

The Role of Agent Based Modeling for Fulfilling Pitfalls of Urban Planning Process: Challenges and Opportunities in the Context of Sri Lanka.

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Abstract

After 30 years long ethnic crisis, Sri Lanka was recognized as a place for development due to its inherent potentials as an island nation. Currently, Colombo and main city centers are experiencing the development boom while the world has recognized countries' potentials of development in different ways. At the same time country is investigating the plausibility of adopting smart urban planning solutions.

Since Urban Planning is a broader discipline, narrowing down to physical urban planning factors and process of the same is complex in its nature. It could be dealt with only rationalize thinking and some general knowledge and scientific aspects of planning.

World is yearning for fast and smart urbanization. Thus urban planning paradigm is trying to link with other supportive paradigms such as technology, software, social science, etc. With that, new planning techniques and technologies are being invented and currently used to an affective urban planning process. As such Space Syntax, Neural network, Cellular Automata (CA) model and Agent Based Model (ABM) play a major role in that aspect.

Since 1970 ABM has been used for urban planning process in multifarious stages and for multitude of purposes. This paper mainly concentrates on the ABM as an urban planning tool and its role in the urban planning process in the Sri Lanka. Particularly to uplift the planning process and as tool of fulfilling pitfall of the process.

Key words: Agent based modeling, Planning process, Sri Lanka

1.0 INTRODUCTION TO CASE

18.2% of Sri Lankan population lived in Urban areas in year 2018 ("Annual Report 2018 | Central Bank of Sri Lanka," n.d.). It is expected to grow up to 40% by 2030 and 50% by 2050. Sri Lankan urban economy generated 70% of GDP while many secondary and tertiary level generators are boosted via urbanization process ("Annual Report 2018 | Central Bank of Sri Lanka," n.d.). Further, it is showing the sector specialization occurs with the advanced force urbanization. Thus, the Sri Lanka is expecting rapid

urbanization growth in a sustainable way and country needs to bridge gaps in the process.

At present most of the Urban Planning proposals have been emulated from other countries. There are many constraints in the conventional planning methods in today's world. Developed countries, such as Netherland, Singapore, United State and United Kingdome are adopting many high-tech developed methods for the planning. Despite having provincial level master guidelines, it is hard to see whole to part intervention, which is essential for planners to think in terms of planning aspects and to implement the same in present context of Sri Lanka. Considering the size of the country and urbanization level of the major cities, the country needs a holistic view for the urban planning and it is in a stage of adapting good practices. This is the most apt time to reevaluate the Urban Planning process, with new technologies in this digital era for achieving smart cities for the country.

Scholars have carried out research in specific aspects of the urban context in Sri Lanka. Waste management(Lakshi Karunarathne, 2015), Urban heat island (R. Emmanuel, 1995), traffic management(K. S. Weeraseskera, 2011)(A. S. Kumarage, 1997), energy management(P H Ganiesha Jayamini De Silva, 2017) are some of the examples for such studies. There is a need to integrate those outcomes into planning system for the betterment of urban living in Sri Lanka.

The issues of urban planning are common in developing countries. Due to the unavailability of transparent systems ad-hoc planning decisions are made. Political influence for the planning decisions, corruption and lack of whole to part intervention are some of the common factors to be addressed in the planning. World is moving with the new planning solutions to overcome planning problems. Some of the newest intervention paradigms are Open source platform (Zhilin et al., 2018) integrating Cellular Automata (Arnaldo Cecchini et al., 2004), (Ghafari et al., 2012) Artificial Intelligent (Reinhard Koenig, 2018) etc. The country is in right juncture to adapt new technology for the planning process and the paper takes into discourse the

role of ABM in the Sri Lankan context to smoothen the planning process.

1.1 URBAN MODELLING TRENDS IN URBAN PLANNING

Both practical and theoretical ground, since 1960 urban modelling used for urban planning process as a result of emerging data, are based on computing and methodological development. Many global challenges require appropriate model for distribute development aids, security related issues, transportation issues, migration, Invention of Geographical analysis system, Geographic information system (GIS), and statistical analysis improving the urban modelling systems.

Simplification of reality can be identified as any modelling. Further, it helps to explore, explain, understand, and forecast a given situation in Urban Planning. Urban modelling provides a new way to explore urban dynamics at different spatial levels and temporal levels without intervene to physical setting. This enables (us) to explore more on urban planning realm. Thus, urban modelling is a laboratory for urban studies which help us account with real world system. It can be used for experiment theories and proposals to sense the prediction, for better understanding on the aspects of predictions to realize the unrealized situations.

Urban modelling provides parsimonious way of doing any amount of experiment for the betterment of urban planning process. This is a better way of visually representing the complex dynamics of urban modelling where user friendly output which can easily expandable by the planner.

With the development of urban modeling, the top down conventional planning process was changed to a bottom up process. Portugal (2000) cities are more likely a biological system than a mechanical systems, further it is explained that an urban related design/products as an evolution process rather than grand designs.

As a result of planning system and software development of past three decades, urban planning modelling also developed parallel in nature and currently being used in many perspectives. Some of them are data based modelling, method based modeling, theory based modeling and philosophy based modelling using for many purposes in the planning process. The theoretical and empirical foundation of the model should be improved according to the expectation of output. Since both were equally important, there will be based factors for testing emerging complex science of the city.

2.0 WHAT IS ABM

According to Eric J. Miller (2018) there are two different ways of modelling approaches. First is the Agent-based

formulation which arguably provides an attractive implementation framework of potential flexibility for implementing behaviorally sound models of adaptive choice. The second is machine-learning methods that are well suited for exploiting big datasets in new and interesting ways. In this section the study intends to exemplify different interpretations of ABM and initiate a critical discussion in order to understand what is ABM.

Formally ABM is a computational based modelling method that has been adopted to understand, analyze, or experiment with model of agents and its environment. Liang Chen (2012) interprets ABM as a powerful tool that offers bottom-up understandings to complex consequences in decision-making and problem- solving processes, as opposed to traditional aggregated modeling approaches.

“Agents is an encapsulated computer system that is situated in some environment and that is capable of flexible, autonomous action in that environment in order to meet its designed objectives”. Wooldridge (1997)

The hallmark features of ABM are, it opens avenues for new knowledge and stir up the ability to understand dynamics of real world. While allowing to realize interaction, behavior and action emerge from agents from a computer simulation. Further, Axelrod and Tesfatsion (2006) defined about four types of ABMs: empirical understanding of situation, normative understanding, heuristic, and methodological/tools.

2.1 MAIN FEATURES OF ABM

To create an effective ABM, there are three main elements to deal with. First is the characteristic of Agent and its autonomous behavior in the environment. Second is the specification of environment and interaction of agent with environment. Last, the properties of the environment (Franziska Klügl and Ana L. C. Bazzan, 2012). Two main components of ABM can be discussed as follows:

i. Agents

Agents represent various social groups of various individuals who would act over the time with particular urban environment or the cells space. The behavior of the agents depends on its quality, how they interact on each other, react on environment factors. In the modelling itself it is hard to define the agent behavior since it depends on individual application of ABM.

Common features of the Agents are as follows(Crooks and Heppenstall, 2012),

Autonomy: Agents has their own behavior which is autonomous and the agents take independent decisions. They will act over the time and interact with other agents with time but it does not effect for their autonomy.

Heterogeneity: agent represents individual identity. Each agent has its unique attribution and certain rules according to which that they behave in the environment concerned. Active: Active features of the agent can be identified as follows:

- Agents has their specific goals to achieve.
- Agents are designed with the sense of environment.
- Agents designed to be adaptive and constructing Complex Adaptive Systems
- Agent is mobile in the mode environment.
- Agents are able to communicate/interactive extensively with the other agents.

ii. Environment

Environment is an urban space, specified area or a cell space which has its own properties enable to agent to behave in the modeling facilities. Environment can define in terms of boundaries, in terms of functions or the agent's behavior. Agent does not have universal knowledge of environment and agent has rational bounded knowledge of specific environment. The features of ABM enable to replicate social sciences researchers in simple agent based rules in micro environment to city level.

2.2 AGENT BASED MODELS FOR URBAN SYSTEMS

Cellular Automata and ABM are the latest additions for complex urban modelling. Traditionally, urban planning process, one should build from the scratch. But ABM is a preset platform to use for urban planning. There are two ways to model represent behavior.

1. Mathematical approach.
2. Cognitive framework.

The ABM has used to test two main emerging urban phenomena; they are Social sciences and traffic simulation. Key notion of ABM is individual decision making on local level interaction with land use. However, there are commonalities of different geographical phenomena as shown in figure 01. Setting rules and finding ground data is the critical task of ABM get possible model and find out validation method also unique with the modelling phenomena. Pedestrian dynamic (Crooks et al., 2015), land use changes (Crooks, 2006), urban growing (Crooks, 2006), and traffic behavior in city (Crooks et al., 2015) are some of the social science simulation tested and cycling behavior, cargo behavior, and traffic movement are some of the example for traffic related ABM. Those are some of the examples tested so far. The modelling provides a

chance to check Hypothetical situation with real time data in respect to a particular situation. Further, ABM is a tool which is used to conceptualize the complex relationship between the policies, practice and research findings.

Many dynamic aspects are involved in urban planning process. All aspects should be taken into account when considering sustainable planning solution. But in market

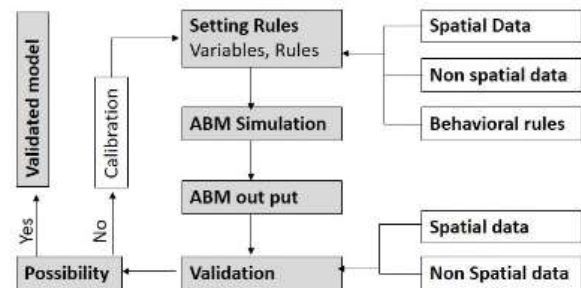


Figure 01: General Framework of ABM. (Source: Author)

scenarios and traditional scenarios of urban planning there is no mechanism to incorporate those proven planning implementations. Thus, ABM can be a solution of micro to macro urban planning occasions.

Setting rules of Agents and setting the properties of the environment is a critical task of ABM. Results will depend on the accuracy levels of modelling software, accuracy levels of the empirical data and its possibility of analysis and extracting micro aspects of it. Finding cognitive measurement or numerical value of complex social sciences is a critical task. Further, realistic modelling output of input data also depend on modeling software. There is no fixed solution as the output and will be a moderated possibility of modeling phenomena.

ABM is currently being used in number of different disciplines. Further, ABM plays a wide range phenomenon in the geographical systems. Figure 2 shows the ABM application in micro environment to urban systems and seconds to years.

There are number of ABM software which facilitate geographical ABM and some add as plugin for existing main software, such as GIS and Rhino. Java, C++ and Scala are some of the programming languages use in the ABM software.

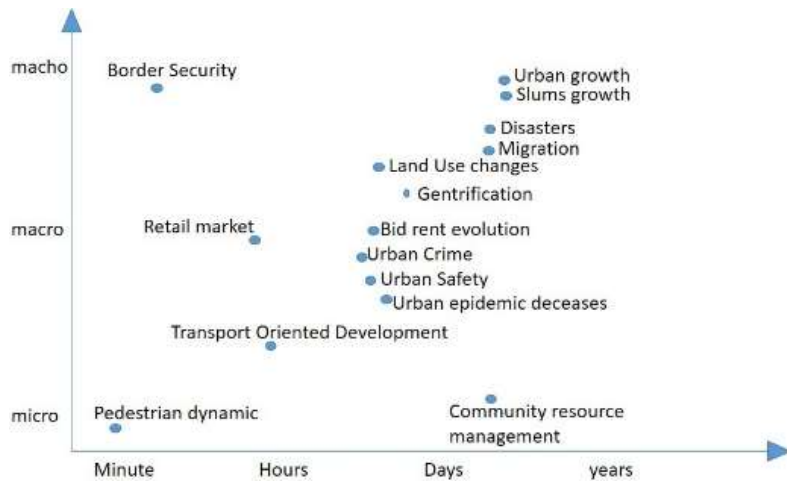
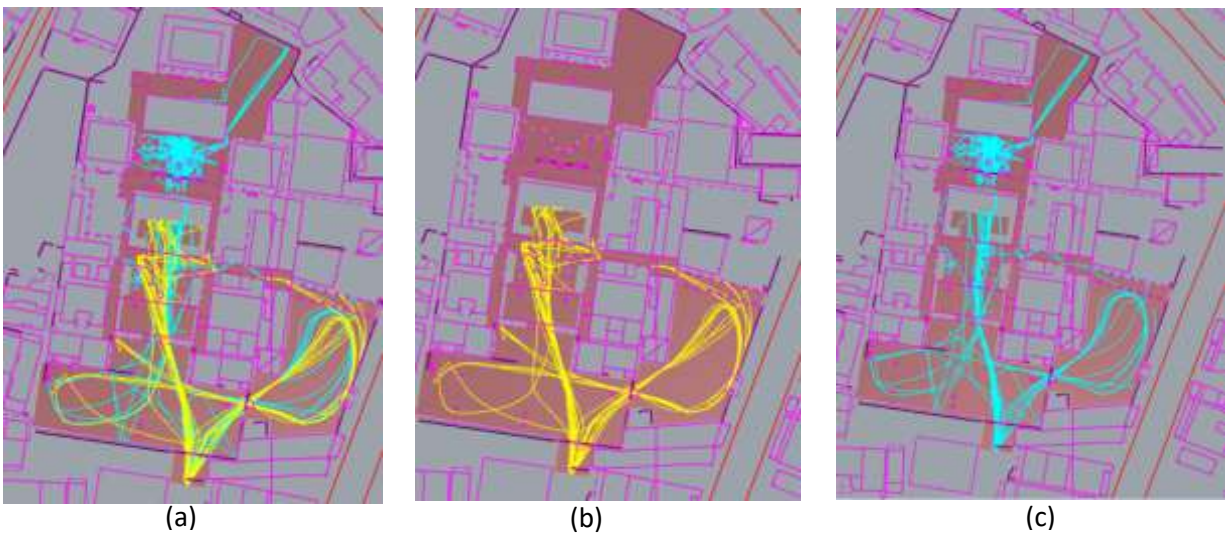


Figure 2: Scope of ABM scenarios (source: Author)



a: Overlay of all movement pattern.

b,c: Different types of user category

Figure 03: ABM of hu
according to the user

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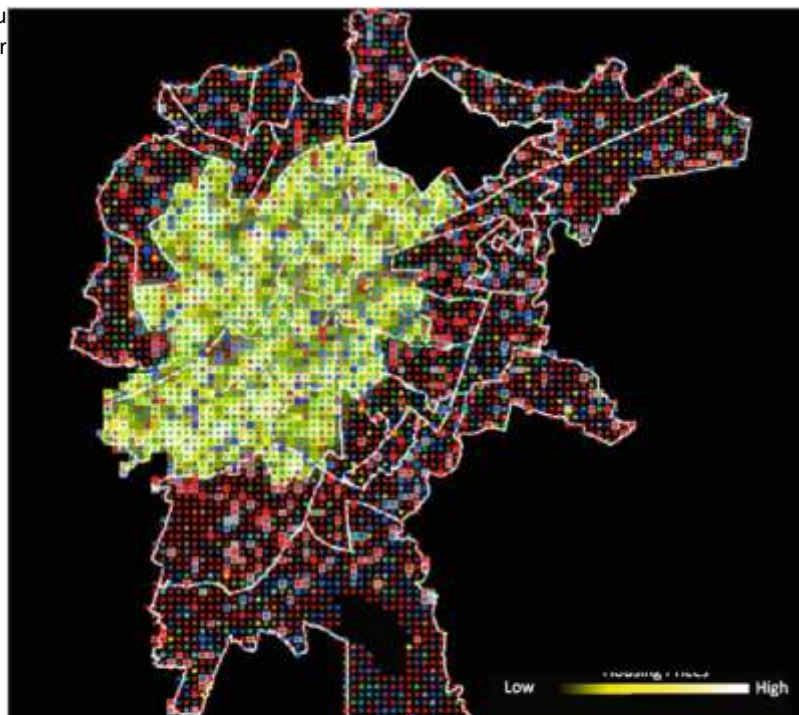


Figure 03: The spatial phenomenon of emergence of slum in the Ahemadabath city.
(Source: www.gisagents.org/2017/08/spatial-agent-based-modeling-to-explore.html)

Figure 3 depicts the examples of how ABM functions in micro environment to visualize the human movement patterns. Parameter for modelling was set according to the use in the same environment and it is clearly visible that the movement pattern is different according to the type of user in short period of time.

Figure 4 depicts the bottom up approach for slum formation modeling in Ahemedabath India which are highly dynamic in space and time with Net Logo. (Patel et al., 2018). The ABM application is example of where ABM can be utilized in wider contexts, for a long time.



Fig 04: Linking academic institution and planning related institutions (Source: Author)

2.4 CHALLENGES IN THE SYSTEM

Ability of model complex social phenomena is the greatest strength in the ABM, especially in the Geographical field. In the field, it has different parameters to deal with in same time to come up solution for such instance. Further, it can model agent as fundamental drive of the system and able to understand consequences of individual variables that can be cited as some of the opportunities in the system.

The ABM is not yet fully developed and to date it is an emerging science. Therefore, it is used in the realm of complex social science, which is developing with the time. Thus, many aspects related to ABM are still under experimental stage. But due to the above mentioned opportunities of the ABM, there is a need to find out where it suits mostly in terms of the current urban planning process.

Finding an empirical data for the model, calibration of the model depending on the situation, and validating of the outcome are some of the pending factors to clarify with the situation. Further, the model implementation or selecting right platform should have done with the collaboration of all fields of expertise which is hard at this stage since all expertise fields are still in experimental stage.

The modelling platforms provide with high degree of freedom to play in design stage. Thus, there were challenges from less experience modelers and less expertise from the field of Urban Planning. The method needs some maturity with the care of all sense to seek efficient use and to reduce the said risks of Urban Planning.

The ABM involves number of parameters to deal with. However, it is essential to comprehend these factors since these meticulous technical details hold a crucial relevance in the process, thus further research is required in this regard. Therefore, if ABM can be developed with less variables, it would be easy to implement. The modelling should be user friendly and open for anyone to access and with the provisions being available to develop the system.

3.0 CHALLENGES AND OPPORTUNITIES OF ABM IN URBAN PLANNING IN SRI LANKA

Urban Planners of Sri Lanka have been following the traditional way of planning due to the lack of technical and lack of opportunities to access and implement newest planning tools. At present, most of the projects are executed with planning ideas and opinions of foreign aided companies without any considerations of the existing urban context of the country. Specially Sri Lankan cities are operated in its inherited way, owing to this predicament some of the projects such as *Petta* floating market, *Kandy* city center and *Hambathota* new town have become failed projects. Therefore, further research should be carried out by considering the Sri Lankan urban planning context to check the quantitative and qualitative aspects. Thus, ABM can be used for such situations for checking the plausibility of new proposals with modeling existing dynamics of the context.

In urban planning context in Sri Lanka, the gap between urban research interest groups and the urban projects implementation groups are clearly visible. Comprehensive

studies are carried out in academic level but there is no link to consider them at project implementation stages. It is essential to bridge the gap between academic institutions concerned with Urban Development related agencies such as Ministry of environment, Urban Development Authority, National Building Department, National Building Research and National Physical Planning Department. Moreover, introducing the ABM platform can be used as an open access forum to meet the research groups and implementation groups for bridging the gaps. Furthermore, ABM facilitates the opportunity of testing new proposals with real ground data collected by research groups and responsible project implementation groups will look for research group data obviously with better results of the modelling.

Considering the other urbanized countries in the world, Sri Lanka is still in the process of Urbanization. Thus, this is the appropriate time to apply bottom up approach scenario. Since the background suit for trial and error on the ground as the primary cost is less compared to urbanized situation, ABM can be a good tool to practice bottom up scenarios. Further, the country situation requires critical planning intervention, which make everyone agree and contribute for the development. Therefore, country needs development boom at present. Due to high level of visualization and interpreting complex data in the ABM, it can act as arbitrator of the situation.

It is common that the political influence towards urban planning in Sri Lanka as third world country. Therefore, ABM will be a good solution to mitigate such loopholes. The modeling can rationalize and interpret the urban planning decisions. It is understood by general public since the quality of data visualization and expressiveness with the individual variables. Moreover, modeling output will be more user friendly than the statistical and technical interpretation. Hence, to avoid such situations we can use the suitable ABM simulations.

The country is going towards a digital era therefore a transformation towards a digitalize functions related when planning cities would be sensible. Thus, the method can be easily employed in the future urban context. The project like "*Bimsaviya*" which digitized the plots of land with GIS. Demography data, statics information of various aspects and CCTV for the Colombo metropolitan city is being under process which is closely supported to build an empirical data base which is directly supported the modelling systems. Thus, there is a need of attempting to prepare for the next stage which can effectively use those data bases. Further it will help to standardize the flow of collecting and data gathering process as well. ABM is an effective tool that can apply to micro context related data to urban systems related applications.

There are good archives of Urban Planning data readily available in Sri Lanka statistical department and National Physical Policy Department. Had those data converted to electronics format that would have been much easier to develop an ABM approach to use such data base effectively for the urban planning process. In future we can use them in the cases such as urban growth, land use related matters and transportation related modeling.

ABM is an effective tool for urban experiment through agent direct interaction, exchange information which can lead to new knowledge and ideas. The new knowledge can be utilized to reach new goals. That will be resultant of vibrant dynamic and efficient urban environment.

Though the ABM is a step forward in the Urban Planning, it is not recommended to fully deviate from the traditional urban planning. Since some of the rationalize thinking is still in need to select suitable measures of ABM. Thus ABM will be a good addition for the Sri Lankan context where it practice traditional urban planning systems currently. The new addition of ABM will smoothen and fulfill the pitfall of the traditional system.

4.0 CONCLUSION.

When analyzing the challenges and opportunities of ABM to Sri Lanka it is conspicuously evident that ABM can play a considerable role for the betterment of the planning process. Further, it is a new layer for the Sri Lankan planning process and the addition is better than the process depends on traditional system. The system enables unbiased rational planning depending on the ground reality.

Since ABM is an emerging science, challenges and the pitfalls of the ABM system itself should be gradually overcome. The magnitude of the application will depend on the case and the implementation which takes considerable time where we cannot use the system abrupt.

The ABM allows researcher to constructively compete for urban planning solutions in terms of testing alternative models and model systems for the specific environment. The model will emerge with the empirical data, best idea and best method developed within the virtual lab with associated research groups with execution group hand in hand.

In one hand Sri Lankan planning process is trying to overcome inherent loopholes which are facing as a third world country where the system needs to prepare for urban challenges of 21st century. The properties of ABM well match with the requirements of the country. Time to come it can be developed towards as a tool for sustainable planning aspects.

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