A USER INTERRACTIVE WEBGIS WEBPAGE FOR DECISION MAKING & RESOURCE ALLOCATION DURING COVID-19 PANDEMIC – A CASE STUDY FOR SOLAPUR CITY, MAHARASHTRA, INDIA

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ABSTRACT
At the end of 2019 year, an infectious disease named corona virus disease(COVID-19) was newly discovered across the globe. In Solapur City (Maharashtra, India), the Solapur Municipal Corporation (SMC) government body witnessed everyday frequent growth in positive cases for COVID-19 across the city. Location intelligence brings a great impact with better management and sustainable workflow against COVID -19. A web page for SMC Government, India has established consisting of user interactive maps and dashboard dated from 12/04/2020 on WebGIS platform providing a standard frame of reference and integrates all types of relevant data COVID -19. to aid in better visualization, understanding, and response planning for decision-makers in a rapidly changing COVID-19 environment. A system architecture is designed for the SMC government organization to visualize, query, analyze the layers, and allocate resources like COVID-19 help center, food-health supply chain, and police allocation to monitor citizens during the lockdowns. Firstly, the database schema consisting primary key, foreign key & relationship between the tables is designed and accordingly the feature layer (point & polygon) is digitized on ArcGIS Pro. Administrative boundary like city boundary and ward boundary was provided by SMC in shape file format. Ward-wise cluster density and weighted overlay analysis were carried out for the layers of COVID-19 positive cases, city population 2020, etc. A model builder was created to automate and extract the required input layers, where Analytic Hierarchy Process(AHP) is used to assign score (high, moderate, low etc.) to the ward layers. Further these input layers were published as web layers on ArcGIS online platform. A job is created where, ArcGIS Python API – Jupyter notebook python 3 is used to update COVID-19 dynamic(everyday) data to ArcGIS portal item layers. Accordingly, the layers used in maps and dashboards are updated on regularly bases. The ArcGIS JavaScript API- 4.15 and HTML5, JavaScript, and CSS are used to establish interactive web pages. An interactive Dashboard was developed using ArcGIS online rest services to retrieve information regarding active positive cases, recovered, meta data etc. for COVID-19 current status of city. Since COVID-19 positive cases in Solapur city are varying regularly i.e. increasing or decreasing daily, therefore, this WebGIS web page & Dashboard helps the government assign and allocate resources in decision-making with dynamically varying COVID-19 data. Currently, on a date, 15/10/2020 ward numbers 3 & 21 (Shahir Vasti– High risk and Gurunanak Nagar-low risk) can be visualized on WebGIS web page, and resource allocation decisions are made accordingly. These results will regularly keep updating and keep on changing with respect to Solapur city COVID-19 data.

Introduction:

Past decades before world have witnessed to several infectious disease pandemics like atleast four strains of influenza, seven waves of cholera, tuberculosis, and the human immunodeficiency virus (HIV) which accounted for the deaths of nearly 100 million people. In the current decade at the end of 2019 year, an infectious disease named corona virus disease(COVID-19) was newly discovered across the globe. In this COVID-19 disease, human can get infected if individual is within close proximity of someone already suffering individual or by touching a contaminated surface and then continuing to your mouth, eyes and nose.

In India, being a densely populated country, there is a rapid spread of COVID-19 disease. At the end of September month 2020, approximately 6.98 million positive cases and 106 thousand dead Indian citizens were registered. In India, every state has been affected by COVID-19 to greater extent. From which Maharashtra, Tamil Nadu & Gujarat states were top 3 states for having highest positive cases in India. To bring control over this rising pandemic situation, a better, systematic and conserved management was required. Various surveys, samples and COVID-19 data was collected by the government bodies across the states. Location of active COVID-19 cases were required to be mapped to understand the proximity of spread over the region. Since the positive cases were increasing vigorously, a better management practice was required to visualize and detect every single positive cases location wise.

Geographical Information System(GIS), provides a platform to visualize COVID-19 pandemic spread digitally. GIS helps to mark every corona positive cases location wise with maintaining other required attribute data. Every data in GIS is available in form of layers containing spatial (location) data and attribute (meta) data. Therefore, using this layer any individual can mark any data required to carry out any analysis or conclusion with respect to COVID-19.

Region of Study and Data:

We use Solapur City, Solapur Municipal Corporation (SMC) as the study region (Figure 1(a)). Solapur city has a population of 9.51 lakhs (2011 census), making it one of the highest populous city in Maharashtra state. The city is located in the south-western region of Maharashtra, India. The city's geographical location is 17.6599º N, 75.9064º E. In the context of COVID-19 outbreak, Solapur city witnessed a sudden increase in the corona positive cases since the first appearance of first case on April 12, 2020 and thereafter has been classified as one of the hotspot cities. To map COVID-19 pandemic, SMC were having data particularly in shape file (administrative boundaries) and excel tables (survey/ registered data)(Sec et al., 2015). Administrative boundaries consist of city boundary, ward boundary (Sec et al., 2015)etc. Whereas excel tables used to contain location of corona positive patient, age, sex, socio-economic data, other infected disease, ward number, locality, street address, building name, plot number etc.

Methodology and System Architecture:

Geo-spatial Boundary and COVID-19 GIS Layer Creation -
Looking at the problem statement, a methodology (Figure 3) was developed to achieve the results. The administrative ward and city boundary (Figure

2(a)) were digitized with symbology and label feature. The excel table containing the survey and registered data of COVID-19 needed to convert to a GIS layer format. Firstly, the excel table formatting and data standardization was done like deleting blank spaces, formatting respective data type, maintaining master table, assigning primary and foreign keys, relationship between the tables etc. After formatting and preparing schema excel table, this table was converted to GIS layer (Figure 2(d)) using its spatial data (Latitude & Longitude) of corona positive patient using add XY tool in ArcGIS pro(Concepts, 1983). Other layers like city population (Figure 2(b)) and city slum density (Figure 2(c)) were taken into consideration to identify risk zone ward wise. SMC, were having licensed version of ArcGIS online(Toms, 2015) which was used to store and retrieve the layers as portal items. Later these created and collected layers were then published as a web feature layer on ArcGIS online server. An ArcGIS rest service API (Application Protocol Interface) (Nourjou & Thomas, 2016)is created to share and retrieve the data across every platform on web.
Analytical Hierarchical Process -

During COVID-19 pandemic, city was under lockdown condition for several months to fight & prevent against the spread of disease. Since, the SMC witnessed lot of shortage of resources and man power during this lockdown. Resources and man power like food supply to poor citizen, medical facility, transportation of required goods and services, hospitals, doctors, administrative police require to monitor lockdown of city etc. A proper management and decision for resource allocation was required for this limited resources. Therefore, it was necessary to identify the risk respective to ward wise so that adequate number of resources can be allocated to the high risk ward in comparison with low risk ward. Many variables can be considered to determine risk analysis. Finally, three variables city population of 2020, slum density and corona positive patient were taken into consideration to identify risk, which was available with SMC in layer format. Weighted overlay analysis was used to identify the risk considering these three variables. In weighted overlay analysis we required to set weightage to all three variables. To assign weightages to the variable, Analytical Hierarchical Process(AHP)(Saaty, 1987) was used. From AHP (Table 1) corona positive variable got 35 percent, slum density 30 percent and city population got 25 percent out of hundred percent. Since after this analysis we could say that since COVID-19 spread human can get infected if individual is within close proximity of someone already suffering individual or by touching a contaminated surface and then continuing to your mouth, eyes and nose therefore, corona positive variable was given highest priority compared to population and slum density.
System Architecture-

Since COVID-19 data for city was varying (increasing or decreasing) day to day. So the next task was to determine such a system architecture where the column values of the published feature layer stored on ArcGIS portal as portal item should be keep updating per day. The system architecture (Figure 4) was identified to achieve automation in updating of feature layer hosted on server. ArcGIS JavaScript API 4.16 and ArcGIS Python API (Toms, 2015)is used to automate the entire process of layer updation. This updation helps user to identify the regular updates with respect to the COVID-19 data across the entire city. A master table named 'corona positive patient' was kept in one folder in file explorer. This excel table contain standard data format and the SMC officers add or update this excel table with COVID-19 information regularly. Python script is designed and created in such a way that, data present in attribute table of hosted feature layer keeps on updating with respect to the updates made in excel table by SMC officer. Therefore, user just need to update data in excel and respective updates are performed on server automatically. This updates are visualized

by SMC on dashboard and customize WebGIS webpage hosted on their integrated municipal corporation portal to allocate resource and makes decision. A python script model was developed to automate and determine weighted overlay analysis and identified risk value like very high, high, moderate (Figure1(b)) will be updated to the ward layer stored on ArcGIS online portal item(Toms, 2015). This created python job keeps updating column value of risk in ward layer published on online portal.

Visualization:

A single window visualization was required for SMC to take decision and allocate resources ward wise during this COVID-19 pandemic. Therefore, a webpage was developed consisting of several maps, customize WebGIS webpage & dashboard (Nourjou & Thomas, 2016)containing COVID-19 data for entire Solapur city. A customize WebGIS webpage (Figure 1(c)) contain user interactive maps i.e. hosted feature layers where user can select feature on map, highlight selected feature location wise, popup displaying meta data of layer info, querying layer, find address, filter feature layer, satellite base map toggle visualizes, zoom in-out etc. GIS functionality (Law & Apps, 2020)has been added to this webpage to retrieve information. A dashboard (Figure 5) contains all COVID-19 information like total number of corona positive till date, total number of death corona patient count till date, date wise bar graph consisting of corona positive cases per day, pie chart indicating statistic of all corona patient status active, dead and recovered, another pie chart indicating percentage of age group affected by COVID-19. Ward name list is provided at left top corner of dashboard("HowtomakeCOVID-19Dashboard (1)," 2020), where user can click to any ward name which dynamically reflects selection of ward in map and highlight all other features with respect to the selected ward name. A date picker is set at top right corner to select the date. When user select the particular date, all the data present on the dashboard is dynamically changed with respect to the selected date. Also, whenever the user selects any ward from map, the rest entire visualization is changed with respect to the selected ward.

Results:

The created GIS webpage helps the government assign and allocate resources in decision-making with dynamically varying COVID-19 data. Currently, on a date, 15/10/2020 ward numbers 3 & 21 (Shahir Vasti– High risk and Gurunanak Nagar-low risk) can be visualized on WebGIS web page and dashboard, and resource allocation decisions are made accordingly. These results will regularly keep updating and keep on changing with respect to Solapur city COVID-19 data.

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Table

DESIGN MATRIX

	CRITERIA COMAPRE				NORMALIZED MATRIX			CRITERIA WEIGHT		CONSISTENT VECTOR			WEIGHTED SUM	LAMDA MAX	LM	4.25
	PC	POP	SLM		PC	POP	SLM			PC	POP	SLM			CI	0.08
PC	1	3	5	PC	0.67	0.37	0.8	0.55	PC	0.55	0.83	0.64	2.41	4.37	RI	0.9
POP	0.3	1	0.25	POP	0.2	0.12	0.04	0.28	POP	0.18	0.28	0.51	1.23	4.46	CR	0.09
SLM	0.2	4	1	SLM	0.13	0.5	0.16	0.17	SLM	0.11	0.07	0.13	0.52	4.16		
SUM	1.5	8	6.25	SUM	1	1	1	1	SUM	0.84	1.18	1.28		4.25		

DECISION MATRIX

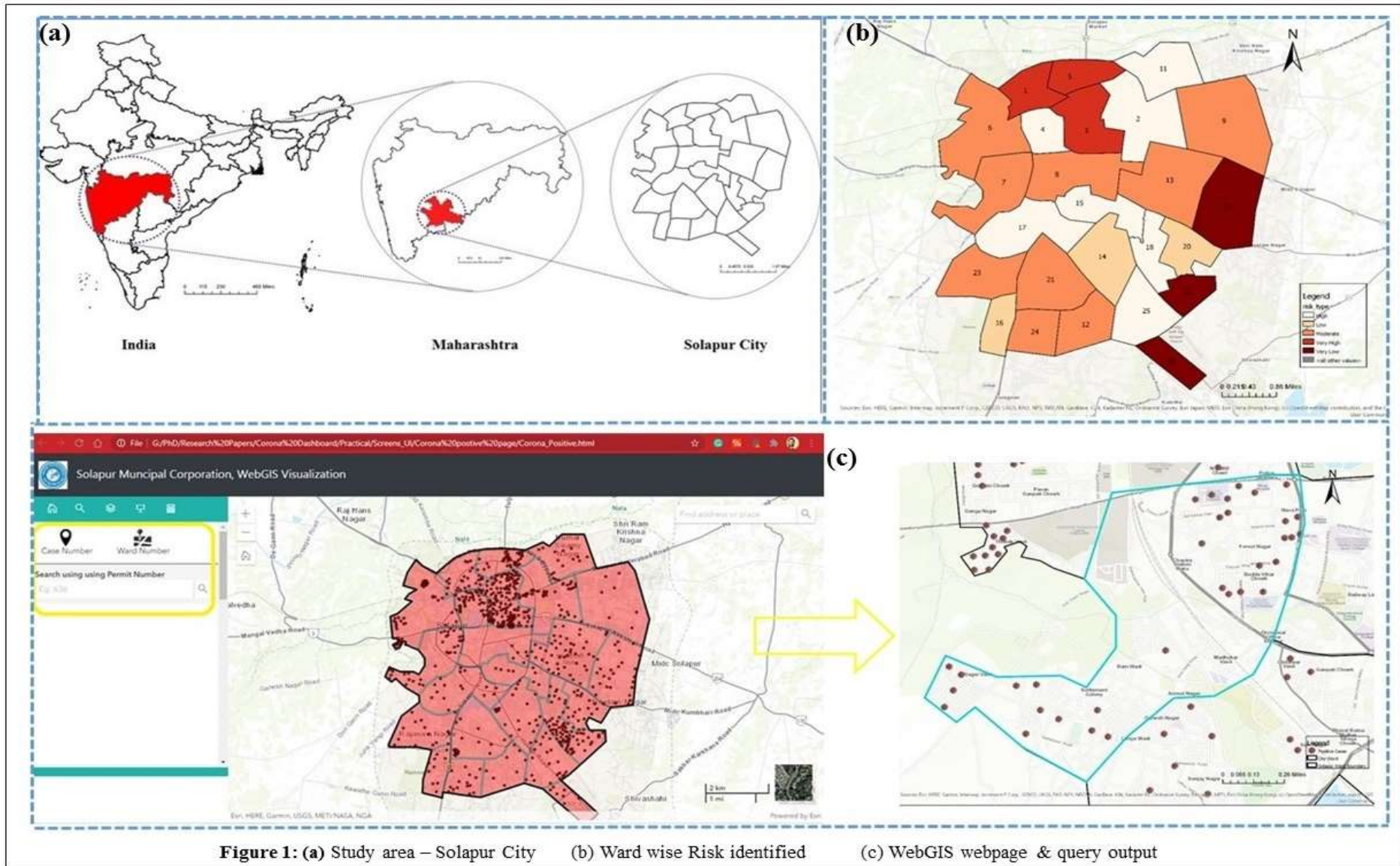|	C1	C2	C3		DECISION WEIGHT	
	PC	POP	SLM		**0.35**	High Weightage
PC	0.5	0.83	0.39		0.25	Low Weightage
POP	0.1	0.28	0.26		0.30	Moderate Weightage
SLM	0.1	0.05	0.18			

Figures

Figure 1: (a) Study area – Solapur City   (b) Ward wise Risk identified   (c) WebGIS webpage & query output
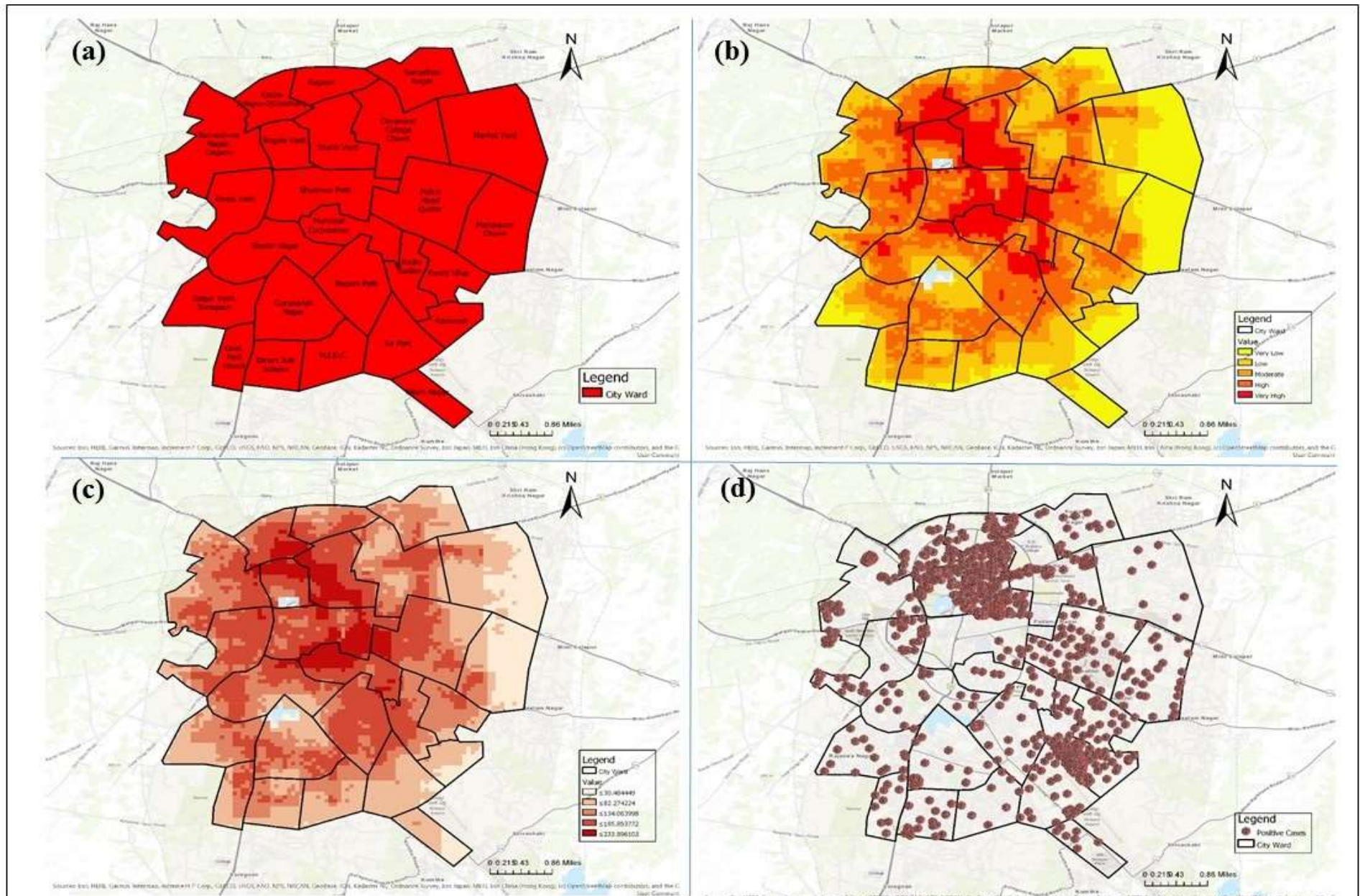
Figure 2: (a) Solapur Municipal Corporation, Ward boundary with labeled ward name. (b) Ward wise population data for 2020 year, ranged from very high value to very low value population. (c) Wad wise slum density data for 2020 year, ranging from lower value to higher value. (d) Ward wise corona positive cases for 2020 year.
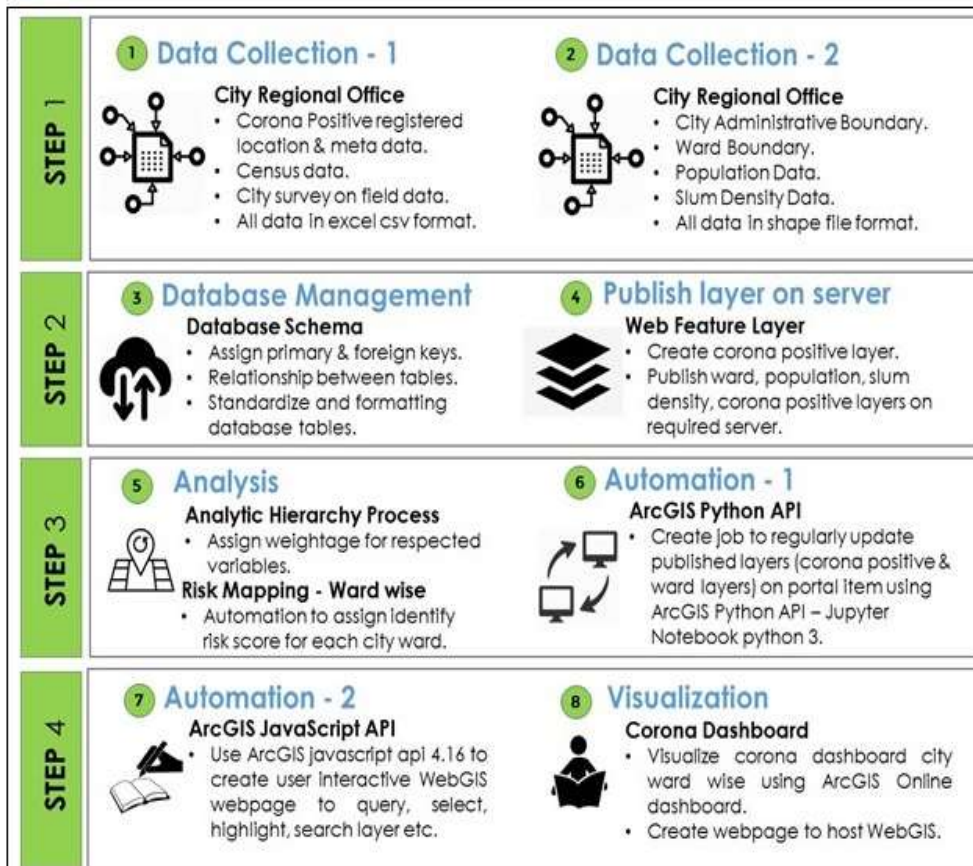
Figure 3: Overview of visualization framework. The proposed methodology consist of steps involved to get required output visualization.
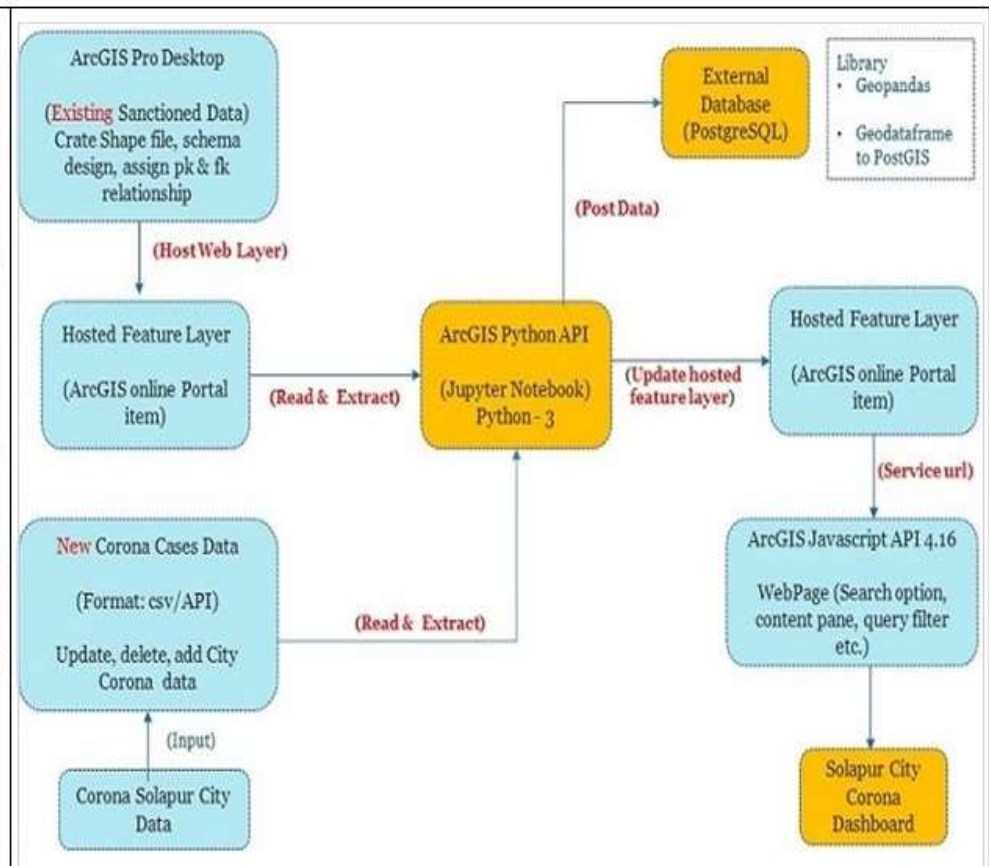

Figure 4: Overview of system architecture for automation required to update published feature layer data from ArcGIS online portal item.
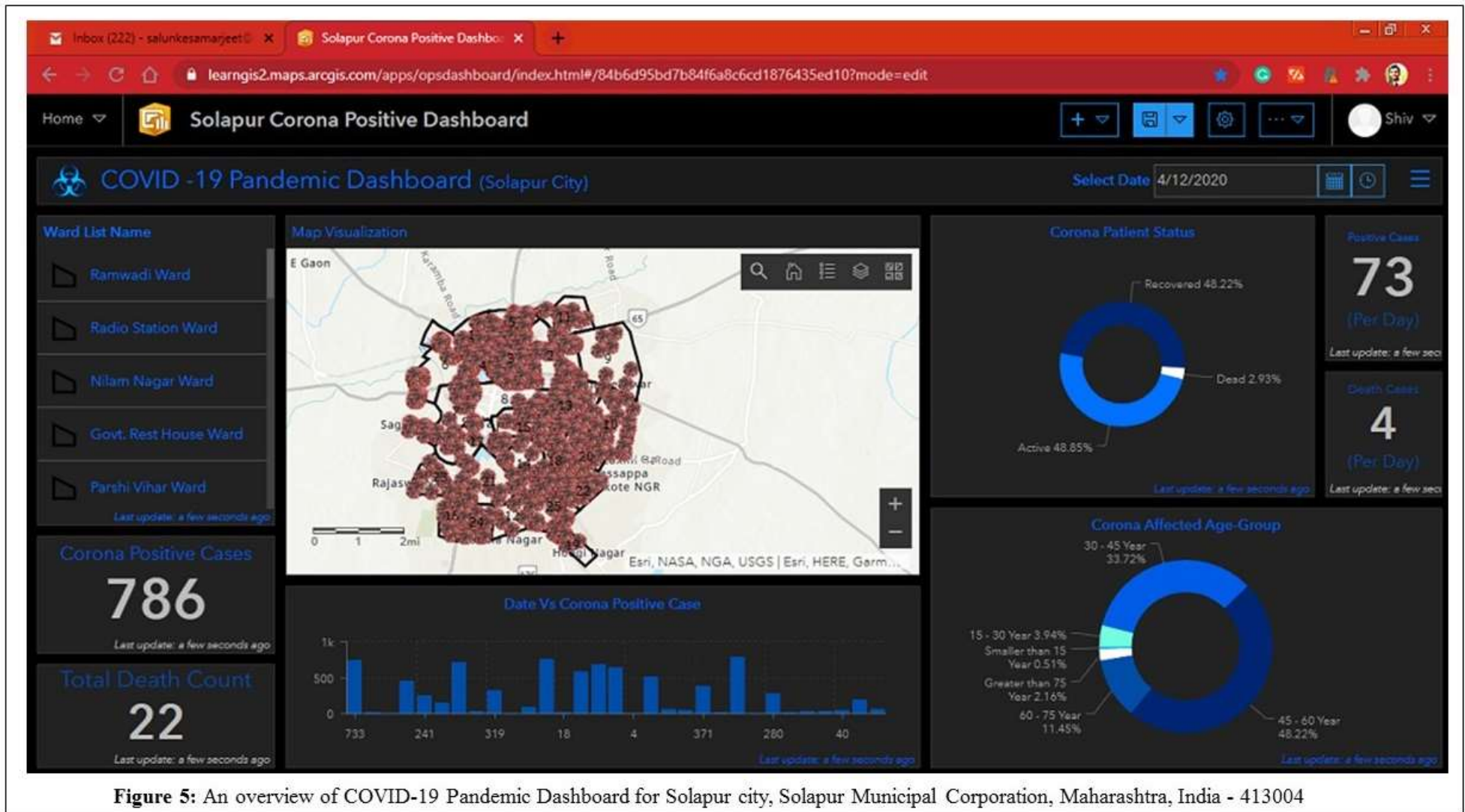
Figure 5: An overview of COVID-19 Pandemic Dashboard for Solapur city, Solapur Municipal Corporation, Maharashtra, India - 413004

Supplementary Material:

Below is the python code to update corona data for hosted feature layer of corona positive layer.

```python
# install library
! pip install pandas
! pip install geometry
! pip install datetime
! pip install shutil

# import library
from arcgis.gis import GIS
from arcgis import features
import pandas as pd

# provide ArcGIS online server url and credentials to access portal items
gis = GIS("https://solapursmc.maps.arcgis.com/home", "samarjeet.salunke_SMC")
Enter password: ABCD

# access published layer with layer id and assign variable to hosted layer
solapur_id = '38231b7cb91d47b29997e96d9cff7a82'
Solapur_layer = gis.content.get(solapur_id)

# access attribute table of published layer
Layer_table = Solapur_layer.layers[0]
Display_table = Layer_table.query()
Display_table.sdf.head()

# get spatial reference of hosted layer
cities_fset.spatial_reference

# read csv data where any update or addition of corona data, from file explorer
csv = 'D:/Samarjeet/sample1.csv'
cities_df_2 = pd.read_csv(csv)

# find overlapping data wrt case_id to update the csv data
overlap_rows = pd.merge(left = cities_fset.sdf, right = cities_df_2, how='inner', on = 'case_id')
features_for_update = []
all_features = cities_fset.features
cities_fset.spatial_reference

# import library to check and project coordinate system
from arcgis import geometry
from copy import deepcopy

# update attribute table of hosted layer wrt to updated csv table
for app_id in overlap_rows['case_id']:
    original_feature = [f for f in all_features if f.attributes['case_id'] == case_id][0]
    feature_to_be_updated = deepcopy(original_feature)
    matching_row = cities_df_2.where(cities_df_2.case_id == case_id).dropna()
    input_geometry = {'y':float(matching_row['latitude']),
    'x':float(matching_row['longitude'])}
    output_geometry = geometry.project(geometries = [input_geometry],in_sr = 4326,
    out_sr = cities_fset.spatial_reference['latestWkid'],gis = gis)
    feature_to_be_updated.geometry = output_geometry[0]
    feature_to_be_updated.attributes['longitude'] = float(matching_row['longitude'])
    feature_to_be_updated.attributes[case_id] = int(matching_row[case_id])
    feature_to_be_updated.attributes['file_no'] = matching_row['file_no'].values[0]
    feature_to_be_updated.attributes['name'] = matching_row['name'].values[0]
    feature_to_be_updated.attributes['latitude'] = float(matching_row['latitude'])
    feature_to_be_updated.attributes['date'] = matching_row['date'].values[0]
    feature_to_be_updated.attributes['cc'] = matching_row['cc'].values[0]
    feature_to_be_updated.attributes['oc'] = matching_row['oc'].values[0]
    feature_to_be_updated.attributes['pcc'] = matching_row['pcc'].values[0]
    feature_to_be_updated.attributes['status'] = matching_row['status'].values[0]
    features_for_update.append(feature_to_be_updated)
cities_flayer.edit_features(updates= features_for_update)

# once check the done updates of attribute table of hosted layer
Layer_table = Solapur_layer.layers[0]
Display_table = Layer_table.query()
Display_table.sdf.head()

# check the number of rows & coulmns of updated hosted layer
cities_fset.sdf.shape
```