwellings improved for household heads of 45 years and older. Still, it deteriorated for those classified as youth between 2002 and 2014 [25].

## CONCLUSIONS

Basic service delivery indicators are helpful since they are the best predictors for in-situ informal settlement upgrading. The study's conclusion points towards the proposed developed urban resilience DRRM framework, which serves a dual purpose by mapping out phases for accessing adequate housing for sustainable human settlement and in-situ informal settlement upgrading. The urban resilience DRRM framework is based on a flexible approach that can fit a DRRM cycle within each phase of the DRRM framework process flow by using the security of tenure as an indicator for measuring urban social resilience, the profiling and

unpacking of shack farming could be understood when it comes to in-situ informal settlements.

Building an urban resilience within sustainable human settlement and informal settlement upgrading is a two-pronged local government approach. Firstly, through the enhancement and advocacy of the formal residential housing market. They are then followed by the acknowledgment of informal housing markets and settlements, which need to be taken care of in terms of essentials and basic services, functional security of tenure, and adding value by retrofitting initiatives in urban metropolitan and non-metropolitan areas. The Spatial Planning and Land-Use Management Act (SPLUMA) provides the context for building urban resilience, which focuses on how both urban metropolitan and urban non-metropolitan areas can use regulations emerging from SPLUMA to support sustainable incremental in-situ informal settlement upgrading while building urban resilience within cities.

The limitation of using Khayalitjha as the only location for a case study is lack of demographic representation of the other 47 informal settlements in the Mangaung Metropolitan Municipality, which are smaller in surface areas and population size. They also mainly consist of single young male adults compared to Khayalitjha in-situ informal settlement, which have a similar national and provincial demographic profile. Therefore, future research should incorporate more locations in other provinces of South Africa.

#### **DATA AVAILABILITY**

Data will be available from the corresponding author (YTB) upon request.

#### **AUTHOR CONTRIBUTIONS**

All authors significantly contributed to the present manuscript's preparation. MC Collected the data and wrote the first draft of the article. AN and YTB. were the supervisor of the first author and aided in the review and the writing of the final draft. All authors have read and agreed to the published version of the manuscript.

#### **CONFLICTS OF INTEREST**

The authors declare that they have no competing interests.

#### **ETHICAL CONSIDERATIONS/ INSTITUTIONAL REVIEW BOARD STATEMENT**

The study obtained an ethical clearance certificate from the University of the Free State General/Human Research Ethics Committee (GHREC), and the reference number is UFS-HSD2021/0660/21. The date of approval of Ethical clearance was 20-10-2021.

## INFORMED CONSENT STATEMENT

Informed consent was obtained from all subjects involved in the study.

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