Agent-Based Simulation modeling Approach for Tenure Security Dynamics

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Keywords: land, tenure securityAccording, agent-based simulation, perceptual dynamics

SUMMARY

Urbanization process governs by the market mechanism tend to marginalize the poor into squatter settlements (Davis, 2006, pp. 1-19). UN-HABITAT report in 2003 shows that 30% of the urban population lived in such settlements and trend becomes severe in coming decades (UNHABITAT, 2003). An inherent characteristic of squatter settlements is lack of tenure security. Insecure tenure lands being underutilized and less economically viable and hence, lands with tenure insecurity become dead capital to a nation (Soto, 2000, p. 29).

Tenure security is one of the main goal of land administration Domain Modelling (LADM) (Lemmen, Ostroterom, and Bennett, 2015). However, land tenure security, unlike other economic indices, is very difficult in quantifying. This is mainly due to the fact that it is mainly depending on human perception (Deininger 2003, p. 36). According to some, development of tenure security is simply a matter of formalizing the title (Soto 2000). However, others argue that such formalization without focusing the possible environmental repercussions (mainly through the land market) may cause market eviction of the tenants. According to them, gradual enhancement of the tenure security, by calculating the possible environmental repercussions, would be the ideal mean of enhancement of the tenure security. However, the practical implication of such an approach may obstruct by the inability to quantify the true impact of tenure enhancement measures on the right holder.

The research hypothesis that Land tenure security is not only cognitive based but also communicational structural. Hence, statistical approaches and other linear approaches for studying tenure security development do not provide accurate feedback. The objective of the research is, therefore, to identify the role of cognitive and social communicational structures in defining the land tenure security.

In order to test the hypothesis, the researchers utilized the TUUD simulation model developed by Piyasena (2015). Accordingly, a framework for defining the tenant interactions as well the limiting environmental factors have decided through a literature review. Different cases have been build-up by changing the learning capacity of randomly selected agent (a land tenant). The results shows that tenure security conditions of the agents within the selected community is not only depending on the individual cognitive structures but also resulting communicational structures as well.

In conclusion, there is a non-linear relation between tenure security and feedback structures as well as communication structure. This highlights the fact that land policies directions towards tenure security enhancement need be based on localized conditions and needs to avoid blue print solutions.

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1. INTRODUCTION

Urbanization process governs by the market mechanism tends to marginalize the poor into squatter settlements (Davis, 2006, pp. 1-19). UNHABIAT report in 2003 shows that 30% of the urban population lived in such settlements and trend becomes severe in coming decades (UNHABITAT, 2003). Inherent characteristic of squatter settlements is lack of tenure security. Insecure land tenure hinders the economic progress of a country. As neoclassical theories highlights tenure security is a precondition for a functional market and hence, the accumulation of the capital. Lack of such security creates uncertainties to the returning of the expected benefits from an investment and thus, demotivating the investment as well. This is especially true with land market. Ultimately, insecure tenure lands being underutilized and less economically viable and hence, lands with tenure insecurity become dead capital to a nation (Soto, 2000, p. 29). According to Soto's study lack of land tenure security has caused loss of $74 billion in Peru, $133 billion in the Philippines, and $240 billion in Egypt (Soto, 2000, p. 29).

Establish secure ownership rights or tenure is one of the main goal of land administration Domain Modelling (LADM) (Lemmen, Ostroterom, and Bennett, 2015). However, modelling the tenure security is a challenging task. Land tenure security, unlike other economic indices, is very difficult in quantifying. This is due to the fact that it is mainly depending on the human perception. As Deininger (2003, p. 36) highlighted land tenure insecurity is determined through the perceived uncertainties of returning the benefits from land rights and their impacts on right holder's economic decision making. Quantifying the degree of tenure insecurity may, therefore, involves with expected outcomes from bundle of rights attached with land, their impacts as well as individual perception on returning of the expected benefits ((Sjaastad & Bromley, 2000, p. 9, Piyasena, 2015).

Research problem: A simple Cadastral System, which is widely practising in the global west, may not be good enough for most of the developing countries in the global east. It carries the essence that, development of tenure security is simply a matter of formalizing the title (Demsetz, 1967, Soto, 2000). However, other argues that such formalization without focusing the possible environmental repercussions (manly through land market) may cause to market eviction of the tenants. According to them gradual enhancement of the tenure security by calculating the possible environmental repercussions would be the ideal mean of enhancement of the tenure security (Davis, 2006, Payne 2001). However, practical implication of such an approach may obstructs by the inability to quantify the true impact of tenure enhancement measures on the right holder.

Research hypothesis: The impacts of land tenure security enhancement measurements are not only depending on the individual cognitive structures but also depending on the resulting

communicational network structures. Hence, land tenure development policies need to embrace these dimensions in order to establish land tenure security, rather than depending on linear and other statistical approaches.

Research Objective: Therefore, objective of this paper is to utilize agent-based simulation approach to identify the changes of individual tenure security status with the environment feedbacks and its impact of the communicational network structures as well as tenure security conditions of other tenants.

2. LITERATURE REVIEW

2.1 Utility of Land Tenure

There is a global debate on the means of enhancing the tenure security. The core of this debate lies in the property rights discussion based on principles of neoclassical economic theories and new institutional economic theories. According to neoclassical economic, rights reflect the peoples' expectations towards a resource (e.g. land) and right holder expect the rest of the community would prevent others from interfering with her rights. And they also serve the purpose of internalize the externalities. Formal recognition of title to land enables the process of internalize the externalities as well as certainty in returning the expected benefits from land resources (Demsetz 1967, pp. 347-348). Such formalization would allows to continuous exploitation of the land resources through land market. This is because, internalization of the externalities forced right holder to make rational decisions and investors are motivated to invest due to certainty in returning the expected benefits (Soto 2000, pp. 29-31). This process may then help to accumulate the capital and thus, allowing to continuous exploitation of land resource. Therefore, according to the neoclassical economists, establishment of tenure security through formalization of land rights of squatter settlers would helps to establish healthy land market and thus accumulation of the capital (Soto 2000, pp. 288-229).

However, others argue that such formalization of land title may cause unintended repercussion from other tenure categories within the land tenure continuum and hence, market eviction of the poor and vulnerable (Payne 2001, p. 9). This make additional burden to the economic progress of a country. Further, such formalization would do harm to the locally evolve institutions which serve the purpose of reducing the uncertainties (Ostrom, 1990, Durand-Lasserve & Selod, 2009). Further, on practical ground, such effort may tend to forced sell the land or expel from the land due to lack of document.

The above debate shows us that enhancement of tenure security is not an easy task. Tenure security itself consist with perceptual component (Piyasena, 2015). As Sjaastad & Bromley (2000, p. 9) highlights Land tenure security implies the perceived uncertainty of the benefit returning from right to a resource. This uncertainty has objective and subjective components and is determined through its characteristic elements (Deininger, 2003, p. 23). These elements (SLATE)can be denote as duration of rights, boundary definition by institutions, subject of rights, properties of enforcing organizational setup, evolution of institutional setup (Piyasena and Eckardt 2013).

According to Piyasena and Eckardt (2013), duration of rights needs to be sufficiently long enough to reap the benefits from an investment. In the case of squatter settlements, perceived subjective and objective uncertainty associated with this element is determined through the behaviour of formal organizational setup and perception on the community strength towards external interventions, respectively. Boundary definition by the institutions determines the capacity of institutional setup to eliminate the externalities. Objective uncertainty associated with this element is mainly determined through dynamics of land policy objectives while subjective uncertainty is mainly determine through the strength of the community to maintain informal institutions to eliminate such externalities. Subject of rights define the attributes of a property regime and is mainly defined through boundary definitions by the institutions, properties of the enforcing organizational setup and evolution of the institutional setup. Properties of the enforcing organizational setup denote the assurance of punishment against the violation of institutional boundaries. Its objective and subjective components of tenure security are defined through performance of formal and informal organizational setup respectively. The evolution of institutional setup ensures that institutional boundaries are up to date according to the new cost-benefit structures. This element consist only objective uncertainty and is mainly defined through the properties of the formal organizational setup. All these elements, except evolution of institutional setup may influence the investment on land and land values, while the evolution of institutional setup is only affecting the investment on land (Piyasena and Eckardt, 2013) (see table 1)

Table 1. Secure Land Tenure Elements (SLATE)

Element	Main Economic Function	Objective Uncertainty Depends	Subjective Uncertainty Depends	Effect on Investment	Effect on Land Value
01- Duration of Rights	Ensure rights are long enough to reap the benefit from an investment	Past behaviour of the formal organizational setup in evicting people and resources allocated for the purpose	Dynamics of the Perception on Community Strength	Yes	Yes
02- Boundary Definitions by institutions	Establish boundaries to eliminate the externalities	Dynamics in land policy objectives and resources allocated	Ability of informal organizations to define boundaries	Yes	Yes
03- Subject of Rights	Define the attributes of the property regime to eliminate the externalities	Element 02, Element 04, Element 05	Element 02, Element 04	Yes	Yes
04- Properties of Enforcing Organizational Setup	Assurance of punishments against violation of boundaries	Performance of formal organizational setup to monitor and punishment	Performance of informal organizational setup to monitor and punishment	Yes	No
05- Evolution of the institutional setup	Change the institutional setup to new cost-benefit structure	Degree of awareness of the formal organizational setup to changes and wiliness to change	No practical relevance	Yes	No

According to Piyasena and Eckardt (2013), utility of land tenure with respect to above SLATE can be defined as;

$$(C_I + \pi S_I)y(k)T + (C_V + \pi S_V)P_s T \quad \text{.....01}$$

Where;

$$C_1 = 1 - O_I^{e1}\phi_{e1} - O_I^{e2}\phi_{e2} - O_I^{e4}\phi_{e4} - O_I^{e5}\phi_{e5}$$

$$C_V = 1 - O_V^{e1}\phi_{e1} - O_V^{e2}\phi_{e2}$$

$$S_I = S_I^{e1} + S_I^{e2} + S_I^{e4}$$

$$S_V = S_V^{e1} + S_V^{e2}$$

$$S_I^{ei} = \frac{Income\,Reduction - Subjective\,Uncertainty\,i^{th}\,Element}{Total\,Income}$$

$$S_o^{ei} = \frac{Income\,Reduction - Objective\,Uncertainty\,i^{th}\,Element}{Total\,Income}$$

$$S_V^{ei} = \frac{Value\,Reduction - Subjective\,Uncertainty\,i^{th}\,Element}{Land\,Value}$$

$$O_V^{ei} = \frac{Value\,Reduction\,Objective\,Uncertainty\,of\,i^{th}\,Element}{Land\,Value}$$

$Where, i = 1,2,\ldots 5$, $\pi = \psi_{e1} = \psi_{e2} = \psi_{e4}$, $\psi_{ei} - Perceived\,subjective\,uncertainty\,associated\,with\,i^{th}\,element, i = 1,2,\ldots,5$, $T - Total\,amount\,of\,land$, $P_s = Price\,of\,the\,squartting\,land$, $\phi_{ei} - Perceived\,objective\,uncertainty\,associated\,with\,i^{th}\,element, i = 1,2,\ldots,5$

2.2 **Self Perception and Land Tenure security**

As we can see from the above equation 01, self-perception is an integral part of the land tenure. This will intern determine the degree of certainty of returning the expected benefits from land rights or tenure security itself.

Self-perception, according to the self-congruity theory, is defined as an enactment of self-images on a given role. These self-images consist with perceived and reference images and enact when a person get feedbacks from her environment. These self-images can be attributed with valance, strength, and salience. Valance represents the expectational attributes. Strength of a self-image defines the degree of certainty with regard to the belief or expectation while the salience is mainly representing the relative importance of the evoke self-schemata (i.e. perceived and reference images) with other such schemata (Sirgy, 1986).

According to the self-congruity theory (Sirgy, 1986), in each feedback, a person may undergo with so called self-congruity process. Within this process the key expectation of the person is to establish highest homeostasis in the phase of each feedback. In other words, she may try lesser the divination of attributes associated with perceived self-image and reference self-image. This may lead to one of the following cognitive status:

positive self-congruity

positive self-incongruity

negative self-congruity

negative self-incongruity

The above self-congruity conditions in turn get modified through the self-consistency and self-esteem effects associated with the person. Depending on the properties of the feedback, impacts of the above feedbacks, and the associated threshold values with respect to self-concept, a person may undergo with self-concept change, dedifferentiate and generalization. Where, in self-concept change, a person may change the valance of the perceived self-image associated with given role. In self-concept differentiation the valance associated with reference image may change. In self-concept generalization change the salience of the reference image. This helps her to predict the outcomes of the event in advance.

In every feedback, not only the valance and the salience, but also the strength of a self-image is change. This may in turn affect the self- knowledge perception associated with the evoke self-image schemata. This is essentially a self-congruity process which named as informational perceptual self-congruity. Within this process a person tend to select the feedbacks that gives her highest homeostasis with respect to the self-knowledge. This process also lead to change the cognitive structures in a similar way as perceptual self-congruity process, namely: self-knowledge change, differentiate, and, generalized. This process is defined by Piyasena (2015) as shown in following figure 1 and 2.

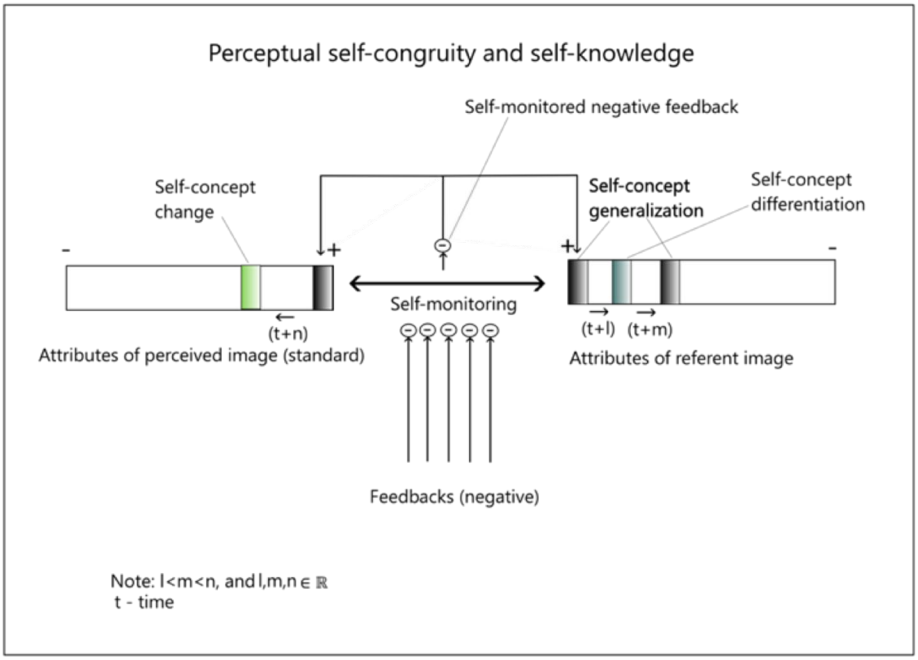

Figure 1:Perceptual self-congruity and self-knowledge (Piyasena 2015)

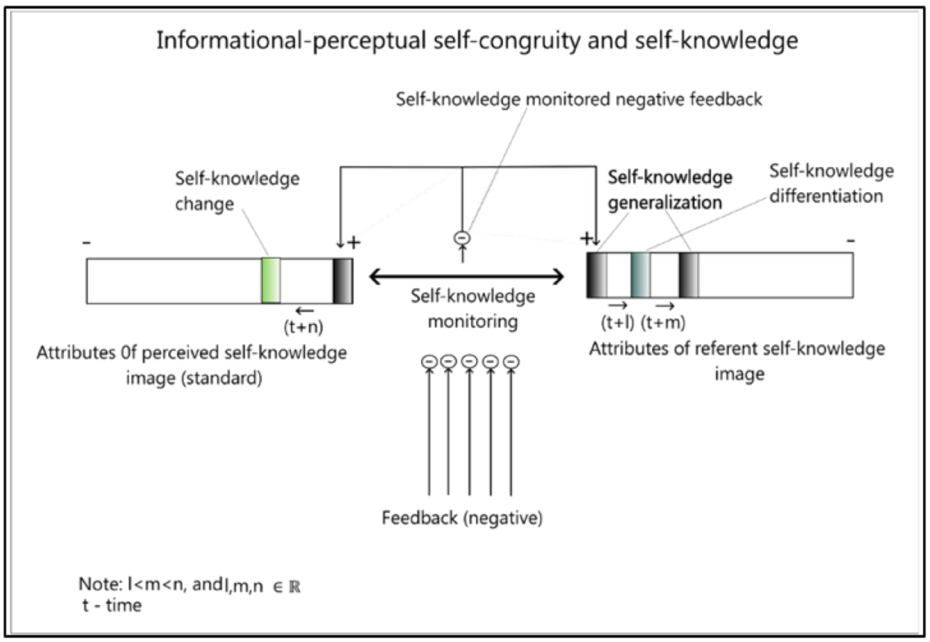

Figure 2: Informational-perceptual self congruity and self-knowledge (Piyasena, 2015)

2.3 Socio-cognitive Structures, Autopoietic Systems and Self-perception

As identified in above equation 01, tenure security of is a function of a perceived uncertainties associated with returning expected benefits from secure tenure elements. According to the above discussed self congruity theory, the self-perception, $\pi(q)_{j(i)}$ of i^{th} tenant in q^{th} community when communicate with the j^{th} in the same community, is in turn, a function of valance, $v(q)^{P}_{j(i)}$, and strength, $s(q)^{P}_{j(i)}$of the self-images of the tenant concerned. Therefore, degree of tenure security can be defined as below (Piyasena, 2015):

$$\pi(q)_{j(i)} = f\left(v(q)^{P}_{j(i)}, s(q)^{P}_{j(i)}\right) \quad \text{02}$$

Those properties of the self-images are however, not stagnant, but subject to change with the feedback that a tenant may get. In such case, a tenant may seek highest homeostasis with respect to self-perception and self-knowledge perception of SLATE. This may, in turn, change of land tenure security at a given moment.

The above process of searching the maximum homeostasis with respect to self-perception and self-knowledge perception may then lead formation of social communicational structures as well. This is because each tenant tent to communicate with someone who maximize the homeostasis with respect to self-knowledge perception. These communicational structures can be taken the form of Mutihub, Pyramid, or web structures (Martin 2019). According to piyasena (2015) the utility of communication of a tenant can be represented as follows;

$$U_{j(i)j(r)} = utility\left(\max_{r=1}^{n_j}\left(SM_{j(i)j(r)}(t)\right), \max_{r=1}^{n_j}\left(SKM_{j(i)j(r)}(t)\right)\right) - U\left(D_{j(i)j(r)}\right) \quad \text{03}$$

Where:

$U\left(D_{j(i)j(r)}\right)$– *Utlity of communication accross the geopraphic distance of* i^{th} *agent* $\in j^{th}$ *community* $\wedge r^{th}$ *agent* $\in i^{th}$ *community*

$U_{j(i)j(r)}$– *Utility of communication of* i^{th} *agent of* j^{th} *community with* r^{th} *agent of* j^{th} *community*

$SKM_{j(i)j(r)}(t)$– *Self – knowledge perception monitoring when communicate between* i^{th} *agent* j^{th} *community wthi* i^{th} *agent* $\in j^{th}$ *community*

$SM_{j(i)j(r)}(t)$– *Self – perception monitoring when communicate between* i^{th} *agent* $\in j^{community} \wedge i^{th}$ *agent* $\in j^{th}$ *community*

The feedbacks coming through the communicational structure change the cognitive structures of a tenant according to equation 02, which in turn affect the communicational structures. The process is continuing in a recursive manner. As such, the cognitive and communicative structures change their structures based on receptive external feedbacks. Hence, it can be argue that they behave exactly as a large autopoitic system where structures are self-determined with the external feedbacks (Piyasena, 2015, Varela, Thompson, & Rosch,1992, Maturana, 1972, 2002)

3. TUUD SIMULATION HEURISTICS

Within the TUUD simulation (Piyasena 2015), it is assumed that a tenant (agent) within a community tend to maximize its utility with respect to Secure Land Tenure Elements mentioned in table 01 (SLATE). Within this maximization process, the agent faces two scenarios: being evicted or not evicted (Jimenez 1985, Piyasena 2015).

In the case of not being evicted the agent utilize the initial wealth, borrowed funds, and income to maximize her next period wealth and current consumption. In the case she is evicted, in addition to the initial wealth, borrowed funds and income, she spends additional cost of getting new land parcel from the land marker. Therefore, the remaining wealth she utilize for the purpose of maximizing the next period wealth and current consumption. The objective function of the agent is then to maximize the utility of wealth and the consumption in between the above two scenarios. If we assumed diminution marginal utility with the increase of wealth and absolute risk aversion decreases with the wealth. The indirect utility of being squatting under tenure insecurity can be written as (Piyasena, 2015) :

$$v^s = \pi v^e + (1-\pi) v^n \quad \text{.....04}$$

Where:

$v^n \equiv f(I, r, s, w_o, p_s, \pi, B_i, B_v, \rho)$, $v^e = f(I, r, s, W_0, p_s, \pi, B_i, B_v, p_f, \rho)$, I – Income of the tenant / day, r – Interst rate,

s – Credit ration, W_0 – Initial wealth, p_f – Price of the land formal sector / m^2, p_s – Price of the land informal / m^2, π – Uncertainty associated with SLATE,

B_i – Expected benefit reduction of investment, B_v – Expected benefit reduction of land value, ρ – Coefficent of the risk averstion

However, the above perceived uncertainty associated with the SLATE cannot be determined with a priori, rather it is changed with the feedback that agent gets from the inside and outside of the community. These feedbacks received by the agent according to the communication heuristics that defined in equation 03. This change the properties of the tenure security defined in equation 02. This will in turn change the communication structure and the process happens in recursive manner. Accordingly, the TUUD simulation gives the tenure security condition of each agent at a given time as well as its utility of land tenure.

3.1 Defining the Agent Properties within the Community

In order to test the hypothesis of the paper, it has build a scenario that more or less fit with the Sri Lankan context. The parameters of the agents are selected as bellow;

Table 2: Possible range of values for econometric parameters in squatter settlements

Econometric parameter	Possible range
Total amount of land	5 - 100 (m^2)
Capital to land ratio	7-10 (US$/$m^2$)
Income	360 - 2160 (US$/annum)
Consumption	150 - 1500 (US$/annum)
Initial wealth	700 - 5000 (US$)
Cost of squatting	30 - 1000 (US$)
Price of land (formal and informal)	28 - 280 (US$/$m^2$)

The above table 2 derived from the general characteristics of a squatter settlements (Tsenkova, 2010, Srinivas 2005, UN-HABITAT 2003,). The selected community represents the properties of tenant group who live in un-regularized squatting area. The general structural, sociometric and econometric properties of these agents within the community and the surrounding communities can be defined as follows:

Table 3: Socio and econometric properties of agents within the community

type	Structural	Sociometric			Econometric			
	Structure type	Valance of self-images	Valance of the self-knowledge	Learning rate (homeostasis)	Expected benefits secure tenure elements	Initial wealth	Income	Possible tenant group
Type 01	Less organized	Strong -ve	Low	Low	Low	Low	Low	un-regularized land
Type 02				Low	Low	Low	mod	
Type 03				High	Low	Low	Low	
Type 04				High	Low	Low	mod	
Type 05			High	Low	Low	Low	Low	
Type 06				Low	Low	Low	mod	
Type 07				High	Low	Low	Low	
Type 08				Low	Low	Low	Low	

The General strictural, sociometric, and econometric properties of agents live in negihbouring communities

Type 21	Highly Organized	Srong –ve	Low	Low	Low	Low	Low	Squartting tenant-Support by others
Type 31		Moderate -ve	High	Low	Low	Low	mod	Squatter owner
Type 41		Strong +ve	Low	Low	Mod/High	Mod/High	Mod/High	Free hold land

The scaling of the self perception and self-knowledge perception of an agent has done according to the following table 4

Table 4: Scaling the valance of the self-perception images

Self-perception image	Possible valance range
Strong +ve	+4 to +5
Moderate +ve	0 to +3
Moderate -ve	0 to -3
Strong -ve	-4 to -5

Table 5: Scaling the valance of the self-knowledge images

Self-knowledge image	Possible valance range
Strong	+7 to +10
Moderate	+4 to +6
Week	1 to +3

The strength of the self-knowledge image is depending on the degree of authoritativeness of the agent and that has defined as follows:

Table 6: Scaling the strengths of self-knowledge images

Agent type	Degree of authoritativeness (i.e. strength of self-knowledge image)
Impactors	7- 10
Leaders within a community	4 - 6
Normal tenants	1-3

As mentioned in above section 2.2 the resultant self-congruity conditions are then moderated through the self-esteem and self-consistency motives. As mentioned by Piyasena (2015) self esteem and self-constancy motives can be considered as constant for given community and can be characterize as follows:

Table 7: Possible values for the self-esteem motive and self-consistency motives

Self-congruity condition(SCC)	Value for self-esteem motive(SE)	Value for self-consistency motive(SC)
+ve self-congruity	SE2: 0.700	SC2: – 0.007
+ve self-incongruity	SE1: 0.500	SC1: 100
-ve self-congruity	SE3: 0.500	SC3: 100
-ve self-incongruity	SE4: -7160.000	SC4: -0.007

The values of the above table 3-6 were obtained from the calibration parameters of TUUD simulation model (see Piyasena 2015, p. 200 -203).

By considering the above tables from 2-6 the possible land tenure continuum and their specific econometric, social and communicational structural parameters of agents can be defined as follows:

Table 8: Specific econometric, social and communicational structural parameters of agents

Community type	Community 01 (T1)	Community 02 (T2)	Community 03 (T3)	Community 04 (T4)
Continuum	Squatter tenant without support from any public or private organization	Squatter tenant supported by public and private sector Squatter 'owner' on un-regularized land	Squatter tenant supported by public and private sector Squatter 'owner' – regularised subdivision Owner-unauthorized subdivision	Full ownership
Econometric properties				
Dependancy on SLATE (elements 03, 04, and 05)	Can vary depending on the scenario	Moderate expected benefits due to moderate demand and moderate organizational properties	High expected benefits due to high demand and high organizational properties	High expected benefits due to high demand and high organizational properties
Initial wealth	US$ 800-1000	US$2000 -4000	US$5000 -7000	US$10000 - 15000
Income	US$/day 2-3	US$ 5/day	US$ 8/day	US$25/day
Household size	10m² to 15m²	10m² to 15m²	15m²-20m²	40m²-100m²
Value	US$/m² 700-800	US$/m² 1000-2000	US$/m² 2500-3000	US$/m²4000-5000
Cost of squatting	US$120 -150	US$240	US340	-

Sociometric properties				
Valance of perceived self-image	Can vary depending on the scenario	Moderate negative image	Moderate positive image due to high organization	High positive image due to support from formal organizations
Valance of perceived self-knowledge image	Can vary depending on the scenario	Can be low due to poor education system	Can be moderate due to moderate educational system	Can be high due to high educational system
Learning rate	Can be vary depending on the scenario	Can be vary depending on the scenario	Can be vary depending on the scenario	Can be vary depending on the scenario
Structural properties	Can vary depending on the scenario	Moderately organized	Highly organized	Highly organized
Variance in authority	Generally low	N/A	N/A	N/A
Possible type of tenants	Type 01 to Type 08 (see table 10-6 & annexure A for details)	Type 09 to Type 20 (see table 10-6 & annexure A for details)	Type 29 to Type 36 (see table 10-6 & annexure A for details)	Type 37 to Type 40 (see table 10-6 & annexure A for details)

When deciding the values for the other properties of agents within a community following rules have been followed:

Defining the rule for agent's dependency on SLATE:

The degree of dependency on SLATE determines the degree of impacts of the external feedback on the utility of land tenure. If the dependency is high then the impact is high and vis-à-vis

Defining the rule for Learning capacity of an agent:

This has been characterised through the rage of homeostasis and the associated threshold values for activation the respective cognitive functions as well as values for self-esteem and self-consistency motives mentioned in section 2.2. For the purpose of this study we have kept the above two motives same for all the agents in order to proportionate the learning rate to homeostasis range. The characterization of the slow learning agent to fast learning agent has been done according to the following rule:.

Rule: Slow learner's deviation between maximum and minimum homeostasis of self—perception is higher. The threshold value for positive self-perception and self-knowledge perception differentiation are relatively higher while that of the negative self-perception and self-knowledge perception are relatively lower. The vis-à-vis of the above is applied for the fast learning agent. The same rule has adopted for the self-concept generalization and self-knowledge concept change and generalization.

Defining the rule of agent interactions:

There are 8 agents in the community .These agents were tagged as T_11 to T_18. Some of these agents receive periodic external positive feedbacks when they interact with external impactors. These impactors can be bankers, local politician or any other who give positive impacts. Apart from that these agents may communicate with agents in other communities

catheterized in table 3 and they were denoted in the model as T_21, T_31 and T_41 respectively.

Defining the rule for initial tenure security conditions (continuum)

It has characterized the self-images of the agents of the selected community with negative self-congruity conditions with respect to the tenure security. The agents in other communities are also, therefore, having negative land tenure security self-congruity conditions with respect to the lands within the selected community. According to the general understanding, their self-congruity conditions should be relatively lower than that of the agents living in the selected community (see annexure A for details). However, through the communication with the tenants within the community, their perception may change (See annexure B for their tenure security condition) according to the rules defined.

Defining the rule for market eviction:

Market eviction of an agent has been calculated with respect to the change of marginal utility of land rights in agents within the community 01 and that of the agents in other communities on the lands in the community 01. If the neighbouring community has less marginal utility than the agents in the community 01 then they may not face any risk of market eviction. But if the marginal utility become higher of the neighbouring community then they face great risk of eviction. The annexure A gives the characteristics of the all the agents mentioning in the above.

Testing the hypothesis:

In this simulation we intend to identify the vulnerability of market eviction and tenure security conditions of each agent within the community with the change of learning capacity of an agent in community 01. As mentioned, the learning capacity of an agent is a function of their homeostasis range and associated threshold values as well as self-esteem and self-consistency motives. We proportionate the learning rate to homeostasis range by given similar values to the self-esteem and self-consistency motives. In the second case we change the learning capacity of randomly select agent T_13 within the community 01 in order to test the hypotheses.

4. THE RESULTS AND DISCUSSION

The following figure 03 shows the marginal utility of eviction of each agents according to their learning capacity and the figure 04 shows resulting final communicational structure after 12 feedback cycles. The blue colour lines represent the communication structure within the community 01. The green line and yellow lines represent the communications with other agents and impactor, respectively. Width of the lines represents the frequent of communication.

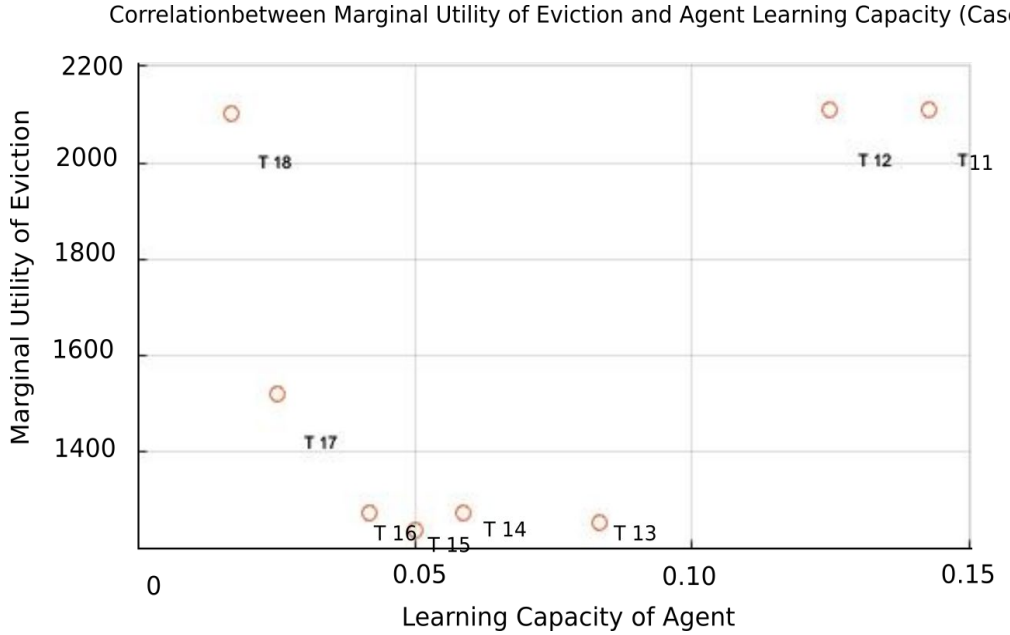

Figure 3: Agents' learning capacity and marginal utility of eviction (Case 01)

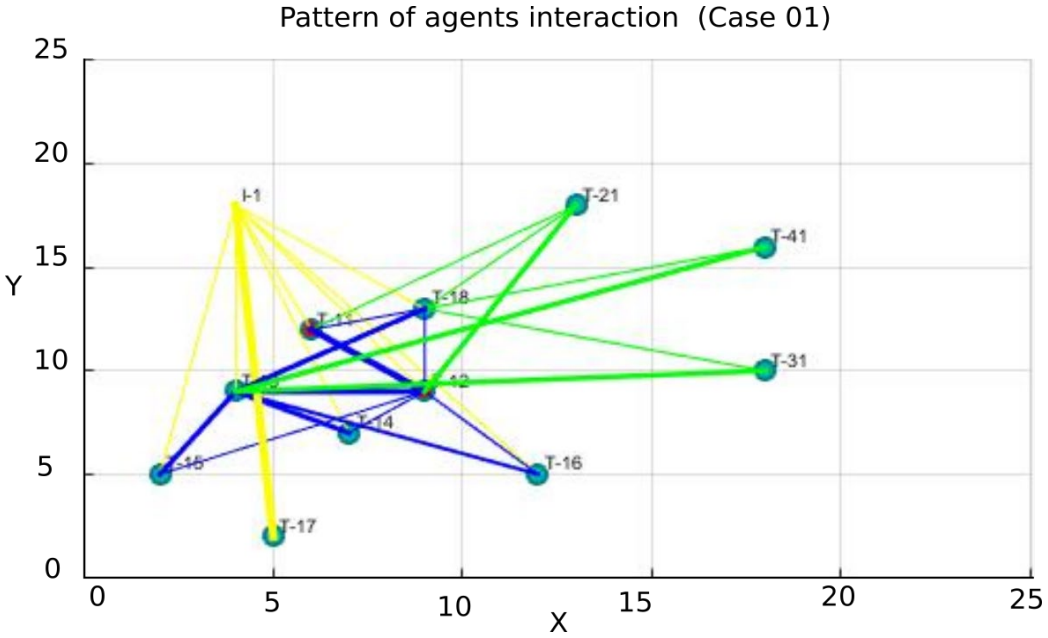

Figure 04: Emerging communicational structures (Case 01)

The following figure 05 shows level of market eviction of all agents after changing the learning rate of agent T_{13} and the figure 06 shows the resulting communication structure after 12 cycles of feedbacks.

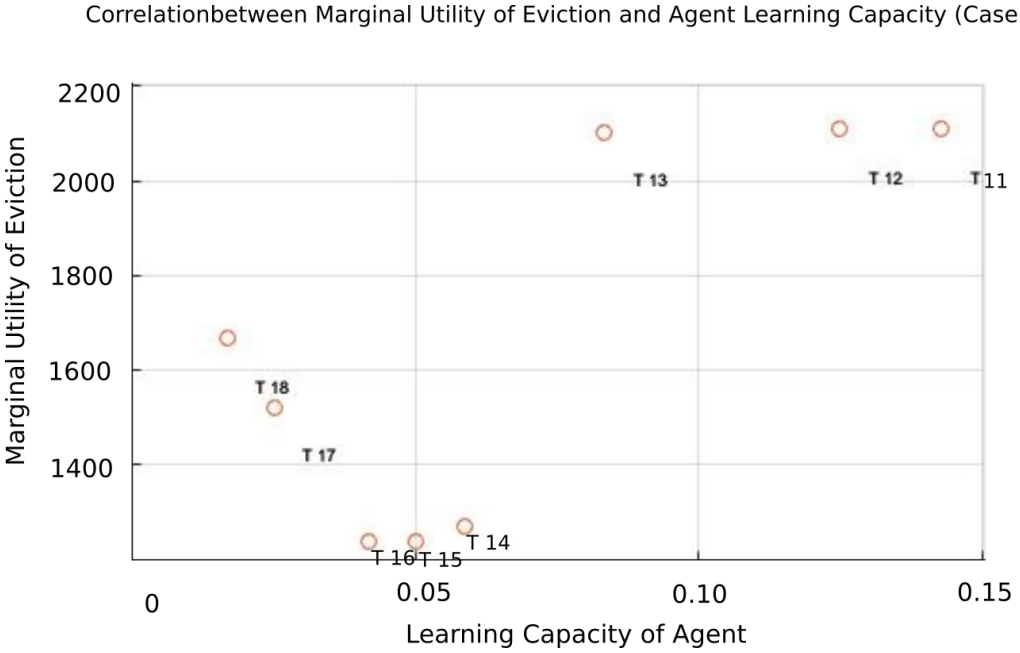

Figure 5: Agents' learning capacity and marginal utility of eviction (Case 02)

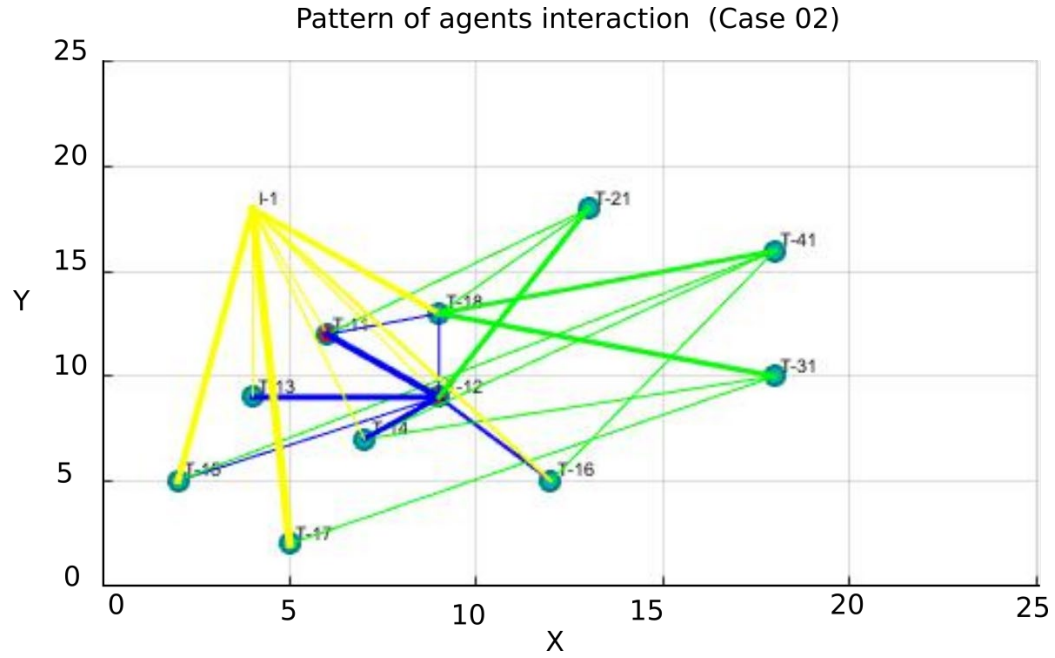

Figure 6: Emerging communicational structures (Case 02)

According to the result in figures 03 and 05 it is clear that even change of the learning properties of a single agent T-13, makes changes to utility of land rights and thus level of market eviction the agent concerned and other agents, especially agent T_18. Marginal utility of land rights, as defined in equation 04 is direct function of tenure security. Hence, change of cognitive properties of a one agent may result in change of tenure security conditions of the other agents as well.

Further, communication structures of the two cases in figure 4 and 6 have also changed. Since other parameters remain unchanged, the main reason for this change is the change of the learning property of agent T_13. This will in turn affects the feedback structure .` Therefore, tenure security of agent live in a community may not only change according to the cognitive properties of agents but also change with the communicational structural properties as well. This also confirms the total-element relation highlights in autopoiesis theories. Hence, liner approaches for analysis the tenure security dynamics may not effective on practical ground.

5. CONCLUSION

The study aims to identify the impact of cognitive and social communicational structures on the land tenure security conditions. Accordingly it hypotheses that land tenure security is a product of cognitive structures and social communicational structures. In order to test the hypotheses, it has utilize a simulation model, named TUUD simulation model. Behaviour of the agents within this model has defined according to a predefined rules derived from a rigid theoretical frame. Within the simulation, two cases have been simulated by only changing the learning property of a randomly selected agent.

Accordingly, the change of the learning properties of agent may not only change the tenure security condition of the agent concerned but it also impacts on the tenure security conditions of other agents as well as social communicational structures. This prove that land tenure security is a product of individual characteristics as well as communicational structures. Hence, tenure security is not only subjective but also depending communicational network structures as well.

Any policy making process towards the tenure security enhancement, therefore, need to incorporate the complex dynamics of the tenant-environment interactions and the resulting dynamics. However, actual implication of this agent-based simulation into the real-world practices needs in-depth study of the agent cognitive behaviours, especially with regard to dynamics of the self-images with external feedbacks. Successful integration of these dynamics into agent-based simulation modelling makes it a vital tool in effective policy making and monitoring the impacts.

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BIOGRAPHICAL NOTES

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