デジタルデザインを自動化するための地域計画支援ツールのプロトタイピング
－静岡県裾野市の新駅計画を事例に－

Prototyping of A Citizen-oriented Regional Planning Tool to Automated Digital Design Process : A Case Study on the New Station Planning in Susono, Shizuoka Prefecture

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本論文は、地域計画プロセスに関するラフなアイデアを具体化するために、市民指向のデジタルデザイン地域計画ツールの最初のプロトタイプを示している。このツールは、カスタマイズ機能として将来の都市形態を予測するために定義された、ウェブベースの市民参加型プラットフォームの都市計画作業支援ツールの一部を構成している。地域計画の作業は、ゾーニング、自動配置、コストと効果の計算、3D モデル生成の 4 つのアクションに分かれており、地域計画のプロセスを加速し、単純化するために、地域管理者の都市計画の動きを計算に基づいたパターンにコード化することを試みている。本稿では、静岡県裾野市でのケーススタディをもとに、プロトタイプの実装について説明する。

Keywords: Regional plan, Citizen-oriented, Digital design, WebGIS
地域計画, 市民参加, デジタルデザイン, ウエブ GIS

1. Introduction

1-1 Background and related work

Citizen collaboration is an important issue in regional management work(Sugisaki, et al. 2003), especially in cases of land readjustment projects or urban redevelopment projects as it is necessary to reach an agreement with the opinion of inhabitants. Now advances in technology have changed the idea of public participation from a one-way process of citizens receiving services from the government to citizens having the power to govern autonomously through their own technical ability(Hasegawa, et al. 2019), not only in the field of urban planning but also infrastructure management(Seto and Sekimoto 2019). However, regional management or urban planning work is quite complex and professional work, tied to a considerable amount of data and policy information. At the same time, different cooperators need plenty of collaboration by departments considering many social fields. Planning work also needs to stay connected with stakeholders and citizens for their feedback, yet normally it is not an easy process for the citizen to understand the detail. Thereby, the citizen participation approach for managers usually lasts for long period. Furthermore, estimating the budget of projects is also a significant part in the preproduction phase which may affect whether the project goes ahead or not and when for the financial issues of government.

Automated urban design has been widely studied and implemented for engineering designs in order to quickly explore different design possibilities so that the designers could have a comprehensive overview and understanding of different design choices through their interaction with the computing tool. In 2012, Beirão proposed a generative urban design tool on the IDE of AutoCAD Civil 3D (Beirão 2012). Then in 2014, Dahal and Chow developed an ArcGIS toolset for automated subdivision of land parcels (Dahal and Chow 2014). Koenig and Miao, et al. also developed a new component of Grasshopper/Rhino3D for fast conceptual urban design prototypes (Koenig, et al. 2017). However, those tools are all focus only on the morphology of urban structure and mainly used for urban designers, therefore implemented based on professional designing software.

1-2 Objective and workflow

In order to improve the efficiency and simplify the working flow of regional planning work, we have developed a first prototype implementation of a citizen-oriented digital design regional planning tool. By using this tool, the detail of future form can be exhibited to citizens and stakeholders with a clear and accessible interface in a webpage, to give support for collaboration between citizen and manager. Here, we defined the manager as those who work for urban planning in regional development/redevelopment and related staff of government. Upon receiving the input of land use information, this prototype can simulate the future form of the region and cost & effect for citizens and help regional managers to do the decision making.

The goal of this implementation is to show that:

1) By using the generation pattern we can create the future urban form and 3D model based on input parameters automatically and exhibited in an intelligible interface.
2) By using the calculation pattern the predefined structure of the cost and effect calculation can export the project budget immediately.

These all can contribute to the collaboration between citizens and managers in a more efficient way. In this article, we will concentrate our attention on the second point. To illustrate the regional planning tool as we suggested above, a WebGIS-based prototype was implemented as a web application as a customized function of the digital city platform, which integrates multi-source basic spatial data of the urban area and working on compact city simulation.

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This platform is a preferential choice because it can be accessed on any PC device whenever necessary and user-friendly as our target user is citizens as well as regional managers. WebGIS is a product from the combination of Web technology and GIS technology, which makes the expression of geospatial data can be accessed by any Internet user. Recent years, WebGIS-based application has been developed and proved to support the citizen participation work and be proved effective(Manabe, et al, 2001, Ohba 2005, Karashima, et al, 2014, Hasegawa, et al. 2019).

2. Method

2-1 Form generation

In our research, we define the urban layout consists of zones, blocks, lots, and buildings. Land use zone is defined as types of the urban area allocated according to a future vision of land-use module. There are twelve categories of Land Use Zone and each of them has specifications concerning the uses of buildings(Table-1) which can be constructed in the zone, the volume and height of buildings are also controlled under provisions of the 'Building Standard Law'. The regulation of Land Use Zone is designed to prevent a mixture of buildings used for different purposes in one area, and to ensure the suitable environment for the specific type of land use (Ministry of Land, Infrastructure and Transport 2003). In order to create an interaction more friendly with non-profession, in this research, we defined the zone also concerning the uses of buildings inside but we display the zone type as their typical use such as Supermarket Zone, Residential Zone, Park Zone and so on. Referring to the regulation of building use and Floor Area Ratio & Building Coverage Ratio, we labeled each zone type with a new land use zone code. Table-2 shows how we define the land use zone code with BCR & FAR based on the regulation and real condition of Susono city, as industrial use is not designed in our study case so it is not included. Generally, BCR and FAR have the meaning of both the actual presentation of building coverage area and floor area to the site area as well as the value permitted by law for a site. In order to make a clear distinction, we define BCR/FAR as permitted value by law in this article.

Table- 1 Control of building use by land use zone in Japan(Source: Ministry of Land, Infrastructure and Transport 2003)

can be built　usually cannot be built

Examples of buildings	Category I exclusively low-rise residential zone	Category II exclusively low-rise residential zone	Category I mid/high-rise oriented residential zone	Category II mid/high-rise oriented residential zone	Category I residential zone	Category II residential zone	Quasi-residential zone	Neighborhood commercial zone	Commercial zone	Quasi-industrial zone	Industrial zone	Exclusively industrial zone	Areas with no land-use zone designation (Urbanization Control Areas are excluded)
Houses, Houses with other small scale function (store, office, etc.)													
Kindergartens, Schools (Elementary, Junior High, Senior High)													
Shrines, Temples, Churches, Clinics													
Hospitals, Universities													
Stores (mainly selling dairy commodities)/Restaurants with floor space of 150m² max. on the first or second floor (excluding※)												D	
Stores/Restaurants with floor space of 500m² max. on the first or second floor (excluding※)												D	
Stores/Restaurants not specified above (excluding※)				A	B								
Offices, etc. not specified above				A	B								
Hotels,Inns					B								
Karaoke boxes (excluding※)													
Theaters, Movie theaters (excluding※)							C						
※Theaters, Movie theaters, Stores, Restaurants, Amusement facilities and so on, with more than 10,000m² of floor area													
Bathhouses with private rooms													
Independent garage with floor space of 300m² max. on the first or second floor													
Warehouse of warehousing company, Independent garage of other types than specified above													
Auto repair shop					E	E	F	G	G				
Factory with some possibility of danger or environmental degradation													
Factory with strong possibility of danger or environmental degradation													

Note A : Must not be built on the third floor or higher. Must not exceed a floor area of 1,500m².
B : Must not exceed a floor area of 3,000m².
C : Audience seating floor area must not exceed 200m².
D : Stores and restaurants must not be built
E : Floor area must not exceed 50m².
F : Floor area must not exceed 150m².
G : Floor area must not exceed 300m².

'Block' in this research is defined as a kind of enclosed land unit surrounded by roads and consists of lots. The block size varies greatly from country to country, or even different in cities. Here, to this tool, the block size is determined as 30m-60m in length and 20m-40m in width based on the real condition of urban structure in Susono. The terms 'parcel' and 'lot' are often used with similar meaning, here in this article, 'lot' is used to describe the cadastral parcel, which belongs to a single landowner. In this sense, 'lot' is the minimum unit and undividable in our model.

Table- 2 Land use code and BCR & FAR

Land use code	BCR	FAR
R1(residential use type 1)	60%	100%
R2(residential use type 2)	60%	150%
R3(residential use type 3)	60%	200%
C1(commercial use type 1)	80%	200%
C2(commercial use type 2)	80%	400%
G(urbanization control area)	0	0

There are four steps for us to generate each component separately but at first, we need to prepare the dataset for the generation work(Table-3). All projects start from an input of the project redline and conservation area, which is initially decided by the manager and citizen in the regional master plan, as well as the basic geography information of the target site and surroundings. Here the geography information including but is not limited to the land use information, road network information, building information, nature and water information. The land use type in current land use data covers 15 categories, here we recategorize them into 1. Natural land 2. Residential land 3. Commercial land 4. Industrial land 5. Public land.

(1) Inputting basic information

The urban planning road in Japan can be classified into the national road, prefecture road, and city road based on the subordination, which is managed by different administrations, and the expenditure also covered by governments at each level. In this research we focus on the regional planning project which

Table- 3 Action & Patterns of prototype

Action & Patterns		Description
Inputting basic information		
Regional data	Current land use	From Urban Planning Basic Investigation.
	Current road network	Labeled with hierarchy and width.
	Current building	From Urban Planning Basic Investigation.
	Nature and water system	From Urban Planning Basic Investigation.
Project data	Redline	From regional master plan.
	Conservation area	Decided by regional manager.
Creating zones		
AddAxis		Create axes from the midline of reserved road.
OrthogonalAxis		Calculate axes that perpendicular to a selected axis and pass-through reference points.
GridToCell		Insert the cells as polygon by inverting from the area of axes offset with the width
Creating Blocks		
MainAxis		Choose the main axis from two option:1. the LongerLine; 2, one of lines closer to north-south orientation
AddAxis		Generates a grid of axes considering the block dimension. Offset new axes until a grid is completely filled
GridToCell		Insert the cells as polygon by inverting from the area of axes offset with the width.
Lots subdivision(Dahal & Chow,2014)		
ShortAxis		The short axis of block's minimum bounding rectangle is divided by 2.
LongAxis		The long axis of block's minimum bounding rectangle is divided by user-assigned value of lot width.
Creating 3D building		
BuildShape		Scaling the lot polygon with the middle of the feature as anchor and used BCR as the scale.
AddHeight		Creating cuboid based on building shape with the height of each building.

is usually carried by local government, so we set the national road and prefecture road as reserved elements in the target site, and will be the derivation of our design process. The width and structure of road are stipulated in road law varies by road hierarchy and region hierarchy and also consider with the landform and other factors. In order to simplify our model, we defined the road system has 4 hierarchies: *level_1*(16meter), *level_2*(14meter), *level_3*(10meter), *level_4*(6meter). The width of road described here includes the width of components such as car lanes, bicycle path, median strip and sidewalk. As the road structure is not involved in this research so each road is only labeled with its hierarchy and width.

(2) Creating zones:

AddAxis firstly creates axes from the midline of reserved road, which usually be national road or prefecture road, as line entities. And the intersection point of surrounding road and target site is recognized as point entities. OrthogonalAxis calculate axes that perpendicular to selected line entities and pass-through selected reference point entities to build an axes grid. And then zones created by this grid. As each axis represents a road, so it is equipped with a pseudo width. GridToCell inserts the zone cells as polygon by inverting from the area of main axes offset with the width.

(3) Creating blocks:

Here in our prototype, we choose the grid type of structure as the basic region morphology. Two steps are created to develop a grid road network. MainAxis determines the main axis from two option: 1.the longer line, 2.one of lines closer to north-south orientation. AddAxis creates axes from offsetting the main axis by block dimension until a grid is completely filled. Then GridToCell inserts the block cells in the same way as zone.

(4) Lots subdivision:

The location and design of a subdivision are driven by developers' motivation for profit and individual choices of homebuyers (Bowman, Thompson and Tyndall 2012). The decision about the shape and size of lots, width and tortuosity of streets, built density, and spaces for other amenities is made based on technical strategies often guided by heuristics and best practices, local subdivision ordinances, and homeowner preferences (Schmitz 2004). While as a digital design tool, we referred to the method of a Parcel-Divider Tool developed by Dahal and Chow (2014). The minimum bounding rectangle(MBR) of the block cell is created first and then ShortAxis divide the short axis of the MBR by 2, LongAxis divide the long axis of MBR by a user-assigned value, which can decide the rough size of most lots. Certainly, some adjustments need to be done to prevent the tiny lot.

(5) 3D model generation

In this prototype, the 3D model only consists of 3D building presented in the form of a cuboid and locate intermediately, regardless of the building form restricted by the height restriction policy(Watanabe, et al, 2017). BuildShape firstly creates a shape of building coverage area by scaling the lot polygon with the middle of the feature as the anchor and used BCR as the scale. The AddHeight creates the cuboid based on the building coverage shape with the height of each building.

2-2 Future land use simulation model

This model works on simulating the distribution of future land use on lot cells in Action 3. In the previous actions, we have created zone cells, determined the zone type, created block cells and determined the land use allocation in each block. Then in Action 3, after the subdivision process, lot cells are created and labeled with land use zone code. As we know, the land use zone is designed considering the use of building inside and the regulation may lead to a difference of components. The land use composition in the existing urbanization promotion area is analyzed. In each land use zone, 5 types of land use are randomly distributed based on the ratio from the result shown in Table-4.

Table- 4 Proportion of land use types in different land use zone types

Land use zone type(FAR/BCR)	Nature land	Residential land	Commercial land	Industrial land	Public land
R1(100/60)	22.77%	59.78%	5.65%	0.00%	11.80%
R2(150/60)	30.51%	54.38%	3.11%	1.52%	10.48%
R3(200/60)	18.67%	49.45%	11.07%	3.54%	17.27%
C1(200/80)	3.51%	45.22%	25.50%	0.00%	25.77%
C2(400/80)	0.22%	17.94%	73.01%	0.00%	8.82%

Furthermore, the BCR and FAR we defined means a permitted value rather than the BCR and FAR in use. Thus the parameter α and β are proposed as the value indicating the utilization rate of building in the lot. This value can reflect an equilibrium of the land price and construction cost, as well as the building height regulation. Generally, in the metropolitan area with expensive land price compare to construction cost, the landowner will build the housing as large as possible for financial rationality while in local cities the condition may be different. The data from the '2018 National housing and land survey' also demonstrates a discrepancy in the utilization rate of building area for different prefectures(Fig-1). Thus, the used building coverage area(u_BCA_i) and used floor area(u_FA_i) in lot *i* will be calculated as.

$$u\_BCA_i = \alpha * A_i * BCR_i$$
$$u\_FA_i = \beta * A_i * FAR_i$$

Here the A_i shows the area of lot *i* and the BCR_i/FAR_i show the permitted building coverage ratio/floor area ratio of lot *i*. α and β are two parameters show the utilization rate of BCR/FAR. To estimate the value of α and β, the analysis of current status in the target city is necessary. In our case study, we calculated the ratio of building coverage area to site area and floor area to site area in different kinds of land use type within urbanization promotion area in Susono city using the land use data and building data, the result shows $\alpha = 0.5, \beta = 0.5$ in residential land and commercial land while $\alpha = 0.3, \beta = 0.3$ in public land, $\alpha = 0, \beta = 0$ in natural land, $\alpha = 0.25, \beta = 0.25$ in industrial land.

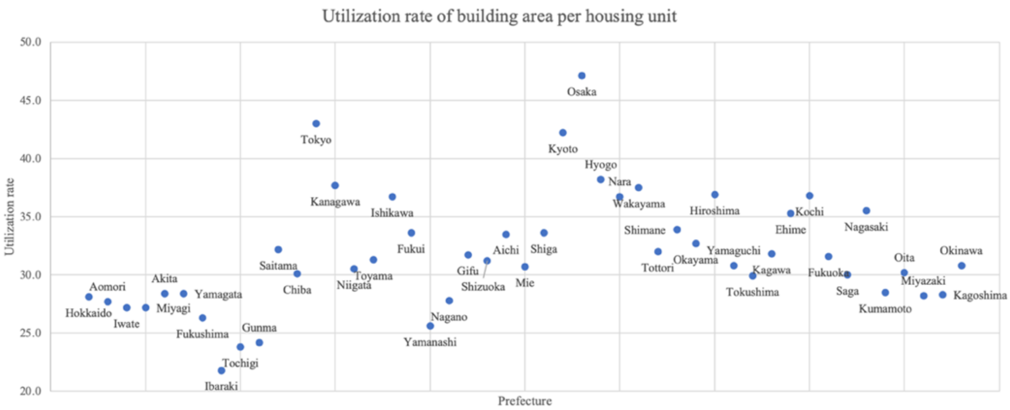

Figure- 1 Utilization rate of building area per housing unit (Source: 2018 National house and land survey)

2-3 Cost & effect calculation model

The cost & effect calculation model works in Action 3, after land use type and used BCA/FA has been simulated in the previous step. The workflow of calculation module is presented in Fig-2 with the data used for estimating the indicators in the model(Table-5) and the method of calculation in each substep(Table-7).

Table- 5 Data source of the indicators

Indicator	Data name and year	Data source
c_p	Building starts data(2019)	Ministry of Land, Infrastructure, Transport and Tourism.
clp_k, flp_i	Real estate transaction-price search data(2009-2019)	Ministry of Land, Infrastructure, Transport and Tourism, Land General Information System.
σ_j, σ	Table of standards for certifying the tax base price of newly constructed buildings(2021)	Ministry of Internal Affairs and Communications, ShizuokaDistrict Legal Affairs Bureau.
a_h	Population and households of Japan, Population census(2015)	Statistics Bureau of Japan.
α, β	Urban planning basic investigation(2016)	Urban Affairs Bureau, Transportation Infrastructure Department, Shizuoka Prefecture

To the calculation of building construction cost, c_p stands for the unit construction price of building from the 'Building Starts Survey' but the construction cost in the survey reveals a set price rather than the actual cost. And in addition to the building cost of architecture, there are several additional costs like surveying and mapping that should be included (Ministry of Land, Infrastructure, Transport and Tourism n.d.). Thus, we set a parameter γ to correct this price. Here, based on the correction survey from the 'Building Start Survey' and experience of additional cost, we set this parameter as 1.1.

The current unit land price clp_k is estimated from the 'Real Estate Transaction-price Search Data'. The future land price is estimated based on a land price estimation model. We created this model using the 'Real Estate Transaction-price Search Data' for 10 years(2009-2019). The method of modeling is multi linear regression, 'Distance to station(min)', 'Site area(m^2)', 'Width of adjacent road(m)', 'FAR', 'Frontage(m)' are chosen as independent variables and the adjusted R-squared of the model is 0.63.

2-4 Future population model

In the future population model, future living population is simulated based on the population-household type aggregation data and living space data from the "Population Census Survey" in 2012, both of them are on a prefecture base. Table-6 exhibits the data of Shizuoka prefecture as an example. In this step, lots are divided into the residential part and non-residential part. We assume citizens only live in residential land. For those lots in residential use, 7 types of households are randomly distributed based on the ratio from the census. The future living population(POP_i) in lot *i* will be calculated as:

$$POP_i = \frac{u\_FA_i}{a_h} \cdot HT_i$$

Here the a_h shows the living space for different types of household, HT_i shows the household type of lot *i*.

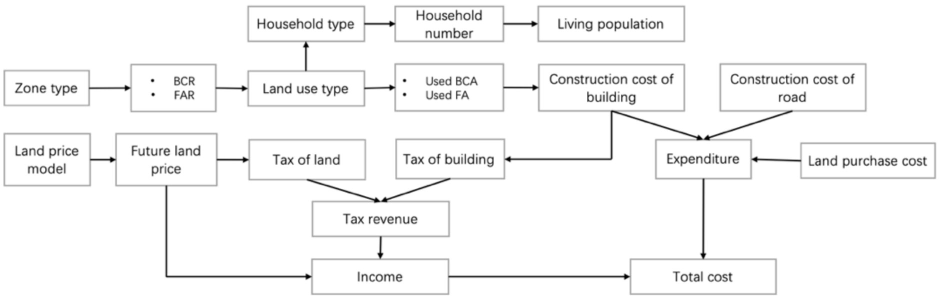

Figure- 2 Work flow of calculation pattern

Table- 7 The proportion of household types and living space(Shizuoka prefecture)

Household type (person/household)	**1**	**2**	**3**	**4**	**5**	**6**	**≥7**
Proportion	25.66%	27.31%	19.8%	15.79%	6.52%	3.24%	1.68%
Living space(m²)	39.48	60.17	64.44	68.15	75.52	88.32	97.86

Table- 6 Calculation method in each substep.

Name	**Formula**	**Description**
Road construction cost	$CC_R = cr_p \cdot RA$	cr_p: unit price of road construction(10000yen/m²). RA: area of road(m²).
Building construction cost	$CC_i = c_p \cdot U\_FA_i \cdot \gamma$	c_p: unit price of building construction(10000yen/m²). γ is a correction parameter.
Building sale price	$BSP_i = CC_i \cdot \mu$	μ: sale parameter(usually is 0.7)
Current land price	$CLP = \sum clp_k \cdot A_k$	clp_k: unit land price of land use type k (10000yen/m²). A_k: area of land use type k(m²).
Current building price	$CBP = \sum c_p \cdot \mathrm{FA}_j \cdot \sigma_j$	FA_j: floor area of building j(m²). σ_j: correction rate for price reduction over time of building j.
Future land price	$flp_i = a + b \cdot D_i + c \cdot A_i + d \cdot FAR_i + e \cdot W_i$ $FLP_i = flp_i \cdot A_i$	flp_i: unit land price of lot i (10000yen/m²). D_i: time to nearest station (min). A_i: area of lot i (m²). W_i: the width of road adjacent to lot i(m).
Current property tax	$CPT = CLP \cdot \varphi \cdot \omega \cdot r_p + CBP \cdot r_p$	r_p: property tax rate. $\varphi = 0.9$, price correction parameter. $\omega = 0.7$, price correction parameter.
Future property tax	For residential land: When $A_i < \theta$: $FLPT_i = \frac{1}{6} \cdot FLP_i \cdot \varphi \cdot \omega \cdot r_p$ When $A_i \geq \theta$: $FLPT_i = \frac{1}{6} \cdot flp_i \cdot \theta \cdot \varphi \cdot \omega \cdot r_p + \frac{1}{3} \cdot flp_i \cdot (A_i - \theta) \cdot \varphi \cdot \omega \cdot r_p$ When $u\ FA_i < \varepsilon$: $FBPT_i = \frac{1}{2} \cdot CC_i \cdot r_p$ When $u\ FA_i \geq \varepsilon$: $FBPT_i = CC_i \cdot r_p - \frac{1}{2} \cdot \varepsilon \cdot c_p \cdot \gamma \cdot r_p$ For other land use type: $FLPT_i = FLP_i \cdot \varphi \cdot \omega \cdot r_p$ $FBPT_i = CC_i \cdot r_p$ $FPT_i = FLPT_i + FBPT_i$	$\theta = 200$ in Susono, tax preferential land area. $\varepsilon = 120$ in Susono, tax preferential floor area. $FLPT_i$: future property tax of land for lot i. $FBPT_i$: future property tax of building for lot i.
Future urban planning tax	For residential land: When $A_i < \theta$: $FLUT_i = \frac{1}{3} \cdot FLP_i \cdot \varphi \cdot \omega \cdot r_u$ When $A_i \geq \theta$: $FLUT_i = \frac{1}{3} \cdot flp_i \cdot \theta \cdot \varphi \cdot \omega \cdot r_u + \frac{2}{3} \cdot flp_i \cdot (A_i - \theta) \cdot \varphi \cdot \omega \cdot r_u$ For other land use type: $FLUT_i = FLP_i \cdot \varphi \cdot \omega \cdot r_u$ $FBUT_i = CC_i \cdot r_u \cdot \sigma$ $FUT_i = FLUT_i + FBUT_i$	r_u: urban planning tax rate. σ: correction rate for price reduction over time.

3 Result of case study

Now, our prototype has been applied to a real project case in Susono city. In the ‘Fukara grand design book(2020)’, the regional master plan and zoning of a new Fukara station have been proposed based on the previous workshop with habitant. Therefore, the case study implements with the input of information from the master plan and zoning. Here shows the form result by the tool interface and calculation result.

3.1 The interface of the prototype

On the top page of the tool website, there is an action button and a basic map of the site area including the current road network, building information, and POI. The page for a new station project in Susono, Shizuoka prefecture, is shown as the case study of our prototype in Fig-3a. Action 1: Zoning can be launched with a click of “自動設定” button. Next, zones appear with their zone type in different colors. Users can change the zone type by a click of each zone area. Here, based on the regional master plan, we set 11 zone types. Users can click the “自動作成” button to start the Action 2: Automatically locate. The new block form is presented like Fig-3b. In this action, users can input the ratio of different land use by click each block area. About the land use ratio, we have the default settings so users can only change wherever they want to simulate their idea. Then, by clicking the “自動配置” button, the result of Action 3: Automatic placement of lots will be shown. In this action, a cost & effect calculation function is added thus by clicking each lot area, users can see the detailed information of each lot, including basic lot information, construction cost, future population and so on. Here, the building coverage ratio and floor area ratio can also be adjusted by users to simulate the cost & effect result in different situations. At last, by clicking the “三次元表示” button, users can get a view of the 3D model like Fig-3d.

Figure- 3 Interface of the prototype(a: Action1, b: Action 2, c: Action 3, d: Action 4)

3.2 Result of cost & effect calculation

For the cost and effect analysis of the urban development project, we assume the project expenditure consists of the land purchase cost and construction cost, while construction cost includes road construction cost and public building construction cost. The project income comes from the sales of land, as well as the tax revenue growth after the project. Thus the project cost is equal to the difference of income and expenditure. As the tax revenue is an annual income it is presented separately. And the future living population is regarded as the project effect. In order to exclude the influence of model randomness, an iterative test was run to check the result of our calculation model. Fig-4 displays the change of maximum and minimum value of project cost, tax revenue and future living population, which indicate that the range of result stabilized after 800 iterations. And with the initial setting described above, the result suggests in our case study the project cost is in the range of paying 2.14 billion yen to earning 676.68 million yen. The tax revenue of the first year is in the range of 380.27 million yen to 431.51 million yen. And the future living population is in the range of 1825 to 2787 people. Fig-5 presents the distribution of the project budget and a linear-regression analysis indicates the project cost is negatively correlated with expenditure which demonstrates the project cost highly depends on the volume of the public-use building. On the other hand, there is no significant correlation between the project cost and the tax revenue. However, it can not be figured out as “high investment without high return” for urban development projects as we only count two kinds of municipal tax while the value of development will also reflect on other social fields such as regional economic growth and consumption stimulation.

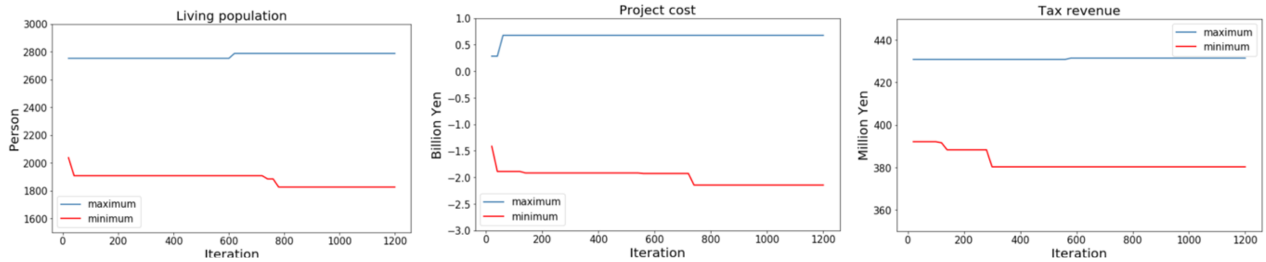

Figure- 4 The result of iterative test

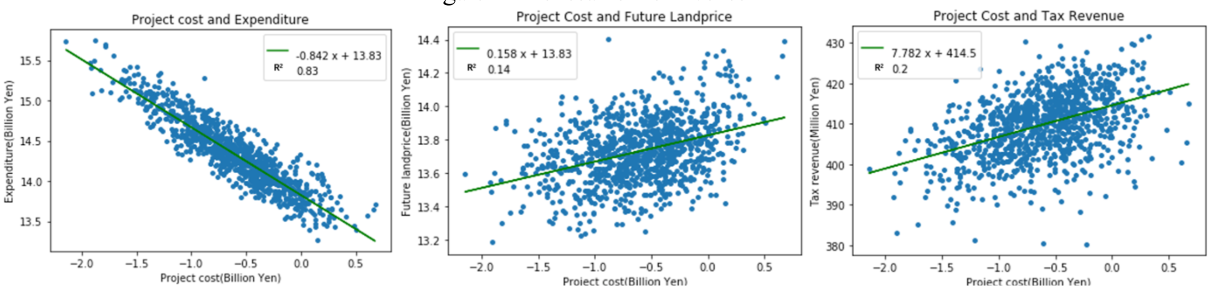

Figure- 5 Linear regression examination

4 Discussion and next step

In this article, a web-based prototype of a citizen-oriented digital design regional planning tool is proposed, it is implemented in a real urban development project as a case study. The tool contains a generation module to create the future urban form and 3D model and a calculation module to export the project cost & effect at the same time. This tool can be useful for both regional managers and citizens as the latter can get a real future form of their community while the former can receive the budget under different scenarios as well as the feedback from citizens.

Nevertheless, the proposed tool has some limitations and can be benefitted from further enhancement. In the generation module, only a grid type of street structure is provided in our prototype while the urban structure is not so monotonous displaying in one performance. In the future, multiple division and subdivision style should be offered to match the geometric and locational attributes of land selected for development. On the other hand, the effect of a regional development case is complicated related to multiple fiscal and policy issues. Based on this prototype, new factors, controls and functions need to be progressively added in the future to obtain complex programs.

Also, this tool is designed as citizen-oriented production, it will be valuable to practice with regional managers and try out in citizen collaboration occasions for testing the effectiveness and getting feedbacks. We plan to put it into real citizen collaboration occasions in Susono city and get feedbacks from residents and managers in the near future.

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