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# Applications of Python in Urban Planning and Smart Cities: Some Recent Developments

*1 Dr. Saikat Dalui

*1 Assistant Professor, Department of Physics, Sonamukhi College, Sonamukhi, Bankura, West Bengal, India.

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***Corresponding Author**

**Dr. Saikat Dalui**

Assistant Professor, Department of Physics, Sonamukhi College, Sonamukhi, Bankura, West Bengal, India.

**Abstract**

A smart city is where integrated urban services with advanced infrastructure such as sensors, electronic devices, networks are available following strictly the norm of sustainability. For those services, it is crucial that the city's available infrastructure, land area, weather, climate, hydrology, and air quality are accurately and quickly modelled. By quantifying energy, water, and mass fluxes, among other things, various models can simulate interactions between the urban environment and citizens' infrastructure. Today Python is used extensively by the urban planners for data analyses and numerical modelling to implement and delivery of different services to their residents. Why Python? Because Python is one of the most popular programming languages in the world, thanks to its simplified syntax that makes learning and using it very easy. Besides, it is also supported by a vast ecosystem of libraries and packages and is a powerful tool for customising architectural designs. Local government bodies like municipalities, as a component of 'smart city' endeavours and to enhance compatibility, are progressively integrating open-source software into their processes for data management, analysis, and visualization. In this paper we have documented few models/schemes based on python to automate processes and leverage real-time data for quick and informed decision-making for smart city. Those python-based schemes are mainly for identifying opportunities and scope of a project, analyzes available data of existing needs and policies in a given area/city for urban development mission.

**Keywords:** Urban Planning, Python, SuPy, Storm Reactor, City Seer-api.

## Introduction

At present around 55% of world's population lives in urban areas i.e in different cities. For India, this number is approximately 35%. This percentage is growing steadily and it is expected that by 2050 more than half of the Indian population will live in urban areas. For long it has been believed and partially proved that urbanization is necessarily beneficial for economic growth. But it cannot be taken for granted. Our cities have to overcome numerous challenges in order to realize their potential as growth engines. Again, growth without sustainability is a nightmare for near future; a good city should be safe for both the people and the environment. Here comes the concept of smart city. A smart city is defined as an urban environment that delivers a high quality of life to residents with advanced infrastructure such as sensors, electronic devices, networks while also generates economic growth. This means transform present-day urban conglomerates into citizen-friendly and environmentally sustainable living spaces with growth engine running. There are different aspects of smart city and urban planning. The digital infrastructure of smart cities generates a huge amount of data that could help us better understand operations and other significant aspects of city life. Data collection, aggregation, logic, data analysis, access, and service delivery-tasks carried out by various tools-relate to the primary technological challenges with Smart City solutions. 43% of these tools use Python for development, while 60% of them can only be accessed through the Smart City API (Application Programming Interface). Smart city services and apps are made possible by a range of smart city APIs, but the operation of these services and applications rely on architectural solutions that allow city users and operators to go from data to services, take use of data analytics, and offer services through APIs. In other words, urban planning is becoming more and more data-driven, and Python offers a strong tool for data manipulation, analysis, and visualisation for more intelligent urban planning and its implementation [1-4]. Why Python? Because Python is one of the most popular programming languages in the world, thanks to its simplified syntax that makes learning and using it very easy. Besides, it is also supported by a vast ecosystem of libraries and packages and is a powerful tool for customising architectural designs.

## Uses of Python as Urban Planning Tool

Before we elaborate programming tools for urban planning, we must recapitulate what is urban planning. According to Susan S. F., (Susan, 2014) it can be defined as the design and regulation of the uses of space that focus on the physical form, economic functions, and social impacts of the urban environment and the location of different activities within it. This general concept of urban planning framework can be described by a block diagram as shown below.

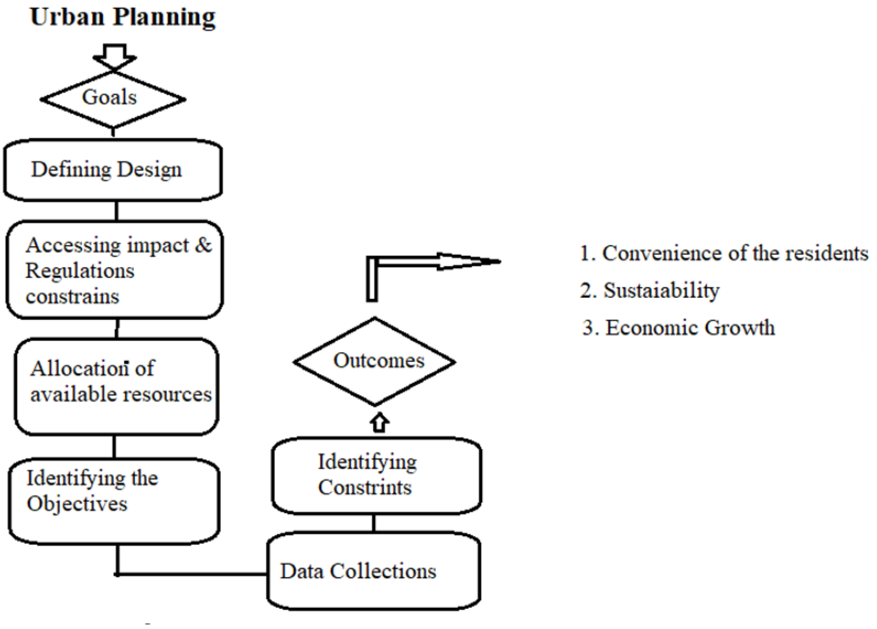
Urban Planning
Goals
Defining Design
Accessing impact & Regulations constrains
Allocation of available resources
Identifying the Objectives
Data Collections
Identifying Constrints
Outcomes
1. Convenience of the residents
2. Sustaiability
3. Economic Growth

**Fig 1:** Block diagram of a typical urban planning framework

To implement what is shown in the above block diagram, we have the tool of programming. By identifying opportunities and scope of a project, Urban Development Programming (UDP) analyzes available data of existing needs and policies in a given area/city for urban development mission [6]. This way we can achieve a consistent and effective urban development approach. In other words, using programming tools we implement urban projects from the very scratch to its fulfilment.

Recently, Surface Urban Energy and Water balance Scheme (SUEWS) [7] is a widely used urban land surface model (ULSM) to simulate urban–atmospheric interactions by quantifying the energy, water and mass fluxes. Researchers [8] found that SuPy (SUEWS in Python) which is a Python-based data stack, can be used to streamline the pre-processing, computation and post-processing for the common modelling-centred urban climate studies. Besides, deployment of SuPy via PyPI (Python Package Index) can be done with automated workflow for cross-platform compilation to make it available for all mainstream operating systems like Windows, Linux and macOS. Locations and licence information for SuPy are provided in the following link (https://doi.org/10.5281/zenodo.2574405) [8] and SUEWS (https://doi.org/10.5281/zenodo.3267306) [8], respectively. One can easily estimate Python has make the efforts of making different models for different SUEW schemes more suitable and easier compared to other available programming languages.

In an urban landscape, a reliable and cost-effective method for treating stormwater pollutants is real-time control by distribution of storm water in available sewage and treatment plants. Recently, a new water quality package named Storm Reactor is being implemented as Storm water Management Model (SWMM) which provides an open-source Python programming interface for simulating complex pollutant generation, treatment, and real-time control processes [9]. Though we are not showing any programming details in this paper; one can easily find the resources from the following link and find how effective Python is: https://github.com/kLabUM/StormReactor

Another computational package based on Python is cityseer-api. It can be applied to smart cities to analyse the street network and land usage, as well as to identify the morphological factors that contribute to vibrant neighbourhoods. In order to deliver contextually specific metrics for any given street-front position, it is supported by network-based techniques created from the ground up for localised urban analysis at the pedestrian scale [10]. Cityseer-api computes a variety of node- or segment-based network centrality techniques, mixed-use and land-use accessibility measures, and statistical aggregations. Aggregates may optionally contain network breakdown and spatial impedances to improve spatial precision. Dynamically generated aggregates are produced over the street network while taking approach direction into account. In this case Python is advantageous over other languages when we use different computational tools for geographic topology, network manipulation, and NetworkX (NetworkX), as well as the numpy stack of scientific packages. Online documentation for the above scheme is available from https://cityseer.benchmarkurbanism.com, and the Github repository is available at https://github.com/benchmark-urbanism/cityseer-api.

## Conclusions

To conclude we can say that large-scale urban data can be collected and analysed to gain valuable inputs for decision-making. We can improve efficiency, sustainability, and quality of life by predicting water distribution, traffic patterns, energy consumption and can make resource allocation with high accuracy beside optimizing urban systems and services. All these become possible by urban planning programming and Python is a very good candidate for the above job.

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