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**ARTICLES**

- Spatial suitability for urban sustainable densification in a borderland city** 266  
Erick Sánchez Flores and Marisol Rodríguez Sosa
- Development of an informal cadastre using social tenure domain model (STDM): A case study in Kwarasi informal settlement scheme Mombasa** 278  
Bartholomew, C. Mwanyungu, David, N. Kuria, Moses, K. Gachari, Godfrey, O. Makokha and Malachi Odongo
- Factors affecting farmers' land tenure security after the implementation of rural land registration and certification program in Hulet Eju Enese district, Amhara region, Ethiopia** 289  
Gebrie Tsegaye

*Full Length Research Paper*

## Spatial suitability for urban sustainable densification in a borderland city

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The traditional approach to pursuit of sustainable urban development involves an integrated, long-term planning process based on a series of environmental, economic, equity and livability societal values, for creating healthy and prosperous communities that not only meet the physical needs but also the aspirations of their residents. Urban land plays a central role as the material basis of this process; therefore, assessing its suitability for livable and sustainable conditions is critical in contemporary cities. The efficiency of different urban density and centralization patterns, making livable communities demands to avoid oppressively dense or overly scattered and fragmentary development was discussed. In this research, land suitability for urban densification in the border city of Ciudad Juárez, Chihuahua, based on a spatial multi criteria analysis (SMCA) of environment, economy, equity and livability variables were assessed. The result model for each group variables showed that suitable areas for densification are associated with the consolidated part of the city. The main variables affecting suitability distribution in an integrated model were distance of public transportation routes, location of poverty zones and land values. Selecting potential areas for densification derived from this analysis requires appropriate strategies for affordable, diverse and accessible housing provision, which contributes to the creation of livable sustainable communities.

**Key words:** Urban densification, spatial multi criteria analysis, land suitability.

### INTRODUCTION

Solving the current social, economic and environmental issues that threaten urban viability in many growing cities is one of the most pressing challenges for the decades to come in developing countries. It is predicted that by 2030, for every one person now living in cities in developed countries, there will be four in the cities of developing world, indicating that 90% of the growth in urbanization will occur in these regions (Burgess and Jenks, 2000).

Contemporary urban planning has shown a host of

alternatives to attain the visionary idea of sustainable urban communities that gives their inhabitants opportunities for better lives (Godschalk, 2004; McKendry and Janos, 2015). This is in fact, the permanent quest in planning, finding a way to create places that are both sustainable and livable at the same time (Berke et al., 2006).

The traditional approach in pursuing sustainable communities involves an integrated, long-term planning

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process that seeks to protect the environment, expand economic opportunities, while meeting social needs for healthy and prosperous development (American Library Association, 2006).

Integration of these societal values, referred to as the three E's (environment, economy and equity) triangle in the planning process, has been lately complemented by the incorporation of livability as a fourth node in what have been called the sustainability prism model 3E's+L (Berke et al., 2006), for creating communities that not only meet the physical needs but also the aspirations of their residents.

From each perspective in this model, urban land plays a critical role as the material basis of certain processes in the city. The economic approach considers urban land as a commodity for the production, consumption and distribution of products and services for profit (Logan and Molotch, 2007).

From the vertex of the environmental values, the city is seen as an organic element that consumes resources and produces waste, making it particularly important for its functioning in the protection of its resources and interlinked ecosystems, dependent on land health and availability (Kennedy et al., 2011).

The equity perspective focuses on the need to solve conflict arising from the spatial distribution of resources and services, to create equal access opportunity structures, according to the needs, aspirations and relevance of the different groups in the community (Witten et al., 2003).

Incorporating the livability value into the urban planning process means considering the design of public spaces to encourage community engagement; an equilibrated mix of land uses and building types to accommodate a diversity of activities; the preservation of historic structures to promote sense of place; and the proximity to public mobility systems to enhance accessibility at the intra urban and regional scales (Bohl, 2002; Barnett, 2003). According to Berke et al. (2006), suitability factors for livable residential areas should include:

1. Accessibility and transportation systems
2. Safe environment free of danger of traffic and hazards
3. Privacy (secondary and tertiary streets)
4. Proximity to service, community facilities, shopping and activity centers, employment
5. Infrastructure capacity for basic services: water, sewer, gas, electricity and cable
6. Proximity and access to social facilities: educational system and health facilities
7. Proximity and everyday access to place-making in public space (streets, sidewalks and parks), open-space network, nature, places for recreation, relaxation and socializing
8. Mixed uses and diversity of activities
9. Preservation of historical structures: sense of place, belonging, pride and satisfaction

10. Housing compatible with different budgets and life-cycle stages (income and age).

Besides considering proximity to public space, service and social facilities, livable communities also requires a sufficient capacity of basic service infrastructure in an urban environment that guarantees safety, privacy and proper diverse housing conditions for people with differentiated needs and capacities at distinct age and productive life stages. All these requirements rely ultimately on the land as the foundation in which the materialization of urban structures occurs; therefore, identifying its potential and suitability is critical for livable and sustainable conditions in contemporary cities.

### Land use planning for urban densification

Although, a general consensus has been achieved in the literature on close relationship between shape, size, density and land use pattern of a city and its sustainability, the relative efficiency of different urban density and centralization patterns for the rational use and distribution of its resources is still discussed. While certain urban forms and densities appear to be more sustainable, for example, in terms of mobility at the intra urban scale, others might have the same positive effects at the citywide or regional level (Burton et al., 2013).

What seems to be true in general is that, making livable communities demands shaping their growth to configure sensible and attractive patterns avoiding oppressively dense or overly scattered fragmentary development (Levy, 2016).

Achieving this equilibrium requires meeting a sort of physical and structural urban characteristics that guarantee accessibility and connectedness for easier interaction at the human scale. This condition, associated typically with relatively denser urbanization patterns, requires taking into account not only urban form, but also urban processes to achieve the elusive goal of a sustainable city (Neuman, 2005).

According to the vast amount of evidence, the common leapfrog low-density development pattern that dominated urban growth during the second half of the 20th century, resulted in the inefficient spread of fragmented suburban and exurban landscape (Burchell and Otrós, 2002; Ewing et al., 2003), which proved to be an unsustainable model with very negative effects, exceeding the benefits of building residential areas on cheaper rural land, in close contact with nature (Irwin and Bockstael, 2004).

The large rural land consumption rates of urban sprawl placed intense pressure on environmentally sensitive areas (Johnson, 2001); increased the costs of public infrastructure and services (Carruthers and Ulfarsson, 2003; Zhao, 2010); augmented environmental pollution and traffic congestion (Allen and Lu, 2003); and fostered auto dependence with its derived negative effects on

public health, due to the increasing commuting times (Frumkin, 2002; Ewing et al., 2003).

As one of the responses to the urban sprawl problem, the compact city paradigm requested for the need for more efficiently used urban spaces that maximized land savings and optimized intra urban transport for improved accessibility. This model, exhibited its own disadvantages in terms of the relatively low tradeoffs for energy resource savings; the potential for expanding transit use and promoting transit-oriented developments (TODs); the costs and benefits of suburbanization; the low efficiency gains from compactness; the impact of telecommunications on the density of development; and the poor acceptability of its higher residential densities (Gordon and Richardson, 1997; Burton et al., 2004).

Burgess and Jenks (2000) tentative definition of contemporary compact city calls for increase in built area and residential population densities to intensify urban economic, social and cultural activities through the manipulation of urban size, form and structure, in pursuit of the environmental and social benefits derived from the concentration of urban functions.

Nonetheless, there is need to clarify the actual effects of the compact city approach on 'sustainable urban development', since the particular relationship between spatial centralization and decentralization forces determining form and density in developing country cities, is complex and still barely understood (Burgess, 2002).

Besides the unsolved dilemma between the effects of urban sprawl and compactness, other pernicious trends threatening sustainability, such as the increase in mass production of poor quality housing and reduction of urban green spaces have produced inequitable environments affecting everyday lifestyles and accentuating growing inequity among cities at global level (Burton et al., 2013).

Planning, for the suitable combination of urban pattern, size and density produce the right equity and livability effects according to the economic potential, environmental capacity, social aspirations and cultural background of a community, a crucial undertaking of sustainability which is a goal to attain.

Since urban land use are complex systems integrated by components, factors and agents from both natural systems related to land resources and human systems related to land uses, the search for the ultimate sustainable urban form should take into account an integrated approach considering a wide array of key variables and their interrelations that truthfully represent the urban reality (Allen and Lu, 2003).

When it comes to land use planning and density, those interested in reducing the negative effects of suburban sprawl and automobile dependence have embraced the concept of "smart growth" in the last decades. The movement for smart growth aims to shape the future urban growth mainly from the logic of the "rural-to-urban transect", having as one of the main goals, achieving neighborhood livability (Duany et al., 2010).

This approach prioritize the idea of planning the progressive increase of density from the more rural environments towards the urban core, and presents a more operational update of well-known ecological and traditional urban theories, such as the "valley section" of Geddes (1916) and the "rings of density" of Alexander et al. (1977).

The central idea is that density of dwellings should not be planned in a homogeneous way for the whole city, but in transects, to allow a harmonious integration of the city and the natural environment. This means that both high and low densities are desirable, with lower densities towards the edges of the city and higher towards the urban core.

In that logic, the Smart Code version 9.2 (Duany Plater-Zyberk and Company (DPZ) (n.d.)), suggests the normative details for six sub-transects on the rural-to-urban transect:

T1: Natural Zone, T2: Rural Zone, T3: Sub-urban Zone, T4: General Urban Zone, T5: Urban Center Zone, T6: Urban Core Zone.

In this progression, the densest transect T5 and T6 corresponds to the more dense perimeter towards the center of the city: T6 consists of a high density and high height urban core with residential density up to 96 units/ac (gross (240 dwellings/hectare) mostly apartments); and T5 consists of high density and low height (3-to-5-story buildings) mixed use developments, with residential density up to 24 units/ac (gross (60 dwellings/hectare) and diversity of housing choices).

According to smart growth, density is beneficial for neighborhood livability and vice versa, provided that the capacity of each transect is respected. Higher residential densities favor mixed uses, which in turn improve neighborhood livability, and makes density acceptable:

"The "D word" is a contentious issue among planners and citizens. (...) higher-density developments do mitigate sprawl in several ways. Because they place more people on less land, they help to preserve open space. And since density support transit, they reduce dependence on the automobile. (...) Only if urbanism is practical, walkable and convivial, density will be tolerated by buyers, neighbors and elected officials" (Duany et al., 2010).

Although, it is not clear in the Smart Growth Manual, how to proceed methodologically to assess the suitable land in order to define the denser perimeters in a particular city, it can be concluded that it would be a good decision to identify the urban areas that fulfill the conditions to promote neighborhood livability.

In this research, the authors assessed the land potential for urban densification in the northern Mexican city of



Ciudad Juárez (CJ). This metropolitan area of approximately 1,391,000 inhabitants, located in the border with United States, experienced an accelerated expansion process along the last three decades of the XX century, due to the population attracted by the employment in the assembling industry and the possibility of immigration to U.S.

As part of the government's response to the population growth, an intensive housing policy implemented at national level, fostered the mass building of low quality social housing in cheaper outskirts land, expanding further the urban growth of CJ (Flores et al., 2016). Thus, the kind of densification project considered in this proposal is well suited for medium income population sectors, to ease accessibility and to avoid social segregation.

Since the 1960s, the city has experienced a progressive growth of the municipal urbanized area, at higher rates than population growth, which has led to a progressive decrease of the gross density. According to IMIP (2010), in 1950, the city had 122,556 inhabitants and an urbanized area of 909.2 hectares, and a gross density of 153.21 inhabitants per hectare.

In 1980, the population amounted to 544,496 inhabitants and the urbanized area increased to 10,795.11 hectares, resulting in a decrease in gross density to 60.3 inhabitants per hectare. In 2008, the city had 1,371,494 inhabitants in an urbanized area of 30,052.9 hectares, which expresses again a decrease of gross density to 42 inhabitants per hectare. Hence, there is an urgent need for adequate strategies to promote re-densification, according to the suitability conditions of this borderland city.

## MATERIALS AND METHODS

The study was based on a land suitability analysis (LSA), which provides a rational decision support frame to determine the suitability of a specific area, regarding its intrinsic characteristics (Chen, 2014).

Based on spatial multi criteria analysis (SMCA) performed through a geographic information system (GIS) process, land suitability assesses the aptness of a given location to support a considered use (Carr and Zwick, 2007). The specific importance given to the criteria in the SMCA was determined through a spatial analytic hierarchy process (AHP) relying on expert opinions on the perceived effects of different factors on site suitability, in this case for urban densification (Jafari and Zaredar, 2010).

Taking into account, the equity, economy, environment + livability (3Es+L prism), a spatial model was integrated using 46 variables distributed in each of the four categories. For every variable, the parameters and criteria that a specific location should meet and considered suitable for densification was defined. All the variables, integrated into a digital spatial database covering the urban area of CJ were derived from official databases, field data, and remotely sensed imagery. Variables were then converted into raster format using the WGS84 UTM 13N spatial reference system at a 30 m spatial resolution. The parameters specified the original units used to code each variable, while the criteria define the direction in which each variable was reclassified to meet a suitable condition.

The group of environmental values was composed mainly by physical variables that determined the potential for densification

based on the land capacity to harbor higher population densities. First, only locations with altitude below 1300 m.a.s.l. and terrain inclination lower than 10° were considered, to set a restriction for urban development on the mountain area. Then, the advantage of densification in areas relatively close (<DIST) to different type of water bodies were considered, due to the benefits of surface temperature regulation and aesthetic value, while avoiding immediate contact with restriction buffers of different sizes for safety and protection (VOID).

In the other direction, the authors sought to keep denser areas away (>DIST) from potential risks such as flooding plains, pluvial drains, gas and power lines, and high risk intermittent streams, with restriction buffers according to applicable normative regulations and official recommendations (Comisión Reguladora de Energía, 2001; SEDESOL, 2011; CFE, 2014).

Other potential risk natural and human-dependent features such as freight routes, erosion prone areas and geologic faults were also considered deterrent factors, so, the farther away from them, the more suitable the location for densification (>LOC). Urban contention zones proposed by SEDATU-CONAVI (2015) were also considered. The more consolidated the polygon, the more suitable the densification (Table 1).

The economic variables included the location of retail commerce units and commercial malls, from the National Statistical Directory of Economic Units (DENUE) (INEGI, 2016); as well as availability of employment in commercial activities at the Geostatistical Basic Unit (AGEB) level from the National Census of Population and Housing (INEGI, 2010).

Accessibility to retail commerce was considered an important part of the advantages for any location with higher population density, due to the necessity to satisfy a wide variety of supply demands, so the closer a given location (<DIST) to the concentration of commercial activities, the more suitable the densification (>LOC) (Table 2).

Given the fact that CJ has a well-established industrial vocation with 61.9% of the employment concentrated in the manufacturing sector (INEGI, 2015), location of industrial parks and higher availability of employment in the manufacturing industry were also considered as important factors due to the intra mobility requirements of a big population share. Thus, the proximity of these features was considered a favoring factor for suitability, except for a buffer of 100 m around industrial parks (VOID), to avoid direct contact with denser residential areas.

The location of functional urban centers was also included, since closeness to these service and employment areas is an indicator of higher concentration of urban activity. Finally, in this group of variables, land value at the AGEB level was included, given that the potential for densification projects of medium income housing is highly influenced by the cost of land, favoring (FAV) therefore areas within a price range of \$250 to 1000/m<sup>2</sup>.

In the third set of the equity values, a group of variables associated with the presence and accessibility to infrastructure and urban facilities that improved equity conditions in the community was included. First, the advantage of locations closer to educational facilities (<DIST), favoring different accessibility ratio buffers depending on the school level, was considered.

Nearness to health, cultural, recreation and service facilities were also considered advantageous in the model. Since house abandonment and land underutilization have been identified as critical threats of urban development in Ciudad Juárez, availability of brown fields and areas with higher percentage of uninhabited housing were also considered desirable candidates for densification.

Nonetheless, the model proposed avoiding increased density, the so called poverty zones (IMIP, 2009), since these do not have proper capacity to support higher concentration and require a different strategy for development. Closer location of domestic natural gas distribution lines was favored, as well as longer

**Table 1.** Environmental variables.

Variable	Parameter	Criterion
Altitude	masl	VOID >1300
Slope	Inclination in degrees	<SLOPE>LOC VOID>10°
River	Distance in meters	<DIST>LOC VOID<80
Main Irrigation ditch	Distance in meters	<DIST>LOC VOID<16
Secondary Irrigation ditch	Distance in meters	<DIST>LOC VOID<12
Waterbody	Distance in meters	<DIST>LOC VOID<20
Flooding area	Distance in meters	>DIST>LOC
Pluvial drain	Distance in meters	>DIST>LOC VOID<20
Main gas line	Distance in meters	>DIST>LOC VOID<50
Power lines	Distance in meters	>DIST>LOC VOID<42
High risk stream	Distance in meters	>DIST>LOC VOID<20
Freight route	Distance in meters	>DIST>LOC
Erosion prone area	Distance in meters	>DIST>LOC
Geologic fault	Distance in meters	>DIST>LOC
Urban contention zones	SEDATU zones	<U>LOC LOW=0

**Table 2.** Economic variables.

Variable	Parameter	Criterion
Retail commerce	Distance in meters	<DIST>LOC
Commercial mall	Distance in meters	<DIST>LOC
Commercial employment	Number of job vacancies	>VAC>LOC
Industrial parks	Distance in meters	<DIST>LOC VOID<100
Manufacturing employment	Number of job vacancies	>VAC>LOC
Functional center	Distance in meters	<DIST>LOC
Land value	Cost in \$MX/m <sup>2</sup>	<COST>LOC FAV250-1000

distances of main sewer lines, with a voiding buffer of 20 m, given the risk of line collapse repeated in Ciudad Juárez during the raining season in the last years throughout the city (Table 3).

The four vertex of our urban sustainability model was comprised mostly of variables associated with accessibility conditions. The authors sought locations close to primary and secondary streets, public transportation routes, stops and intersections to ease the access at the intra urban level by different mobility systems.

In the case of the public transportation variables, a buffer of 1 sq km representing a radius of the walkable distance for convenient connection between service and residential areas and transportation was favored. As complement, more suitable locations near bikeways projects, parks and green areas were considered to improve the livable conditions and public space access in denser populated areas. Access to services and urban facilities was also considered in binary variables to favor neighborhood centers and mix compatible land uses, with population densities between 50 to 10 inhabitants per hectare Table 4.

According to the proposed criteria, all variables in raster format were reclassified using an ordinal scale from 1 to 5 with higher values, indicating more suitable locations. The importance of each individual reclassified variable was evaluated by a group of experts in a pairwise comparison, establishing a ranking within each category. Agreement in rank assignment was evaluated in several rounds until variability for each factor was less than one standard deviation. The average rank was then used to calculate a weighted

ranking for each variable according to the following function (Malczewski, 2004):

$$w_j = (1/r_j) / \sum (1/r_j) \quad (1)$$

where  $w_j$  is the weighted inverse ranking,  $r_j$  is the group agreed ranking and  $1/r_j$  is the reciprocal group agreed ranking. Each variable was then multiplied by its corresponding weight and combined into integrated models for each of the four categories with a weighted overlay sum function (Samad and Morshed, 2016). Category models were then combined in a general model with 30% of weight assigned to each of the equity and livability models, and 20% to the environment and economic components. From the final model, the areas above 2 standard deviations were selected to identify only the areas with the most suitable conditions for densification in the study area. These zones were finally overlaid on a spatial database of the available vacant lots to identify potential sites for residential densification as input for the next phase in the project.

## RESULTS AND DISCUSSION

On the basis of the model for urban sustainability

**Table 3.** Equity variables.

Variable	Parameter	Criterion
Preschool	Distance in meters	<DIST>LOC <sub>FAV&lt;750</sub>
Elementary school	Distance in meters	<DIST>LOC <sub>FAV&lt;500</sub>
Middle school	Distance in meters	<DIST>LOC <sub>FAV&lt;1000</sub>
High school	Distance in meters	<DIST>LOC <sub>FAV&lt;5000</sub>
Hospitals	Distance in meters	<DIST>LOC
Cultural center	Distance in meters	<DIST>LOC
Recreation facility	Distance in meters	<DIST>LOC
Public service facility	Distance in meters	<DIST>LOC
Community center	Distance in meters	<DIST>LOC
Brown field	Availability	FAV Av, LOW NotAv
Uninhabited house	% uninhabited house/block	>%UH/B>LOC <sub>FAV&gt;40</sub>
Poverty zones	Distance in meters	>DIST>LOC <sub>VOID &lt;PZ</sub>
Gas lines	Distance in meters	<DIST>LOC
Main sewer lines	Distance in meters	>DIST>LOC <sub>VOID&lt;20</sub>

**Table 4.** Livability variables.

Variable	Parameter	Criterion
Primary street	Distance in meters	<DIST>LOC <sub>VOID &lt;100</sub>
Secondary street	Distance in meters	<DIST> LOC
Public transportation route	Distance in meters	<DIST>LOC <sub>FAV&lt;564</sub>
Transportation route intersection	Distance in meters	<DIST>LOC <sub>FAV&lt;564</sub>
Semimasive transportation route stops	Distance in meters	<DIST>LOC <sub>FAV&lt;564</sub>
Parks and green area	Distance in meters	<DIST>LOC
Bikeway	Distance in meters	<DIST>LOC
Population density	People/ha	<DEN>LOC <sub>FAV50-100</sub>
Neighborhood center	NC	FAV NC, LOW NotNC
Land use	Compatible uses	FAV Comp, LOW Incomp

proposed by Berke et al. (2006) four spatial sub models were created, one for each of the societal values categories; environment, economy, equity and livability. These models, with a continuous scale ranging from 1 to 5 indicate areas less or more suitability for densification, according to the combined weighted effect of the variables considered.

### Environment model

Suitability for densification derived from the environmental variables resulted in a model ranging from 1.6 to 4.4, with higher values towards the urban fringe in the rural portions of the study area.

In fact, the farther it is from the consolidated western part of the city, the higher the suitability values in the model (Figure 1a).

This model exhibits in addition, void zones in the mountain area and in buffers along drains, ditches, power and gas lines, and high-risk intermittent streams. The lower values, assigned to 41% of the pixels, were located where high slopes and erosion prone areas overlap flood

plains and close to intermittent streams.

According to the AHP analysis, most of the weight in this model (55.1%) was assigned to environmental risk-related variables: 30% of the weight was placed on the flooding areas variable; 15.1% on the high-risk intermittent streams; and 10% on the erosion prone areas.

This valuation reflects the experts' concern on the effects caused by extreme meteorological events, recurrent in the Ciudad Juárez region during the summer season, which have already caused considerable material loss and threaten human lives, in social housing developments built in the last decade over flood plains of the southeastern portion of the study area. The rest of the weight was evenly distributed among the rest 15 variables, with irrigation ditches and geologic faults considered as the least important.

### Economy model

As some of the main urban development drivers, the economic variables produced a model that concentrates

suitability for densification, associated with the consolidated part of the city. This model ranged from 1.36 to 4.69 and gave more suitability value to the concentration of commerce and industrial activity, given the location advantage in terms of employment accessibility (Figure 1b).

Favorable access to job sites for middle-income families has always been considered a location asset that fosters productivity in agglomeration economies (Brinkman, 2016); therefore, this is a desirable condition for denser residential areas in Ciudad Juárez, where more than half of the population is labored in the manufacturing sector.

Another important factor, weighted in fact with 38.6% of importance in this model by the AHP analysis, was the land value. It is widely recognized that success of densification projects oriented to middle income population sectors are only viable if they are built on competitive price land that is accessible to lower income strata (CITE). High-priced land tends to increase the final cost of the residential projects limiting the economic viability of socially oriented densification projects.

The other two variables accounting for more than 32.2% of the weight in the model were retail commerce (19.3%) and commerce job density (12.9%), which once again gives an important value to the business activity related to commerce, because of the increasing demand of retailing supply in more populated areas. The remaining 30% of the weight was distributed in the other four variables.

### Equity model

The variables integrating the equity model considered mainly the favorable effect of even accessibility to urban services and facilities, as a means to improve social conditions for sustainable urban communities. These variables include mainly the access to education services from preschool to high school level, to hospitals and to other urban services.

For this reason, higher suitability values were located in the consolidated part of the city, where most services of this type can be found. Nonetheless, suitable areas in this model are more sparsely distributed within the urban border given the effect of pre and elementary schools that are installed relatively early in the newly occupied areas of the urban fringe, and that were weighted with 15.4 and 10.3%, respectively (Figure 1).

Through the AHP analysis, more weight was assigned to the distance to poverty zones (30.8%) given the importance of not promoting densification on areas with limited urban and socioeconomic capacities. The poverty polygons (IMIP, 2009) themselves were void in this model. Despite the fact that densification has been proposed traditionally in many urban policies, as the solution towards the reduction of poverty, its efficiency as

a planning strategy in poor cities, still has many challenges (Caicedo, 2015; Fataar, 2016).

As a borderland city, Ciudad Juárez concentrates in its poverty zones which are highly vulnerable immigrant communities, so, a case for densification in these areas would have to consider not only the current precarious conditions in housing and urban infrastructure, but also the cultural and socioeconomic profiles of their inhabitants. The remaining 53.5% of the weight in this model was assigned more or less evenly among the other eleven variables.

### Livability model

For the fourth node in the 3E's model for urban sustainability, the livability model shows suitable areas for densification within the extension of the Ciudad Juárez urban area, highly associated with the road and transport infrastructure (Figure 1d).

This result makes evident the important role of public and alternative transportation means in favoring livable conditions for a TOD-like type of community. TOD seeks to create compact, pedestrian-oriented, livable and sustainable communities built around mass transit intersection and corridors, designed to encourage ridership on public transportation (Holmes and van Hemert, 2008).

Despite this being a desirable situation in Ciudad Juárez, it is important to recognize that this degree of human interaction in the public domain is difficult, if not impossible to achieve, in much more socially car-dependent urban contexts (Curtis et al., 2009). Public transportation routes thus, were assigned 30.4% of the weight in the model, with the highest value categories in all related variables belonging to walkable distances that ease approachability. Void buffers appear along all main roads, and farther areas towards the boundaries of the study area were less suitable due to constrained accessibility.

Other conditions for livability in TOD communities are also the high-density mixed-use buildings around a transit corridors or urban centers, which in this case are represented by neighborhood centers with 17.1% of the weight and compatible mix land use with 11.4%. This combination would potentially have the effect of encouraging cycling and walking, controlling the flow of automobile traffic and reducing the amount of land devoted to parking (Brendel and Molnar, 2010) or under-utilized as vacant space, as compared to conventional development pattern in Ciudad Juárez.

It is believed that compact development with integrated land uses that cluster commercial, public, and recreational services near transit stations and within walking distance of residential and employment areas, creates a pedestrian friendly environment that reduces the need of automobile use and shortens travel time and distances, reducing

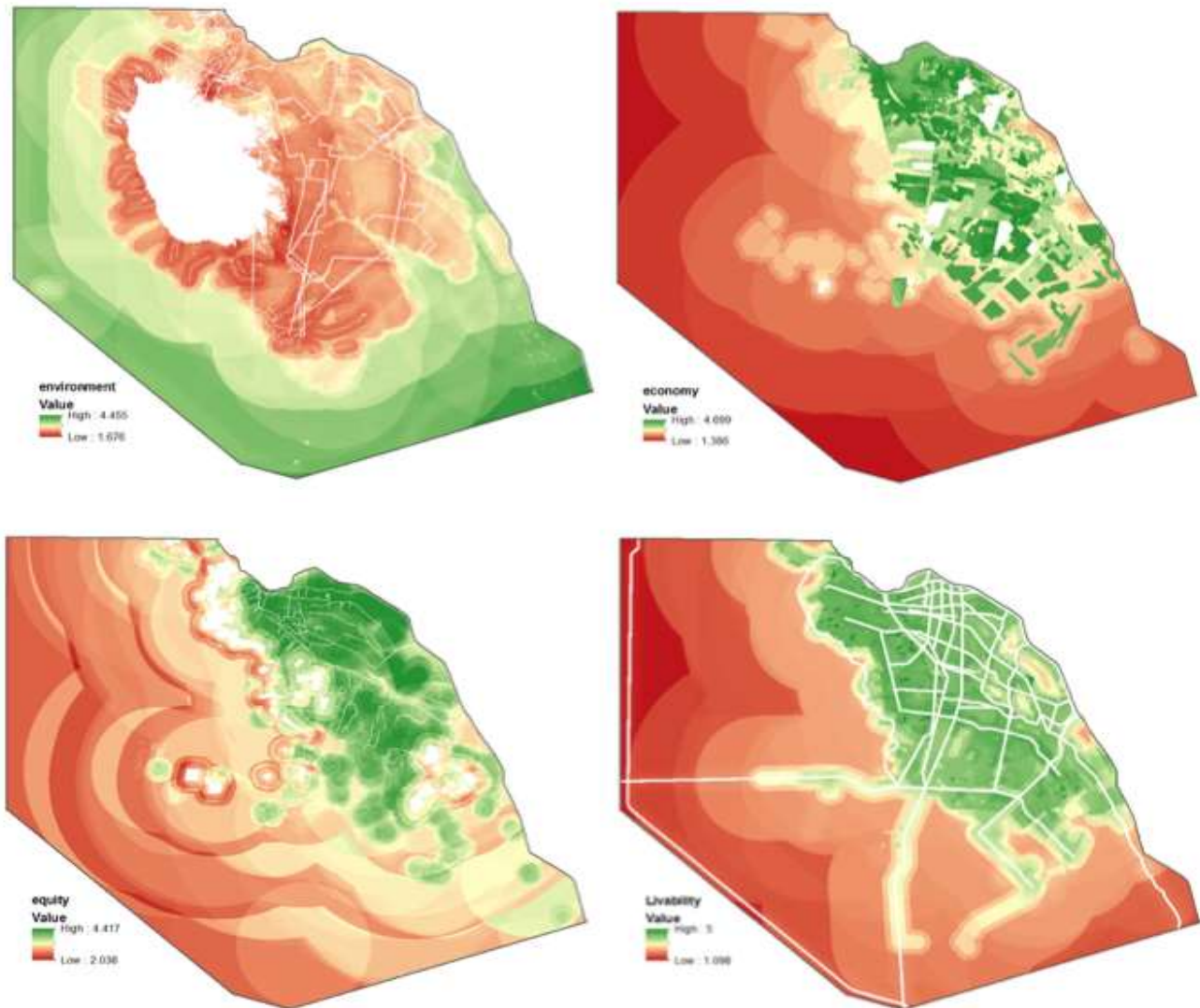


Figure 1. Environment (a), economy (b), equity (c), and livability (d) models.

overall traffic congestion, and improving daily livable conditions for people (Goodwill and Hendricks, 2002).

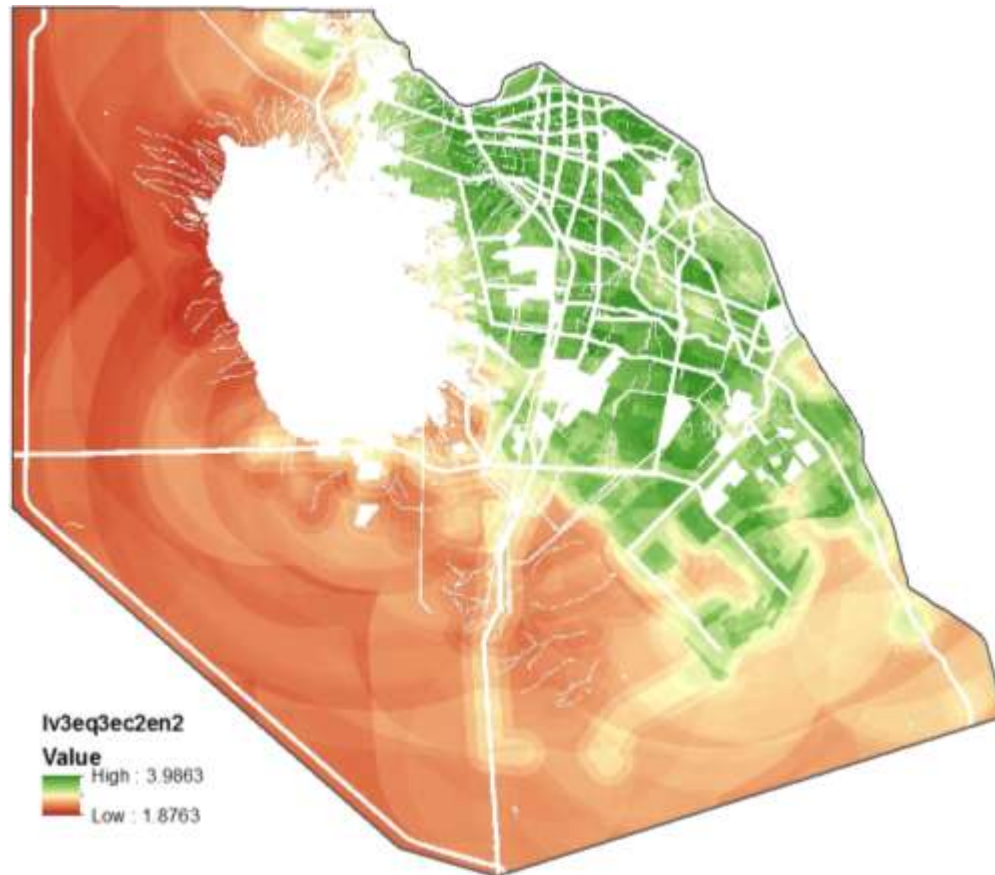
The final model integrated with the proposed sum weight distribution for each of the four categories shows most suitable areas in the Ciudad Juárez urban area with a mean value of 2.92 in a rather stretched range from 1.87 to 3.98 in the 1 to 5 suitability scale (Figure 2). In this case, only 23.23% of pixels showed values above the average and could be considered fairly suitable for densification.

After separating only the areas with positive suitability values 2-standard deviation above the mean, a total of 6297.44 hectares was finally obtained with potential for densification, which means 5.72% of the study area. Out of the 46 variables, 12 were assigned 60% of the weight in this final model, being the three most important: public transportation routes (10%), poverty zones (9.2%) and

land value (7.7%).

Marginal suitability areas in the model, occupying 76.76% of the study polygon were located mostly in the rural area, to west of the mountain range marked as a large void area. Despite low land costs in these natural zones, lower suitability values here are due to the low accessibility to transportation systems, and urban service provision. Accordingly, medium suitability areas were located mainly along the urban fringe and over the southern portion. These areas are not very well connected by public transportation nor do they have the best access to urban services.

High suitability areas for densification in this model were distributed along residential and commercial areas in the city. Three main clusters are visible, one in the northwestern close to the international border; one around the consolidated historic center; and one more in the



**Figure 2.** Final integrated model (Environment 20%, Economy 20%, Equity 30% and Livability 30%).

southwestern where the city extended its boundaries in the 1990 decade. These suitability patterns might allow different alternatives to designing specific densification projects, since in the first case, there is a fairly consolidated area dominated by medium to high-income residential and industrial use. In the second case, the suitable areas were located over a deteriorating portion of city characterized by high abandonment residential rates around the downtown. Finally, the third zone with high suitable values is occupied by large social housing developments alternative of industrial parks.

These results are the input for the next phase of the project, where specific vacant lots will be identified in the suitable zones to develop specific residential projects for densification. Each of these potential areas will require a different kind of solution, given their particular socioeconomic and urban profiles. These solutions should consider among other precepts, designing an adequate strategy to subsidize affordable housing, principally in places where proximity to transit provides ready access to jobs and services without the added financial burden of automobile ownership.

This kind of housing should be alternated with a diversity of housing options for a healthier social

environment, that allow at the same time, access to multiple market segments, thereby achieving faster product absorption (Duany et al., 2010). Taking into account these principles will increase the chances of successful urban interventions for more equilibrated livable communities at the neighborhood level in this vibrant industrial borderland region.

## Conclusion

Modeling suitability for densification on a borderland city such as Ciudad Juárez and applying a spatial multi criteria approach has proved to be an effective method to combine a wide array of factors affecting urban and socioeconomic potential to incorporate projects that promote denser livable communities.

After running the model, it can be concluded that the compact city paradigm is possible, but not in the city as a whole or homogeneously, and thus it is of a crucial importance to evaluate which part of the city is suitable for densification and which is not. Especially in the case of cities characterized by rapid and disorderly growth, defining denser perimeters is not as simple as ideal

concentric rings. In this context, the complexity of assessing suitability for a dense growth that is also livable and sustainable depends on many factors and only the computerized methods of multi criteria analysis can be integrated. The 3Es+L prism model (Berke et al., 2016) proves to be an appropriate approach given that the success of high density developments depends to a greater extent, on the neighborhood livability. This question can be asked:

1. Is it important to consider equity and habitability?
2. How the model would have turned out, if one of the variables (environment, economy, equity and livability) had not been considered?

The model assesses the land capacity to support high population densities, considering it as desirable conditions:

1. Environment: Avoiding the exposure to natural and human-dependent risks.
- 2) Economy: Proximity to higher concentration of urban activity, employment and medium land value.
3. Equity: Even accessibility to urban services and public facilities; and
4. Livability: Pedestrian-oriented and livable communities with diverse mobility and accessibility.

So, if any of the four variables had not been considered, it would mean exposure of higher density residential developments to environmental risk and natural disaster, or the lack of economical and sociocultural opportunities, and urban vitality and amenities. Assigning 30% of weight to equity and livability prevents exclusion, segregation and socio-spatial fragmentation, which are very critical problems in cities in developing countries.

How can we describe the suitable areas for densification? These areas on one hand, have proximity and accessibility to: public transportation routes, primary and secondary streets, stops and intersections, different mobility systems, mixed uses areas, walkable distances to parks, green and open public spaces; also closeness to higher concentration of urban activity, services, commerce, to higher job density areas, medium land value areas, infrastructure, health, cultural, recreation and service facilities, to domestic natural gas distribution lines.

On the other hand, they are safe areas and protected from risks, since they avoid and keep away: geologic faults, slopes and erosion prone areas, intermittent streams, higher land value areas, restriction buffers for safety and protection of water bodies, flooding plains, pluvial drains, main gas, sewer and power lines, freight routes, main roads and poverty zones.

Thus, it is fair to say that these suitable areas are seen as an opportunity to promote "smart growth" in Ciudad Juárez since the "smart growth communities consist primarily of neighborhoods, each of which satisfies the ordinary daily needs of its residents within walking

distances. Each neighborhood should contain a balanced mix of uses, including large and small dwellings, retail spaces, workplace and civic buildings. The most complete neighborhoods also provide their residents with pedestrian access to schools, day care, recreational centers, and a variety of open spaces, as well as opportunities for food production (Duany et al., 2010).

Non-suitable areas for densification in Ciudad Juárez, according to the results of the model, in the case of Ciudad Juárez, should not promote a dense development in the more rural areas to the south and west of the mountain range (marked as a white large void area), where the model identified the most marginal suitable areas.

The west of the mountain range only showed medium results in the variable environment, while low suitability was identified in terms of economy, equity and livability. Towards the edges of the city to the south of the mountain range, only the variable, economy presented suitability, reaching lower suitability in terms of environment, equity and livability. This means that despite the low land costs, these areas do not fulfill the conditions to be considered suitable for medium or high densities and intense residential use, since low density is needed, allowing a harmonious integration to the natural environment. Nevertheless, this does not mean that they cannot be developed, but that developments should target populations who are not affected by automobile dependency and lack access to jobs, services and public facilities.

Although, successful pedestrian-oriented, compact and livable communities are not only dependent on land-use decision, an evaluation of the best suited locations to fulfill these desirable conditions is a first step to achieve balanced and smart growth.

These suitable areas for densification represent a great opportunity to create livable, sustainable, safety and self-sufficient communities, to reduce sprawl, as well as the demand for mobility and spending on infrastructure and public facilities, also, to create inclusive communities properly to integrate the provision of affordable housing for medium income population sectors in Ciudad Juárez. For this reason, it is crucial to regulate land costs in these areas, as this continues to be the main obstacle to planning the provision of social housing with equal rights to the city.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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*Full Length Research Paper*

# Development of an informal cadastre using social tenure domain model (STDM): A case study in Kwarasi informal settlement scheme Mombasa

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The Kenya government together with development partners has embarked on the development of informal settlements. Mombasa County has more than 70 informal settlements; information about the settlements and their relationship to the existing cadastral spatial layer covering the entire Mombasa County needs to be determined in order to support decision making for sustainable development. This study evaluates the Social Tenure Domain Model (STDM) land tool in the development of an informal cadastre by capturing, storing, and manipulating social and spatial information in Kwarasi informal settlement in Mombasa. This case study is an example that can be replicated to the rest of the informal settlements in Mombasa forming a single informal cadastral database for the entire county. Participatory enumerations and the STDM tool were used in this research to present the situation of Kwarasi informal settlement. The housing structures were adopted as the spatial unit for the informal Cadastre over which the rights of the inhabitants were adjudicated, customized and uploaded into the STDM where social tenure relationships were created to form the cadaster in the STDM system. The spatial component of Kwarasi informal cadaster was overlaid on the Mombasa cadastral layer and their relationship determined. It has been demonstrated that the relationship would be useful for decision making to support sustainable development intervention, and ease land administration by maintaining a detail record of the informal settlements.

**Key words:** Cadastre, global land tool network (GLTN), informal settlements, land administration domain model (LADM), land information systems (LIS), social tenure domain model (STDM).

## INTRODUCTION

Millennium Development Goal number 7 that seeks to ensure environmental sustainability, target 11 to have achieved a significant improvement in the lives of at least

100 million slum dwellers by 2020, the Kenya Government has initiated programmes in order to improve the living conditions in the informal settlements

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on its own and with the help of other development partners such as the Un-Habitat, World Bank and United Kingdoms' Department for International Development (DFID).

The initiatives are Kenya Informal Settlement Improvement Project (KISIP), Kenya Slum Upgrading Program (KENSUP), and Mombasa Slum Upgrading Project (MSUP) with the aim of improving the livelihoods of people living and working in slums and informal settlements in the urban areas of Kenya through the provision of security of tenure and physical and social infrastructure (Muraguri, 2011).

However, more information is required about individual informal settlements before any reasonable development intervention can be sustainable. An informal settlement inventory report prepared by the Mombasa County Government in collaboration with Pamoja Trust shows that 65% of the population in Mombasa county live in informal settlements that count to 70 in number and of various sizes (Mombasa County Report, 2013). The spread of informal settlements in Mombasa county is as shown in Figure 1, providing an overview of the situation of informal settlement in Mombasa county.

The Cadastre is a methodically arranged public inventory of data concerning properties within a certain country or district, based on a survey of their boundaries. The outlines of the property and the parcel identifier normally are shown on large-scale maps which, together with registers, may show for each separate property nature, size, value and legal rights associated with the parcel. It gives an answer to the question where and how much (Henssen, 1995).

There is a growing recognition in many countries, international organisations and with land administration practitioners that land administration, and particularly the core cadastral system, has an equally important role in supporting sustainable development objectives, rather than the traditionally narrow focus on land markets (Wiebe and Meinzen-Dick, 1998).

In UN-HABITAT (2008), the various types of land rights are viewed as existing along a continuum, with some settlements being more consistent in law than others. This view makes it possible to include the people with the weakest tenures pursuant to the idea of sufficient legal access (Figure 2).

The Social Tenure Domain Model (STDM) is a pro-poor land tool developed to serve primarily, the needs of the poor (Lemmen, 2010). STDM is a land information system that has been developed using the standards of Land administration Domain Model (LADM) which is International Organization for Standardization (ISO) certified and hence data integration is made possible (Lemmen, 2010; Enemark, 2009). Developed by the the Global Land Tool Network (GLTN), facilitated by UN-HABITAT together with coalition of international partners (Un-Habitat, IIR, GLTN, 2012).

GLTN partners support a continuum of land rights

(Figure 2), which include rights that are documented as well as undocumented, including slums which are legal as well as illegal and informal (Un-Habitat, IIR, GLTN, 2012). STDM is a conceptual model that is descriptive and not prescriptive and records the status quo leaving people-land relationships intact (Charisse et al., 2013).

The main objective of this project was to evaluate the STDM land tool in the development of an informal cadastre in order to support decision making for sustainable development intervention in the informal settlements in Mombasa County. This is by bringing out into view and put into record the informal settlement details of Kwarasi informal settlement in Mombasa county as a model to be used for replication to all the other informal settlements in the county and the rest of the country. This was achieved by:

- (1) Adjudication of the informal rights within Kwarasi informal settlement, relating the rights with the spatial unit and create the social tenure relationships for the settlement in the STDM system.
- (2) Using the spatial and attribute cadastral data in the STDM database to generate reports and produce certificates of residence directly from the system and lastly.
- (3) Overlaying of the informal cadaster on the formal cadaster to bring out the relationship between the formal and the informal cadastral information in Kwarasi in order to aid in decision making for sustainable development.

### Obtaining legal regime in Mombasa county

The Land Titles Act (LTA) cap 282 laws of Kenya (repealed), formerly the Land Titles Ordinance (LTO) is the only law that came close in recognising and institutionalising informal land rights in Kenya. It is a deeds registration act that was enacted in 1908 and operated in the ten nautical miles strip inland of the Kenyan coast including Mombasa town where the project area is situated (Government of Kenya, 1908).

The act recognised rights that may be termed as informal including traditional customary or any describable right and hence phenomena of informal land rights are not new to the persons of the project area. However, the system is manual and therefore for ease, management would required computerisation so that the interests therein could easily be retrieved. The act was designed as both a land adjudication and registration act at the same time. It was institutionalized by the establishment of a court presided by a recorder of title which is only subordinate to the high court of Kenya and a chief surveyor for mapping the adjudicated claims. The principle land registrar administered the registration part.

Most land registration systems adhere to the Latin maxim "Quicquid Plantatur Solo, Solo Cedit" which means "whatever is affixed to the ground belongs to the

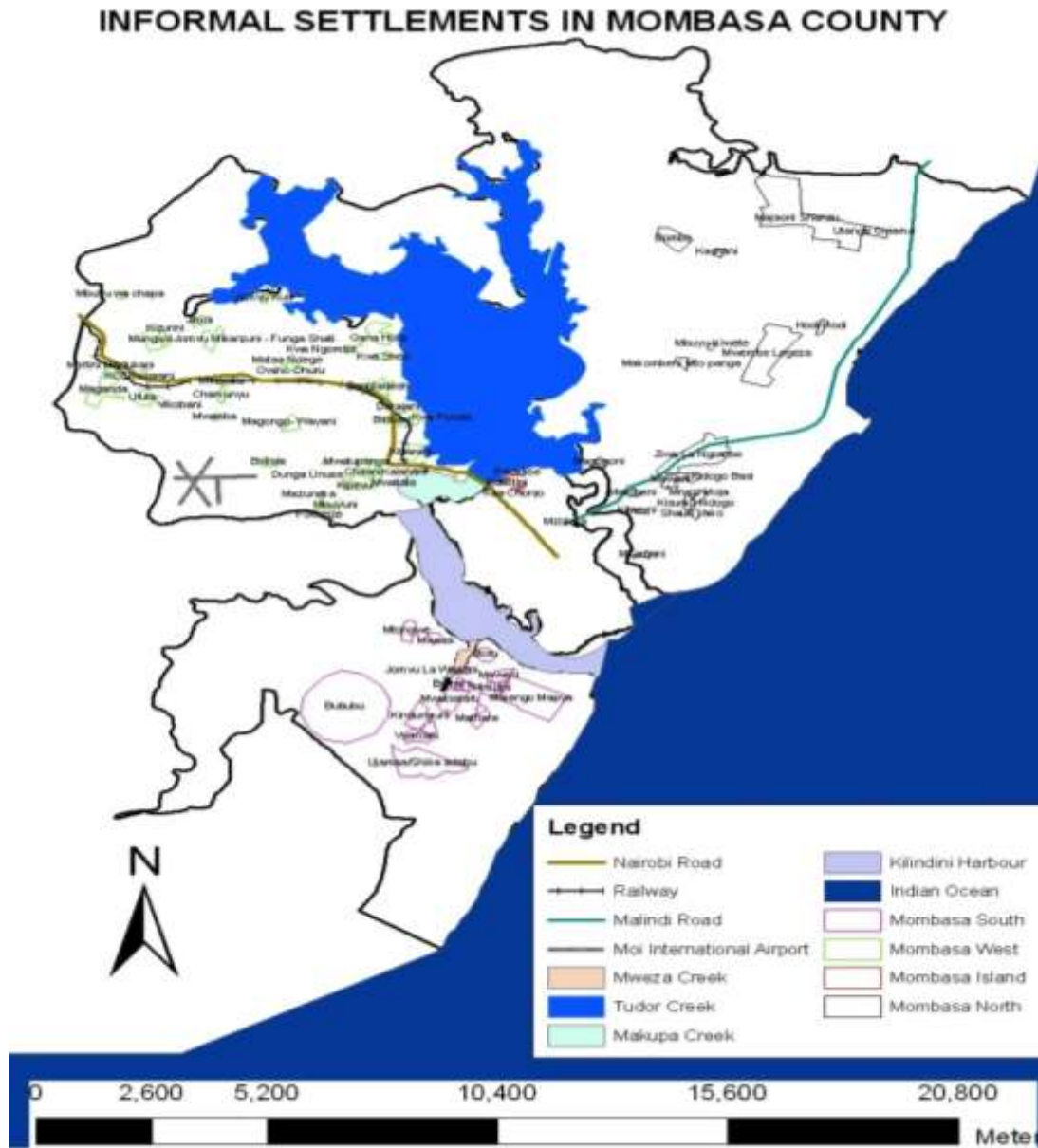


Figure 1. Spread of informal settlements in Mombasa County (Mombasa county report, 2013).

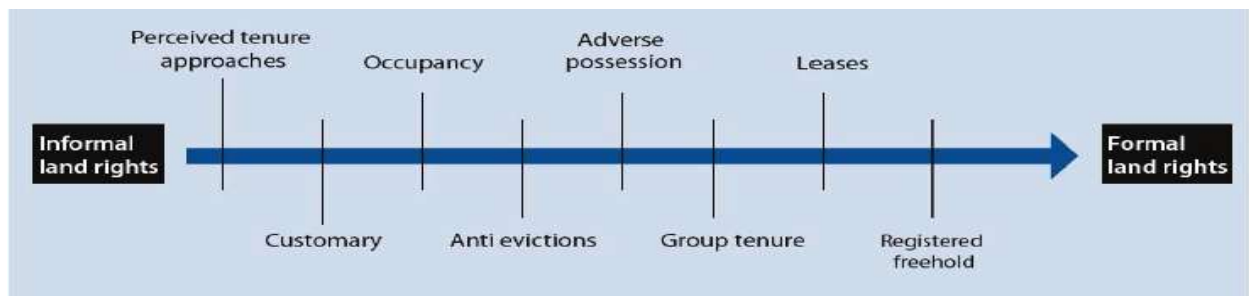


Figure 2. Continuum of land rights (UN-HABITAT, 2008).

ground." Hence, the owner of the title owns all that is permanently attached to the land such as buildings trees crops, etc.

Under this law, fixtures are recognised and can be registered independently and owned by a different person from the title owner. As an illustration, the interest registered over the parcel of land under the LTO was a fixture that would be considered as part of the land in other statutes.

*Makuti* houses in the documents are usually owned by a different person from the owner of the title. The *makuti* house may have been constructed with the consent of the owner of the title of land without necessarily subdividing the land or selling it to the owner of the structures. This is evidence that such a situation is a recordable possibility in this registration system and may include water wells, permanent plants such as coconut and mango trees.

This has been possible due to the fact that the registration model was designed to accommodate such occurrence and designed in consideration of the culture lifestyles and traditions of the local people. Such a state is not feasible in other acts of registration but was possible in the LTA and can be used to enhance STDM. It is very clear that for any process of upgrading informal settlements to succeed, detailed knowledge and information will be required on the prevailing systems of land administration; together all the vested interest by the tenants, extralegal powers and absentee slum lords (Omwoma, 2013).

## METHODOLOGY

### Study area

The study area is Kwarasi informal settlement situated in Mombasa county. Mombasa county located along the Kenyan Coastline (Latitudes 3° 80' and 4° 10' S and Longitudes 39° 60' and 39° 80' E) and has a population of about one million people (Figure 3).

Mombasa is the second largest city and oldest municipality town in Kenya which is a port city that also doubles up as a county managed by a county government. Kwarasi informal settlement is in Mombasa mainland west, Chagamwe constituency. The settlement is composed of tenants and landlords with a total population of about 200 people within an area of about 4 acres.

The constitution of Kenya 2010 categorizes land as public, community and private land (Government of Kenya, 2010). The National Land Policy (NLP) states that squatters are found on public, community and private land (Government of Kenya, 2009). Prior to this categorization of land, informal settlements already existed in Mombasa county. On examining the informal settlement inventory for Mombasa county, the following types of land situations are host to informal settlements:

**(a) Informal settlements on public land:** These are settlements that are situated on public land that is not alienated or land reserved for a public facility such as a school, social hall or any other public amenity.

**(b) Informal settlements on private land:** Informal settlements that are on registered land held by any person under any freehold or leasehold tenure and any other land declared private land under

an Act of Parliament.

**(c) Informal settlements on land owned by absentee landlords:** These legally fall in the category of private land whose owners appear on the lands registry record but cannot be traced. They are mainly people who were registered in the early 20th century as owners on free hold interest or long duration leases who then relocated to other countries mostly Portuguese, Arabs, Asians and Britons.

**(d) Squatting on riparian reserve:** Informal settlements on riparian reserves in Mombasa are mainly areas that about the high water mark of the Indian Ocean, mostly grown with mangrove trees, this land falls under the category of public land.

**(e) Tenants at will:** Tenants at will in Mombasa is where landlords allow tenants to construct houses on their land at a deposited amount of money and subsequently a monthly rent under a lease agreement that is private, perpetual and for as long as the house is in existence. The developments are temporary, not planned and are not part of the city main stream plan. The land lord who holds the free hold title indicates the site of construction in disregard of planning regulations.

All the aforementioned settlements constitute structure owners and tenants on residential and small businesses within the informal settlements.

### Method

Figure 4 shows the general flow of research activities undertaken. Attribute cadastral data modelling was done using Unified Modelling Language (UML) tools in Dia software. Through the situation analysis that was observed from the Mombasa informal settlement inventory and county government records it was noted that the persons that represent the party in the STDM were mainly structure owners and tenants. Structures were adopted as the spatial units for the STDM since there were no land parcels as in the formal cadastral systems in the case of Kwarasi.

### Datasets and materials

#### Spatial data

The Mombasa County Government has completed the preparation of the Integrated Spatial Urban Development Plan (ISUDP) for Mombasa city for up to the year 2035. Part of the data used for the project in the custody of the county government is the Mombasa county aerial photo image in digital format that has been geo-referenced and sheets combined into one continuous mosaic for the whole county. The co-ordinate system of the photo-mosaic is UTM Zone 37 arc 1960 projection. This image acquired in the year 2014 was used in this project to identify and map the structures, the spatial unit of the STDM informal cadastral spatial data. The entire Mombasa county digital cadastral layer was another product of the preparation of ISUD and is also in UTM Zone 37 arc 1960 projection that was used as part of the project data. Others were the site and service scheme plans of World Bank Housing Project II, and site location plans from the county government of Mombasa. The informal settlements including Kwarasi lie on the un-serviced areas of Chaani site and service scheme and spill beyond into other properties.

#### Attribute data

The Mombasa county assisted by the National Government through KISIP has embarked on an exercise of regularization of informal settlements. For that purpose attribute data was collected from

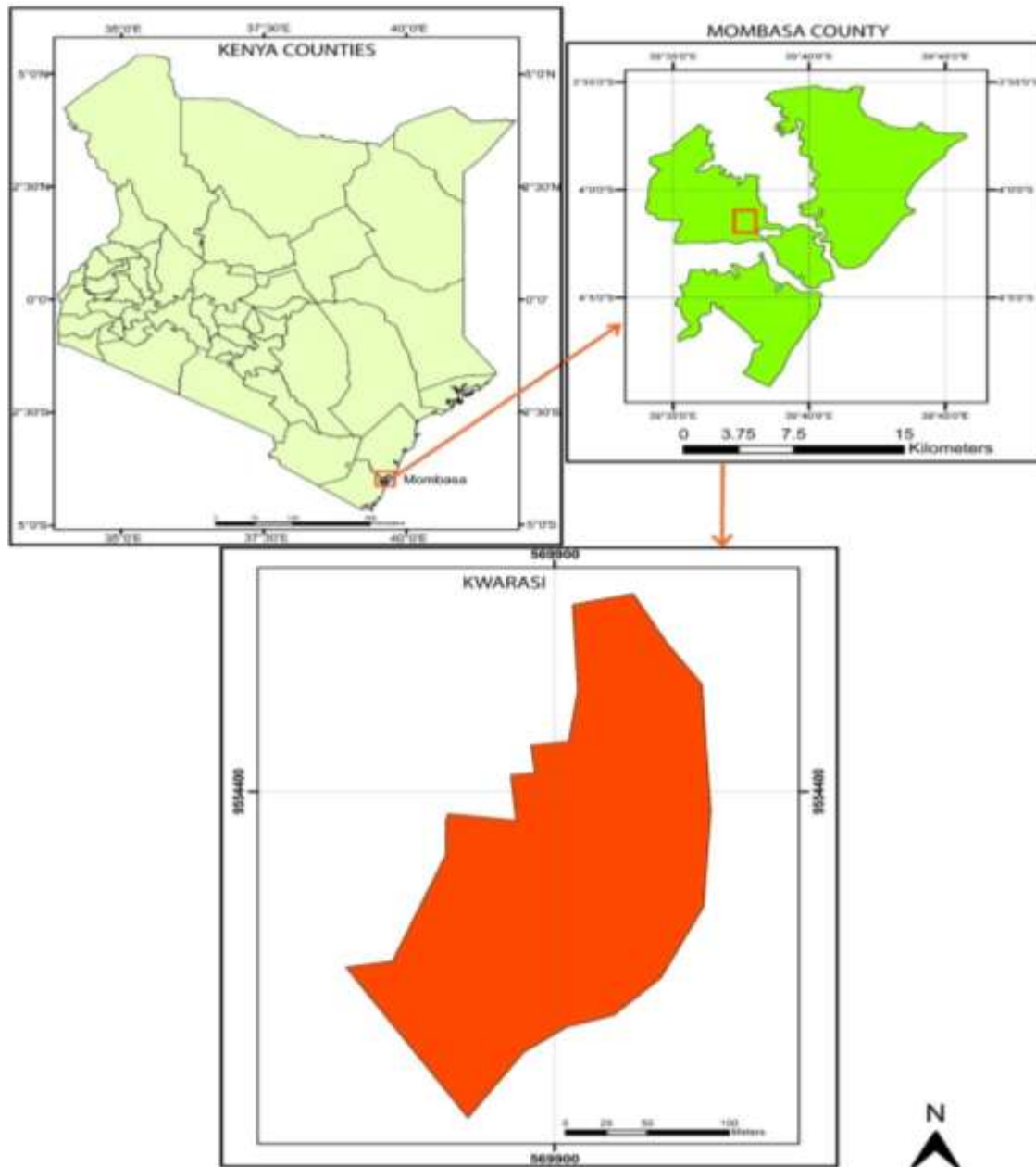


Figure 3. Location of Kwarasi informal settlement.

Kwarasi and other settlements in order to inform the regularization exercise. Kwarasi is one of the settlements where the data was collected and released to the county government. The data was used in this project to decide on the model to adopt for customization to the STDN data model (schema). The data was acquired through the process of public participation by questionnaires and focus group discussions direct from the inhabitants of Kwarasi during the regularization exercise carried out by consultants in collaboration with the county government department of land for the National Government Ministry of Land, Planning and Urban Development KISIP project.

The structures were assigned numbers that were written on the doors of the structures. The numbers referred to as structure numbers were identified with the persons who held an interest on

the structures. The relationship type between the people to structures noted in existence was tenants and landlords, and the spatial units were identified and accepted to be the structures that were marked with unique number labels.

GPS coordinate readings were used to identify the position of the structures on the photo image for those that had full details enough for cadastre data requirement. The house number which was on the door was logged into the GPS coordinate reading and which is the same number used as the structure identifier tabulated with the people relation. This way it was easy to identify and digitize the structures on the QGIS canvas. The secondary attribute data sources were from existing records at the county government of Mombasa.

Existing data was verified during the GPS survey where the

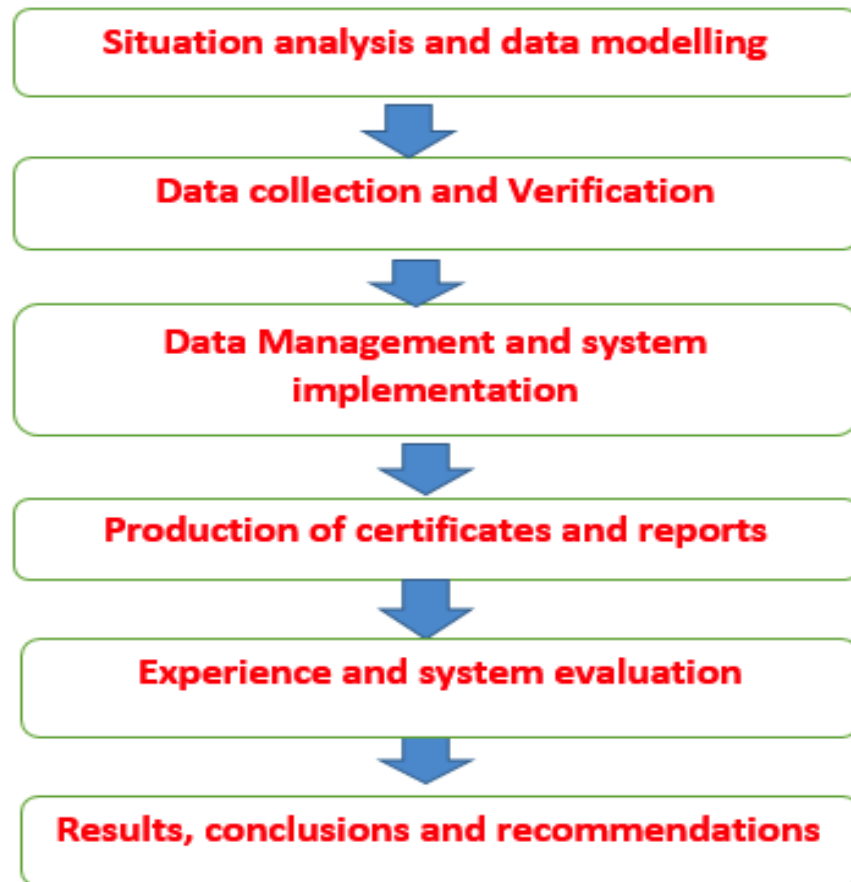


Figure 4. Work flow diagram.

owners could positively identify themselves in relation to the structures that were already numbered. Although the attribute data included other socio-economic information such as availability of amenities and development priorities only ownership, tenancy and party attribute information was considered for the informal cadastral model. Some owners and tenants were not available during the verification exercise and hence full information was not available and to be sourced on another day.

The verification of the structure ownership and tenancy was done at the same time with GPS readings to verify and identify the structure owner with the building and the tenants. The form for party linked the social information with the mapped structures by use of GPS (that is, link socio-economic with spatial STDM).

#### Project implementation process

The STDM system was used to integrate all the relevant data into one, generate reports, print certificates, upload photos and any other information that was of use such as personal details. The tool was used for the digital record, data analysis and production of certificates and reports. The plans that had the required spatial data were scanned, geo-referenced and then digitized into the GIS to extract the spatial information for the cadaster. These included the entire Chaani site and service scheme and the peripheral informal settlements including Kwarasi to show their relation to the site and service scheme. The numbered structures were identified on the QGIS canvas by use of the GPS control points that were obtained

by using Garmin Handheld GPS. The GPS control points were imported into the QGIS canvas from an excel sheet which was saved in CSV comma delimited format.

The digitized structures were identified by numbers that were inscribed on the doors. The Chaani site and service scheme development plan was digitized and over-laid on the photo mosaic of Mombasa county. This enabled the serviced area to be separated from the un-serviced area by creating a boundary between the serviced parcels of land that appear on the development plan and the informal settlements. The other part extent of the settlement was determined by skirting the area that has built up structures that about the main Changamwe storm drain by digitization. This allowed the inclusion of all the structures that were within Kwarasi Informal Settlement Scheme in the project area. Mapping the project spatial extent in order to delimit the project extent was thus completed. The perimeter of the project area was here determined and overlaid on the geo-referenced aerial photo mosaic of Mombasa county to show the structures that fall within Kwarasi informal settlement.

The developments on the project area were clearly visible on the aerial photo at the scale of 1:2,500. The digitization of existing manmade and natural features that are relevant to the project was possible and hence the structures were digitized as the spatial unit for project. These enabled the creation of the structure layer on the QGIS canvass. A layer of GPS control points was also created. Open spaces for passages were also clearly visible at that scale.

Data processing and analysis were done on the platform of the open source QGIS software then imported into the STDM system.

The STDM plug in was used for creating the social tenure relationships between the spatial and party attributes to form the cadastral database within the STDM system. The import of spatial data and attribute data into the STDM and creating the relationships was done after cleaning the spatial data and customising the attribute data to the STDM Model. Note that the STDM does not accept data that is topologically non-compliant or incorrect hence only the digitised layers of structures were imported into the STDM.

The Kwarasi informal settlement structure layer was overlaid on the Mombasa spatial cadastral layer so that the position of the structures in Kwarasi informal settlement in relation to the formal cadastral could be determined to aid in decision making for sustainable development intervention.

The attribute data was linked to the numbered structures to form the social tenure relationship (STR) within the STDM domain. Reports were to be generated by the use of PostgreSql which is adopted by STDM by answering queries from the attribute data. A certificate template was designed to suit the study area and the information in the STDM database. The template was used as a tool in the STDM system for extraction of certificate details directly from the informal cadastral database.

## RESULTS AND DISCUSSION

The results of the project were to assist in the evaluation of STDM as a Land Administration tool for use in decision-making in sustainable development of informal settlements in Mombasa County.

One of the expected results in this research project was an attribute and spatial database hosted in the STDM system that consist of information about the inhabitants of Kwarasi and their relationship to the structures they live in or own within the informal settlement scheme.

This overlaid on the formal cadastral spatial layer of Mombasa county in order to show the position of the informal settlement in relation to the existing formal cadastral parcels of land for decision making in sustainable development. With the spatial and attribute cadastral data in the STDM system reports and certificates of residence were to be generated.

The process of determining the extent of the project area resulted in a perimeter line that included structures that form Kwarasi informal settlement. This was helpful in restricting operations of the project within the project area. Figure 5 shows the extent of the project area overlaid on the Mombasa aerial photo mosaic.

### Verification by GPS

In the case where owners and tenants were available during the verification exercise and hence full information was availed and the structures were identified by GPS readings and given a different colour (Figure 6).

### Informal cadastral database

Attribute informal cadaster information was formed within the STDM system by creating social tenure relationships

between the party and attributes. For spatial units of the cadaster, the structures were represented in the STDM database system complete with structure numbers in order to identify their relative positions for identification. The structure are linked to the party information by the structure number which is in this case the primary key of the party relation. Figure 7 shows the structures with their numbers and GPS points that were used as datum to identify the structures that had full information.

### Certificate of residence

Certificates of residence were automatically generated based on the template by extracting information directly from the database. This enabled production of certificates of residence only for the persons that exist in the database and hence in the settlement scheme excluding non-residents. Figure 8 shows a certificate of residence generated automatically from the STDM system. In addition to certificates and maps, reports too can be generated from the database. The overlay of Kwarasi informal settlement spatial layer of the structures over the Mombasa county spatial cadastral layer revealed the position of the structures in relation to the formal cadastral. Figure 9 shows the structures in Kwarasi informal settlement that fall on parcel number MN/V/3849 which is the Chaani site and service scheme (public land), those that fall on parcel number MN/V/2648 which is privately owned and the others that fall on the boundary of the two parcel. This result would answer the question on what type of informal settlement is Kwarasi.

### Conclusion

The main objective of this project was to evaluate the STDM land tool in the development of an informal cadaster in order to support decision making for sustainable development intervention in the informal settlements in Mombasa county.

With the use of the STDM land tool, the project research demonstrated from the results the spatial and attributes information data can be captured and managed in the STDM system. Informal cadastral data acquisition, documentation, storage, manipulation and its integration with socio-economic, spatial and informal rights data in the informal settlements was achieved.

The party's informal rights over the structures within Kwarasi settlement scheme were adjudicated by participatory approach and the social tenure relationships documented hence creating an informal cadastre for the settlement using the STDM to support decision making in sustainable development.

Certificates of residence were generated directly from informal cadastral database within the STDM system so that they only respond to residents of the informal settlement meaning that if you do not belong to the





**Figure 5.** Showing the extent of the project area overlaid on the Mombasa aerial photo mosaic.

settlement as a landlord or tenant the system will not recognise you nor respond to your details.

The spatial component of the informal cadaster was overlaid over the formal cadastral layer of the Mombasa county and their relationship determined at the Kwarasi area. Hence, position of structures in relation to the Mombasa cadastral layer for decision-making.

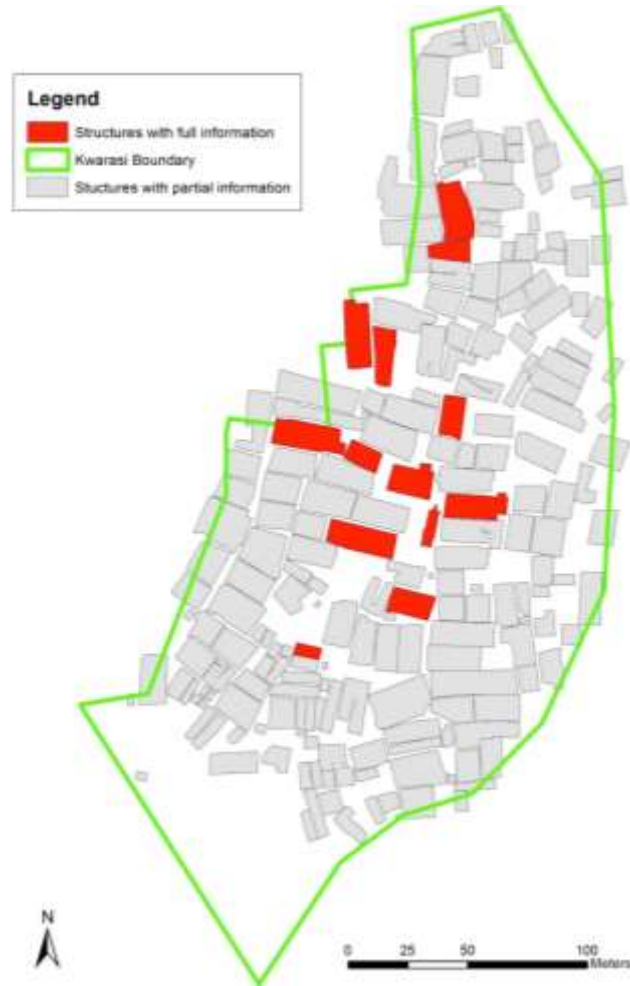
This shows that STDM has the capability to host an informal cadastral system and compare it with the formal cadastral spatial layer in the same environment as initially expected in the start of the research project hence STDM has successfully been evaluated and qualified as potential land administration tool for use in the enhancement of sustainable development of informal settlements in Mombasa county.

The experience of STDM at Kwarasi should be replicated to all other informal settlements in Mombasa county to create a complete overlay of all informal settlements of Mombasa county over the existing cadastral layer. Revision of the Mombasa cadaster layer

needs to be prioritized for accuracy and up-to-date information. STDM should be used for both formal and informal cadastral as a tool to assist in decision making for implementing sustainable development, managing conversion from informal to formal land tenure and contribute as an input in land policy formulation.

STDM is recommended as a quick means of informal cadastral data capture, storage and management for the Mombasa informal settlements. Stakeholder participation is recommended for data collection in sustainable development. While the county government should maintain and manage the database for informal settlements in the entire county; individual settlements should take care of their own data through committees formed by the county government in order to manage changes.

Mombasa county needs to formulate an administrative framework to assist in the management of the informal cadastral to serve along the formal cadastral creating a continuum of rights as in Un-Habitat (2008) (Figure 2)



**Figure 6.** Structures with full information picked by GPS ground control points during verification.



**Figure 7.** Digitized structures as they appear on the STDm system, the GPS points that guided digitization and structure numbers are displayed.



for the ease of land management in Mombasa county.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

## ACKNOWLEDGEMENTS

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*Full Length Research Paper*

# Factors affecting farmers' land tenure security after the implementation of rural land registration and certification program in Hulet Eju Enese district, Amhara region, Ethiopia

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In Ethiopia, land tenure insecurity is one of the major factors that affect the productivity of smallholder agriculture and sustainable development. The present government of Ethiopia designed and implemented rural land registration and certification program in the four major regions to enhance the land tenure security of peasants. The aim of this study was to investigate factors that affect land tenure security of farmers after the implementation of the program in Hulet Eju Enese District, Amhara region. Identifying the main factors affecting land tenure security and investigating the extent of each factors were the specific objectives of the study. The research designs were both quantitative and qualitative research method and the data were collected by questionnaire and interview. Stratified, random and purposive sampling methods were employed to select sub districts, farmer households and key informants, respectively. Binary logistic regression model and narration were used as method of data analysis and interpretation. The result shows that from the stated factors, some of them still affect the land tenure security of the farmer households in the study area. Therefore, in the implementation of the second stage of the program, emphasis should be given to minimize the influence of those factors and to attain sustainable land use practice.

**Key words:** Land, tenure, security, registration, certification, rural, possession.

## INTRODUCTION

Ethiopia is an agrarian country where agriculture plays a central role in the national economy and sustainable development. It supports as an employment area for more than 80% of the population, and 40 to 45% of the national GDP, it also contributes as a raw material for

agro-industries, food security and foreign exchanges (Berhanu, 2006).

In the productivity of agriculture, land is the most important valuable natural resource. According to the World Bank (2007), in most developing countries, land

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accounts for between half and three-quarters of the national wealth and it is a fundamental input in agricultural production. Its function is directly linked to food security and livelihood. Furthermore, it is also used as a primary source of collateral for obtaining credit from institutional as well as informal providers (Dessalegn, 2004). In order to accelerate the sustainable development of agriculture, land needs appropriate policy and implementing agents. The basic policy issue to improve the productivity of land is tenure security; "the degree of confidence detained by the farmers that, they will not be illegally deprived of their land rights and economic benefits gained from it (Nazneen et al., 2005)".

Land tenure security is a critical issue to provide motivation to invest on the land, reduce and resolve land related disputes and to increase productivity (World Bank, 2007). Additionally, secure property rights protect individuals against expropriation by neighbors and other agents, as well as against the state (Dessalegn, 2004).

In the 1990s, the Ethiopian government admitted that land tenure insecurity in the country affects investment on land, aggravates land related disputes and affects agricultural productivity. Hence, in the federal proclamation (Proc No.89/1997), the four main regions of the country (Tigray, Amhara, Oromiya and SNNPR) have issued their region's specific land administration and use proclamation and commenced with land registration system. Then, Tigray region started the implementation of the program in 1998, while Amhara followed in 2003 and Oromiya and SNNPR a year later (Solomon, 2006).

In Amhara region, the program was started and implemented in two pilot districts; Gozamn and Dessie Zuria district in 2003. The regional government progress report indicated that the implementation of the program in the pilot districts could achieve its target significantly and decided to implement in all districts of the region since 2004 (Berhanu and Fayera, 2005; Berhanu Adugna, 2009). Therefore, the main objective of this study was to investigate factors affecting land tenure security after the implementation of rural land registration and certification program in Hulet Eju Enese district, Amhara National Regional State, Northwest Ethiopia.

## METHODS AND MATERIALS

### Study site

Hulet Eju Enese district is one among the 166 districts of Amhara National Regional State (HEEW, 2011). It is found in Misrak Gojjam administrative zone. It has 42 administrative sub district which is 40 rural and 2 urban. Hulet Eju Enese district is located at 10° 40' N to 11° 10' N and 37° 46' 30' E to 38° 9' E.

The study used both primary and secondary data sources for the achievement of the stated specific objectives. Map of the study area is produced in Figure 1. The primary data were collected by using questionnaires and farmers of the study area who have land and received "Book of Rural land possession" (the book provided to the farmers to assure their landholding rights) and key informant interviewees from farmers and experts are the main primary data sources of the study.

A stratified sampling technique was adopted to select the sample area for the achievement of the study. Within the current administrative structure, there are 40 rural sub districts in Hulet Eju Enese district. Based on agro-ecological division, these districts are stratified into *Dega*, *Woina Dega* and *Kolla* which is 12, 20 and 8 sub districts in number, respectively. By using random sampling method, ten percent from each agro- climatic regions were selected, which means 1, 2 and 1 sub districts from *Dega*, *Woina Dega* and *Kolla*, respectively. These sub districts are Chak, Atsede Birhan, Hezbe Selam and Gedam Abo.

List of household (HH) members of each sub districts that received "Book of Rural Land Possession" employed as a sample frame. The list was obtained from the sub districts land administration offices and the total number of households in the four sub districts would be taken as, the sample frame which was 1275. The researcher selected ten percent randomly from each sub district which was a total farmer HHs of 128, this was the sample that the researcher used to collect data by using questionnaire. In addition, interviews were also applied with district officials, each sub district land administration experts and selected key informant farmers. The data were analyzed by using binary logistic regression model. For the operation of this task, SPSS Version 20 (Statistical Package for the Social Science) software were employed. Different models were used to estimate the relationship between the dependent and explanatory variables. In this research, the dependent variable, land tenure security would be treated as dichotomous. For the analysis of this type of dependent variables Hosmer and Lemeshew (1989) pointed out, binary logistic regression (logit) is more important than the others. Because, it is an extremely flexible and easily usable model (Greene, 2003).

### Definition and measurement of variables

The dependent variable was land tenure security (Its) and ten independent variables were used to estimate whether land tenure security is related to these explanatory variables or not. These were age of the household heads (HHs), sex of the HHs, educational status of the HHs, family size and land holding size (Holden and Hailu, 2001), and fear of future land redistribution, absence of clear justice system to settle land related disputes, different government body interventions, lack of experience and knowledge in the local land administration experts and lack of alternative means of livelihood (Bruce et al., 1994; Desalegn, 2004).

#### *Age of the household head*

Age of the household head may have its own effect on the land tenure security of farmers. In the past, farmers who have influence on the community have been perceived to be secured than the others. The oldest farmers lose their influence in the community and may feel more land tenure insecurity than the others groups (Holden and Hailu, 2001). Therefore, the youngest of the household head was more secure than the oldest.

#### *Sex of the HHs*

There is a long history that, male headed HHs has more respect in the community (Holden and Hailu, 2001). The assumption was female headed households were more insecure about their tenure.

#### *Educational status of the HHs*

When the level of education is high, the more they know about the land rights and duties in the proclamation and users book.

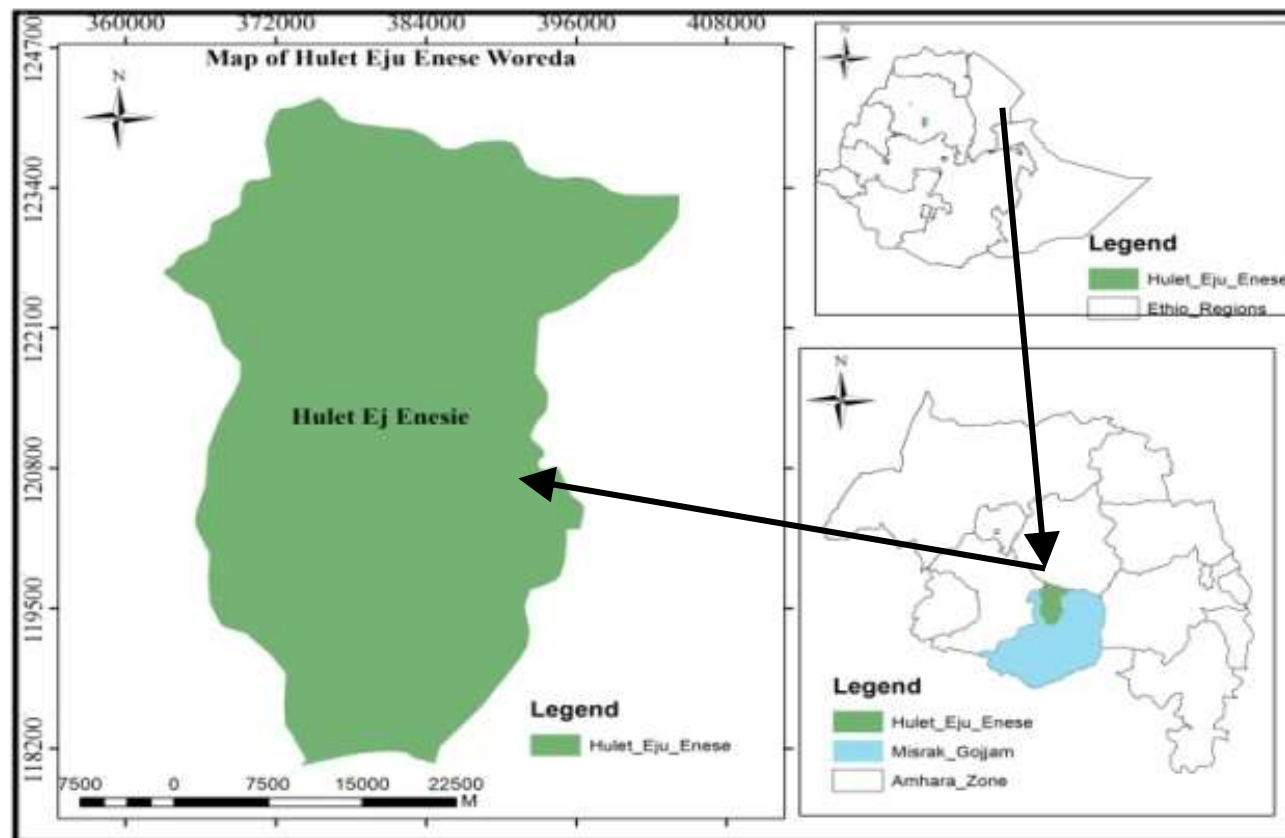


Figure 1. Map of the study area. Source: Constructed by author (2013).

Therefore, literate farmers were feeling more tenure security than the illiterate farmers.

#### **Family size of the respondents**

As almost all of the farmers in the district are depends on agricultural outputs alone, a household with more family size may be insecure by thinking of what will happen to their family in the future.

#### **Land holding size**

Farmers who have more land than others may fear losing their land to the new comers. Households with larger relative farm size feel more tenure insecure than those who have relatively less land (Holden and Hailu, 2001). Therefore, largest landholding size was the other determinant factor that affects tenure security.

#### **Fear of future land redistribution**

In Ethiopian, history land redistribution was conducted so many times and farmers always fear not to lose their cultivated land (Dessalegn, 2004). Especially, in Amhara region, redistribution is a recent phenomenon which is conducted in 1996/7, by memorizing it, farmers of the region fear there may be land redistribution soon (Samuel, 2006). Therefore, fear of future land redistribution was a determinant factor that aggravates land tenure insecurity of farmers after the implementation of rural land registration and certification program.

#### **Absence of clear justice system to resolve land related disputes**

As stated by Dessalegn (2004), during the imperial regime, the only responsible body who listen to any land related disputes was the local courts. However, these courts were highly corrupt and always stand at the side of the rich and powerful peoples. They do not give attention to the voice of the poor. Derg eliminated this court and give the responsibility to peasant associations. While the present government established social courts at the sub district level. But they do not have enough power to listen to land dispute cases. Hence, except simple cases that are solved by the sub district land administration experts in collaboration with committees, most of the land related dispute cases come to the district courts, most of the time in relation to distance, this is time consuming and costly to the farmers and the district court has not enough knowhow on each parcel of farmers land and sometimes the justice system that used to settle land related disputes are not clear (Dessalegn, 2009). It was considered as one of the main factors that affect farmers' perceptions of land tenure security after the implementation of the program.

#### **Different government body interventions**

There are different government bodies that intervene on land matters. These as development agents (DA), the sub district councils, officials from agricultural offices and environmental protection and land administration office. They may pass any decision that may affect the individuals secure land rights.

Therefore, it was one of the main factors that affected land tenure

**Table 1.** Overview and definition of variables included in the binary logistic regression model.

Variables code	Description
Lts	Land tenure security; 0= yes (secure), 1= no (insecure)
hhage	Age of the head of the household.... Continuous variable
hhsex	Sex of the head of the household; male=0, female=1
famsize	Family size of the household; Continuous variable
landhsiz	Total farm landholding size in hectare; Continuous variable
hhedustatus	Educational status of the hhhs; 0 = literate, 1= illiterate
Fflr	Fear of future land redistribution; 0 = no, 1 = yes
Acjs	Absence of clear justice system to settle land related disputes; 0 = no, 1 = yes
Dgbi	Different government body interventions; 0 = no, 1 = yes
Leklae	Lack of experience and knowledge of the land administration experts; 0 = no, 1 = yes
Laml	Lack of alternative means of livelihood; 0 = no, 1 = yes

security after the intervention.

#### **Lack of experience and knowledge by the sub district land administration experts**

Local land administration officials especially district and sub district officials are ignorant of the policy and legislations they are supposed to administer (Dessalegn, 2009). Therefore, it was also considered as one of the factors that affect the land tenure security of farmers after the implementation of the program in the study area.

#### **Lack of alternative means of livelihood**

As agriculture is the only means of livelihood for most of the Ethiopian farmers, if there is any problem in relation to this sector, all the life of the household members will be in danger (Bruce et al., 1994). So, lack of alternative means of livelihood was also the other main factor that affects the land tenure security of the farmers of the district after the implementation of program.

#### **Regression model specification**

The dependent variable land tenure security was a dummy variable. The question raised for the respondents "Is your sub district farmer's land tenure security increase after the book of rural land possession"? The dichotomy value of this dependent variable is indicated as, zero if the farmers replay "no" (not secured) and one if they replied yes (secured).

Ten independent variables were used to see whether or not these were factors that affect land tenure security of the study area farmers after the implementation of the program. These were age of the household heads, sex of the household heads, educational status of the household heads, family size and land holding size (Holden and Hailu, 2001), and fear of future land redistribution, absence of clear justice system to settle land related disputes, different government body interventions, lack of experience and knowledge of sub district land administration experts and lack of alternative means of livelihood (Bruce et al., 1994; Desalegn, 2004). The form of binary logistic regression model with multiple covariates is indicated in Gujarati (2004) as:

$$Z_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \dots + \beta_k x_{ik}$$

Where  $Z_i$  is the dependent variable; which is determined by the

independent variables  $x_1, x_2, x_3, \dots, x_k$  and  $\beta_0$  the constant term and the remaining  $\beta$ 's were the extents to which each independent variables affects the dependent variable. Therefore, the general model of the binary logistic regression for this study was illustrated as:

$$lts_i = \beta_0 + \beta_1 hhage_i + \beta_2 hhsex_i + \beta_3 famsize_i + \beta_4 edustatus_i + \beta_5 landhsiz_i + \beta_6 fflr_i + \beta_7 acjs_i + \beta_8 dgbi_i + \beta_9 leklae_i + \beta_{10} lamli_i$$

Where,  $lts_i$  = land tenure security,  $hhage$  = age of the household head,  $hhsex$  = sex of the,  $famsize$  = family size of the household,  $edustatus_i$  = educational status of the household head,  $landhsiz_i$  = land holding size of an individual  $i$ ,  $fflri$  = fear of future land redistribution,  $acjs_i$  = absence of clear justice system to settle land related disputes,  $dgbi_i$  = different government body interventions,  $leklae_i$  = lack of experience and knowledge in the kebele land administration experts and  $lamli$  = lack of alternative means of livelihood.

## **RESULTS AND DISCUSSION**

For the binary logistic regression model, ten explanatory variables (seven dummy and three continuous) were included in the model. The summary of the dependent and explanatory variables that influence the farmer's land tenure security were presented in Table 1.

The researchers asked the respondents whether the above explanatory variables were factors that affect the land tenure security of the communities in the study area after the program or not and the responses were yes or not. For the response, no is coded as 0 and yes coded as 1. It helps to investigate whether the variables are still factors that affect the land tenure security rights of the farmers in the specified area or not.

#### **Test for goodness of the fit- Hosmer and Lemeshow test**

Hosmer and Lemeshow test is one of the methods that help to measure the goodness of fit of the model. If the H-L goodness-of-fit test statistic is greater than 0.05, it is a well-fitting model. As indicated in Table 2, H-L statistic



**Table 2.** Hosmer and Lemeshow test.

Step	Chi-square	Df	Sig.
1	9.058	8	.337

has a significance of 0.337, this is greater than 0.05 which means the model was quite a good fit.

The final important table that must be interpreted in this model to get the final result was “variables in the equation”. Table 3 indicates the variables and their significance level to the dependent variable land tenure security, coefficients, standard errors, Wald test, significance and Exp (B).

Among the ten explanatory variables included in the model, five variables had a significant level in affecting the land tenure security rights of farmer households after the implementation of rural land registration and certification program. These variables includes, age of the household head, household head educational status, family size, land holding size, fear of future land redistribution and lack of experience and knowledge of sub district land administration experts.

Except lack of experience and knowledge of the sub district, land administration experts which was significant at 5%, the other variables were significant at 10% and except family size, the coefficient of all the significant variables was in a negative sign which indicates these variables affect the dependent variable land tenure security negatively. The other variables were insignificant on their effect on land tenure security presently in the study area.

### Age of the household head

As indicated in the model, age of the household head was significant at 10% and the coefficient was a negative sign that means when the age of the household head increases the feeling of land tenure security is decreased by the Exp (B) value which was 0.916. This could be due to the oldest farmers believe loss of influence in the power of the community than the youngest. This was correctly proved by Holden and Hailu (2001) findings and after the intervention, old aged households are more insecure about their land holding.

### Educational status of the household heads

Educational status of the household head also significant at 10% and the coefficient sign was negative, which means it affects the land tenure security of farmers after the implementation of rural land registration and certification program in Hulet Eju Enese woreda, negatively. The generalization is that, educated farmers had confidence on their land holding rights than the

uneducated farmers (Dessalegn, 2009).

### Family size of the household

Family size of the households was also a significant factor that affects the land tenure security of the landholders in the study area. As indicated by the model, its effect was positive because the coefficient sign was positive. This is mostly contradicting with the assumption that, when the number of family increases, farmer's perception of land tenure security was decreased (Holden, 2010; USAID, 2007). Because, farmers whose family are large in number, they think for their future family life and fear of losing land than those that have small number of families. But, it may be also due to wanting future land redistribution.

### Fear of future land redistribution

Presently, there are two arguments in relation to fear of future land redistribution in the farmers of the study area; one believe that land redistribution will not occur in the future and the other believe that due to population growth and increment of unemployment rate, there will be future land redistribution.

Farmers who have more land now, fear future land redistribution to lose their holdings. Because, if land redistribution will occur in the future; the first losers may be those who have more land now. In other ways, farmers who have small plots of land did not fear future redistribution to lose their land. Because they know their land is small and they also hope that, their children may get land by the new redistribution.

As Hosena (2010) research result in Tigray region stated, many of the farmers have a small plots hoped to gain land by new land redistribution in the future. This is also true in Hulet Eju Enese district farmers who have small plot of land relative to others or who have no land by his/her name hoped to get agricultural land by the future land redistribution and they wants to see land redistribution in the near future.

Fear of future land redistribution was not the only factor a farmer fear of losing his/her land. For instance: As the expert of Atsedo Birhan sub district stated that:

*“Satellite town is planned to be established and farmers fear of losing their land by the establishment of this town and they always ask me about their future in relation to the town, farmers also fear of losing land in relation to cadastral surveying. These farmers may be those who registered their land in a false size in the first stage of the program”.*

Table 4 indicates that, more than 40% of the total respondents fear future land redistribution in the four sampled sub districts. That means, important number of

**Table 3.** Variables in the equation.

	B	S.E.	Wald	Sig.	Exp(B)
Hhage	-0.088	.044	3.936	0.047**	0.916
hhsex(1)	-0.118	1.026	0.013	0.908	0.889
Famsize	0.604	0.270	4.996	0.025**	1.830
hhhedustatus(1)	-1.431	0.791	3.272	0.070***	0.239
Landhsize	0.910	0.686	1.759	0.185	2.486
<b>Step 1<sup>a</sup></b> fflr(1)	-2.095	0.843	6.170	0.013**	0.123
acjs(1)	-0.519	0.702	0.547	0.459	0.595
dgbi(1)	0.297	0.713	0.173	0.677	1.346
leklae(1)	-2.926	1.019	8.236	0.004*	0.054
laml(1)	1.870	1.510	1.533	0.216	6.487
Constant	0.659	2.237	0.087	0.768	1.933

a. Variable (s) entered on step 1: hhage, hhsex, famsize, hhedustatus, landhsize, fflr, acjs, dgbi, leklae, laml. \*, \*\* and \*\*\* significant at 1, 5 and 10%.

**Table 4.** Fear of future land redistribution.

Assessment tools	Sub districts	Atsede Birhan		Hizbe Selam		Gedam Abo		Chak	
		Responses	F	%	F	%	F	%	F
Do you fear future land redistribution	Yes	7	46.7	18	42.9	11	39.3	8	34.8
	No	8	53.3	24	57.1	71.7	60.7	14	60.9
	No response							1	4.3

Source: Survey data, 2013.

respondents still think land redistribution will be conducted in their area and some of them fear losing their lands. The logistic regression model results also indicate fear of future land redistribution was significant at 10% with a negative sign coefficient with land tenure security. That means a farmer who believes land redistribution will be conducted in the future become more insecure than those who did not fear future land redistribution.

Therefore, as both the qualitative and quantitative result indicates fear of future land redistribution is still a factor that affects the land tenure security of farmers in Hulet Eju Enese district and it supports Deininger et al. (2008) findings that conclude the implementation of the program reduced fear of future land redistribution but did not overcome it.

#### **Absence of clear justice system to settle land related disputes**

The regression result indicated that absence of clear justice system to resolve land related disputes was not a significant determinant of land tenure security after the implementation of the program even if its coefficient was negative. This conclusion was the same with the following qualitative responses from both the land administration experts and farmer respondents.

As head of the district environmental protection land administration and use office described, in the past, the justice system could shape to wrong decision by the influential groups, because, there was no legal document that indicates the right user of a certain land. After the implementation of the program, the user's book is the guarantee of farmers to get appropriate decision in relation to land related disputes. Even if, corruption is still aggravated in different forms in the district, absence of clear justice system to resolve land related disputes is not a factor that affects land tenure security of farmers. During the interview with farmers, all farmers do not think absence of clear justice system is a factor that affects their land tenure security rights; a farmer from Chak sub district stated that:

*"I know my rights and obligations and my land is also registered and I received the book holding used as a witness of my user rights, now I do not fear absence of clear justice system may affect my land tenure security right, because, if something is happening arbitrarily in relation to my user right, the book will be used as a guarantee".*

Similarly, experts also assert that, absence of clear justice system is not factor that affect the land tenure security of farmers presently in the district. Because,

farmers have various options to report the problem they are faced in different situations in relation to their user rights. First, a farmer goes to the sub district land administration committees, sub district land administration experts to get a solution for their problem. If they are not happy with the committee and expert decision, they report their problem to the district environmental protection, land administration and use office or the court. Therefore, absence of clear justice system to resolve land related disputes is not a long factor that affects the security rights of farmers in Hulet Eju Enese district after the implementation of rural land registration and certification program.

### **Lack of experience and knowledge in the sub district land administration experts**

According to the head of the district environmental, protection land administration and use office lack of knowledge and experience in both the district and sub district land administration experts affect the security right of farmers directly or indirectly. Especially, sub district land administration experts are not willing to stay on their work as it is remote rural areas and when they got some options, they withdraw from their job. This creates always to lead by new land administration experts.

Additionally, there is not enough trained students in rural land administration departments and most of the employs are from law and other related departments given in different colleges as a diploma level. During the startup of the program, the job is covered by the farmers selected as land administration committees and at that time, some farmers fear, another way of injustice on their land holding like the 1996/7 land redistribution employed in the region. However, after a year, the district environmental protection, land administration and use office employed sub district land administration experts and it is open for any department students who have diploma in a known college and this creates lack of awareness or experience on the sub district land administration experts.

The regression result also indicates that lack of experience and knowledge of the sub district land administration experts is a significant variable at 5% that affect the land tenure security of farmers. Negative sign of the coefficients indicates the negative effect of the variable on the land tenure security of the landholders. Therefore, lack of knowledge and experience in the sub district land administration experts is still one of the factors that influence the security rights of smallholder farmers in the district.

### **Lack of alternative means of livelihood**

As the experts stated that, farmers could not have alternative livelihood strategies in addition to agriculture.

If they face a problem on their agricultural practice, their life will be in danger. Therefore, lack of alternative livelihood strategies is one factor that needs emphasis to increase farmers land tenure security. Even, this also forced farmers to fear facing environmental calamities such as lack of seasonal rainfall and climate change.

Farmers replied that, lack of alternative means of livelihood is a factor that affects their land tenure security. People fear losing land because the land is their only assets, their life were depend on it and most of them replied this is the major factors that forced them to think about their future security. Contrary, some farmer respondents also replied that, presently, some farmers who accumulate capital start another means of livelihood to support their agricultural productivity. For instance, there are farmers who starts trade activities in the rural area by creating connection with the town merchants and they are beneficiaries. These groups conclude, lack of alternative means of livelihood is not a factor that affects the security rights of farmers in the district and this response is also supported by the regression model. It indicates lack of alternative means of livelihood is not a significant factor that affects land tenure security rights of farmers.

### **Different government body interventions**

Different government body intervention is not significant in the model by affecting the land tenure security of farmer households in the study area. Farmers who participate in the interview process also stated that, different government bodies who intervene in different agricultural activities do not affect their land tenure security rather it plays its own role in the productivity of their agriculture. A farmer from Chak sub district stated that:

*“There are different government officials in our sub district who contacted us for different reasons. For instance, presently there are three development agents (DAs) who are responsible for land, forest and livestock production, one sub district manager, one sub district environmental protection, land administration and use office expert, land administration committees and different administrative bodies. But, their interventions on different issues have no effect on the land tenure security of the farmers”*

Therefore, the above interpretation indicated that the intervention of different government bodies on the agricultural activities do not affect farmers land tenure security rather it helps to increase their agricultural productivity.

### **Fear in relation to compensation**

Even if the proclamation stated that, if the government

took farmers land for development project, appropriate compensation will be provided to the users in type (land equivalent to the land they lose) or in cash. But, there are a lot of challenges in the implementation processes of compensation. The best example for this is, during my observation in the sampled sub districts, there is a concert road constructed from the district capital city Motta to Atsede Birhan sub district and it was observed that, the road crosses on the agricultural lands of many farmers. The sub district land administration experts explained that, there is a very complex situation in the compensation process.

When the researcher contact farmers and asked whether they got proper compensation or not, some farmers got compensation even if they claimed that it is not proper in relation to the land they lose and there are also farmers that did not get any compensation. A farmer during the interview process stated that:

*I lost some portion of land by the construction of the road and I did not get any compensation for the land, I always reported to the sub district land administration office. But, the expert did not give good response.*

The sub district environmental protection, land administration and use expert replied to this as:

*"The sub district environmental protection, land administration and use expert there, when the farmers lost their land made a great mistake, he must facilitate the implementation of the compensation process. Presently, there is no document that indicates how many hectares of land farmers lose and also the compensation during the time when the road was constructed and now also, a great variation of these are the main constraints to pay the compensation and I always report to the district and the district announce the losers will get the compensation after the land they lose is measured in a short period".*

The above case indicated that getting proper compensation to the land they lose affect the land tenure security of the farmers. Farmers who lose their land by the construction of the new road are normally insecure in relation to compensation and the other farmers around these groups also fear of getting proper compensation, if the government took their land for development project.

## Conclusion

The implementation of rural land registration and certification program is a good initiative taken by the government of Ethiopia to improve the land tenure security of farmer households and to boost the productivity and sustainable development of the main economic activity of the country agriculture. Presently,

the first stage of the intervention which is providing land holding book has been completed. The intervention improves the feeling of the farmers in relation to land tenure security as compared to the previous time. However, there are still factors which aggravates farmers felling of land tenure insecurity such as age of the household head, household head educational status, land holding size, fear of future land redistribution and lack of experience and knowledge of sub district land administration experts. Therefore, the concerned bodies should give emphasis to reducing the influence of these factors in the second stage of the intervention. Especially, by improving farmers awareness about the role of the program and by providing intensive training to the land administration experts of the district, sustainable land use practice should be attained.

## CONFLICT OF INTERESTS

The author has not declared any conflicts of interest.

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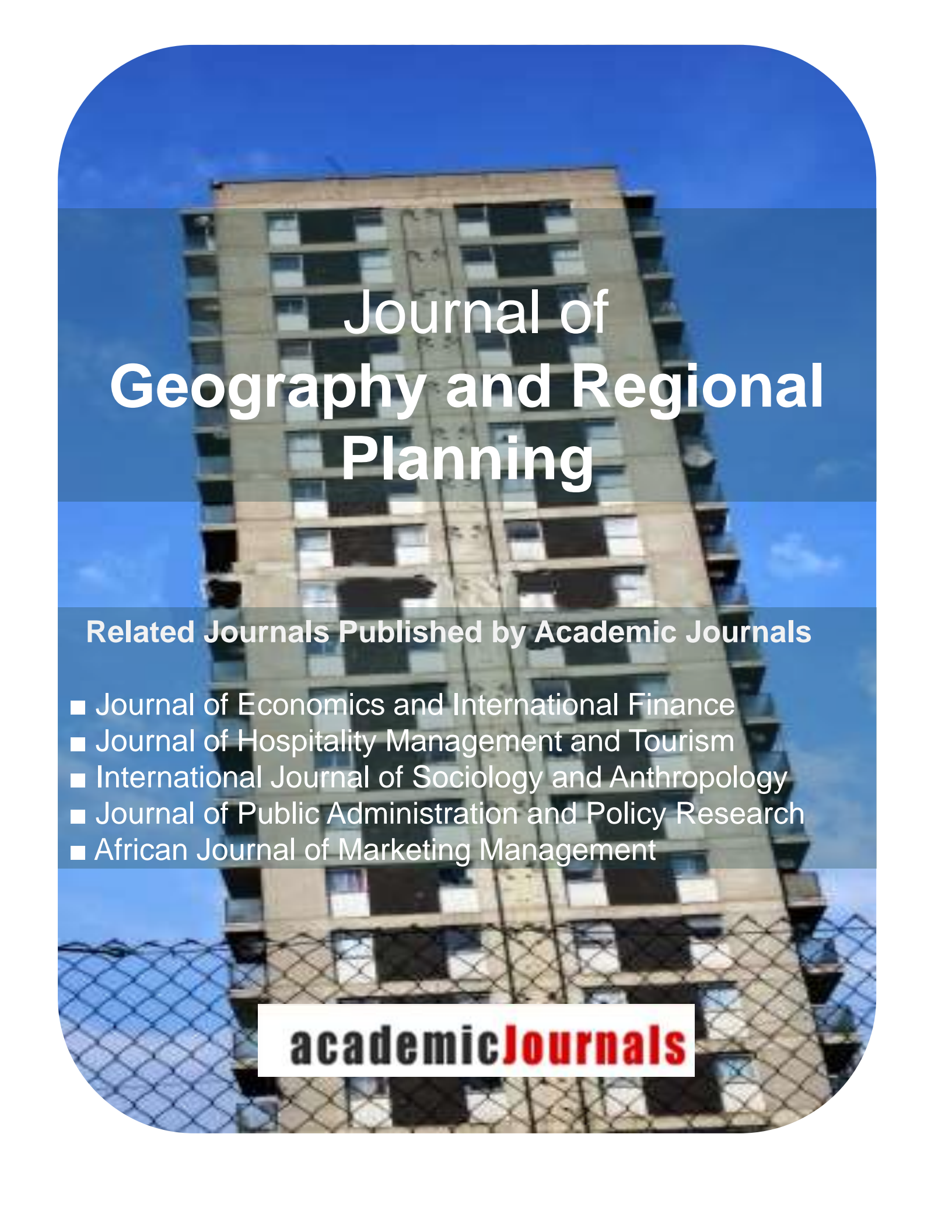
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