GIS-based Forecast of Landscape Changes with the Ito Land Readjustment Project

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Abstract: The purpose of the present research is to attempt consolidation of geographic information into the GIS regarding the Ito Land Readjustment Project presently being implemented in northern Kyushu in Japan, and forecast the landscape changes before/after comparison of the project. First, the topographic map, project plan, 50-meter mesh digital map (elevation), aerial photograph, PFM, land use map, land use zone plan, district plan and other geographic information of the project district were collected from various sources and systematized. Thereafter the data were aggregated using ArcGIS. Next, building and structure data before and after the project were prepared and height data of these buildings and structures were combined with the land elevation data. Then, the major view point fields in the district were selected, to examine the extent of the change of the visibility areas from these view point fields before and after the project. Moreover, focusing on the mountains in the visibility areas, we forecasted how much the visibility area of the mountains would decrease at each view point field after construction of the buildings and structures in the project implementation. Finally, we showed 3-D images of the project district using ArcScene.

Key-words: GIS, Land Readjustment Project, Visibility Area, 3-D Animation

1. Introduction

Land readjustment is a typical urban development and improvement method in Japan. It has been employed in many areas across the country to cope with diverse issues throughout the period from prewar and postwar days up to today.

Presently a land readjustment project is under way at Ito district in the West Ward of Fukuoka City located in the northern part of Kyushu, Japan. Ito district should be developed to serve as a core of the western part of Fukuoka City. In the 7th Master Plan of Fukuoka City, the district, along with Kyushu University's new campus, is designated as a new hub for urban development in the western part of the City. Hence, the district needs to be provided with adequate urban functions including transportation, commercial, residential, and public facilities. Besides, the district is required to incorporate its rich natural environment, historic heritages and other marked features in its development and to be a fitting gateway to the new campus of Kyushu University.

There is a growing public interest in urban landscapes in Japan recently. An aesthetically pleasing landscape is an indispensable element in urban development of the coming age, as it creates a rich and comfortable living environment and helps activate the area with enhanced individuality and charm. Reflecting these circumstances, laws on landscape, urban green spaces, and outdoor advertisements went into effect in December 2004.

The purpose of the present research is to study how the landscape of Ito district would change with implementation of the land readjustment project. Specifically, we set several view point fields within the project area, and compare, using a GIS, the extent of visibility areas and mountain range skyline visible before and after the project from these view point fields. In addition, the pre-project and post-project cityscapes of Ito district are presented in 3-dimensional animations to compare.

2. Overview of Ito District and Its Environs

Ito district is at the base of the Itoshima Peninsula which lies between the Sea of Genkai to the north and the Sefuri Mountains to the south. The peninsula is surrounded by rich natural environments with a beautiful coastline along the contour and lush green forests at the foot of mountains to the south. In the environs of Ito district, there are projects to provide facilities and spaces that allow people to commune with and enjoy nature such as swimming beaches, deep-sea fishing parks, hiking trails, and campground.

Ito district and its environs are spotted by sites of historic importance including Urio and Higushi Shell Mounds from the Jomon Period and Nagahama and Imazu Shell Mounds from the early Yayoi Period. Large keyhole-shaped ancient tomb mounds have also been found in the area around Ito district, of which Otsuka and Yamanohana Tomb Mounds are located in the Land Readjustment Project area.

The Ito Land Readjustment Project covers the area inside the line in Fig. 1 below and construction area is roughly 130.4 hectares (322.23 acres). The project is being implemented by Fukuoka City with the implementation period being 23 years from 1997 to 2010. Presently land preparation is being carried out.

The district land was used primarily for agriculture before the project. Under the project, it is planned that commercial facilities will stand around a new station to be constructed for JR Chikuhi Line with residential area extending peripherally. The two ancient tomb mound sites will be developed into parks. In addition, construction of greenways and an elementary school is planned in the project to create a life-enriching environment.

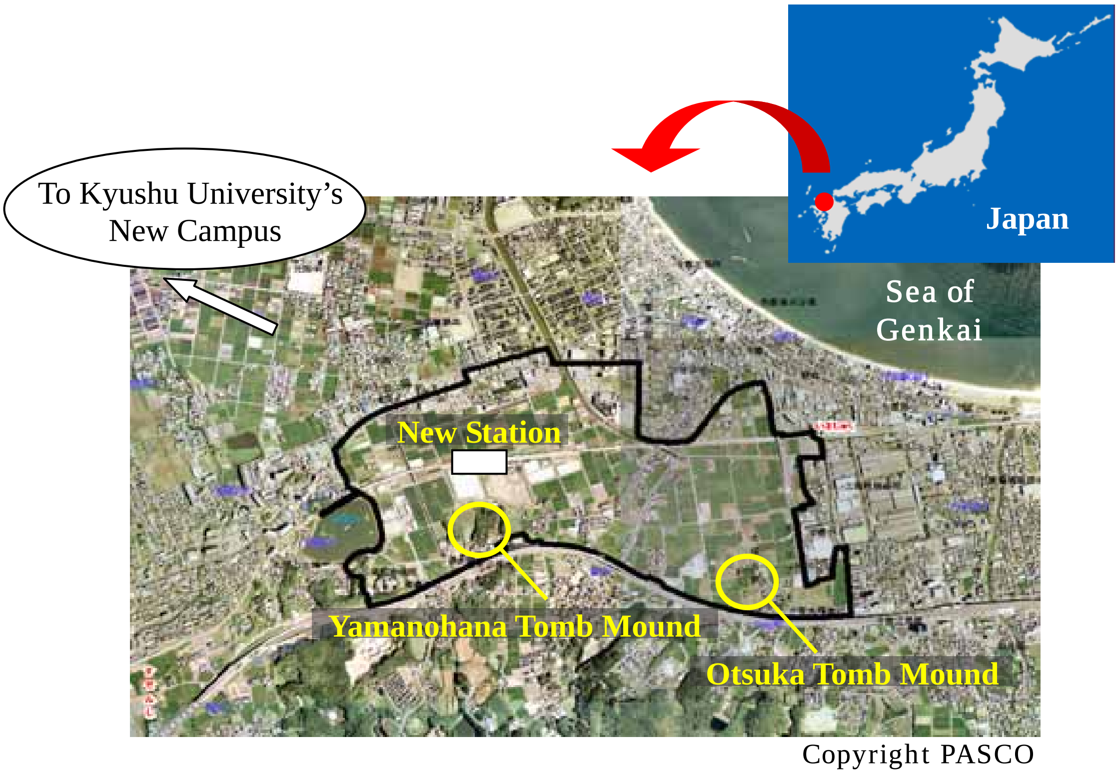

Fig. 1　Ito District

3. Aggregation of Geographic Information by GIS

In this research we first collected geographic information related to the Ito Land Readjustment Project and aggregated the data using ArcGIS (ArcInfo 8.3). Collected data are as shown in Fig. 2. The topographic map, project plan, 50-meter mesh digital map (elevation), aerial photograph, and PFM (Pasco Fresh Map: digital maps by Pasco which can be used as background data on a GIS for medium or small scale display) are digital. The land use map, land use zone, and district plan are paper-based data, which we digitized to load onto the GIS.

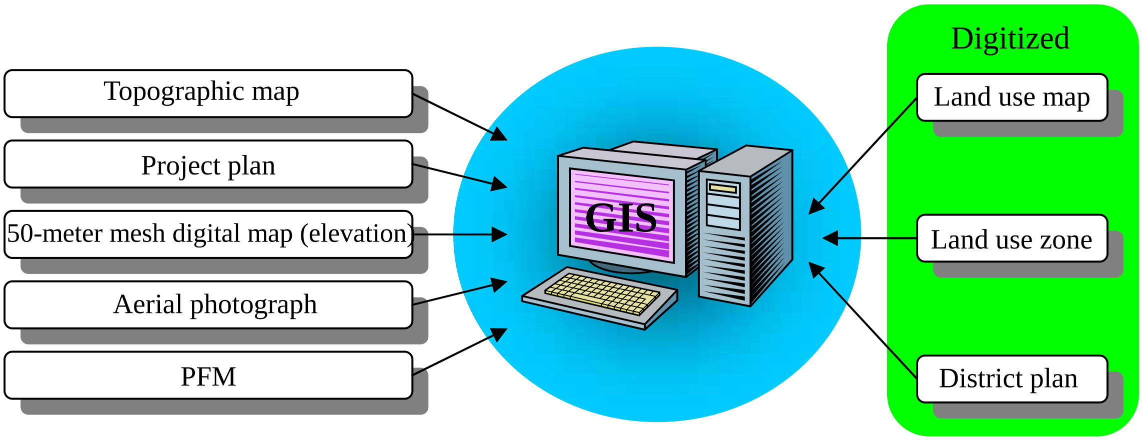

Fig. 2　GIS-based Aggregation of Geographic Information

4. Visibility Areas in the District

Land use in the district will significantly change with the project implementation. While the land was mostly used for agriculture before the project, the district will be urbanized and the land will be put to urban use after the project. It can be easily foreseen that this transition will entail a significant decrease in the range of visibility in the district. We, therefore, investigate what changes in the visibility area in the district will occur with the project implementation. Fig. 3 shows the flow chart of the visibility area computation.

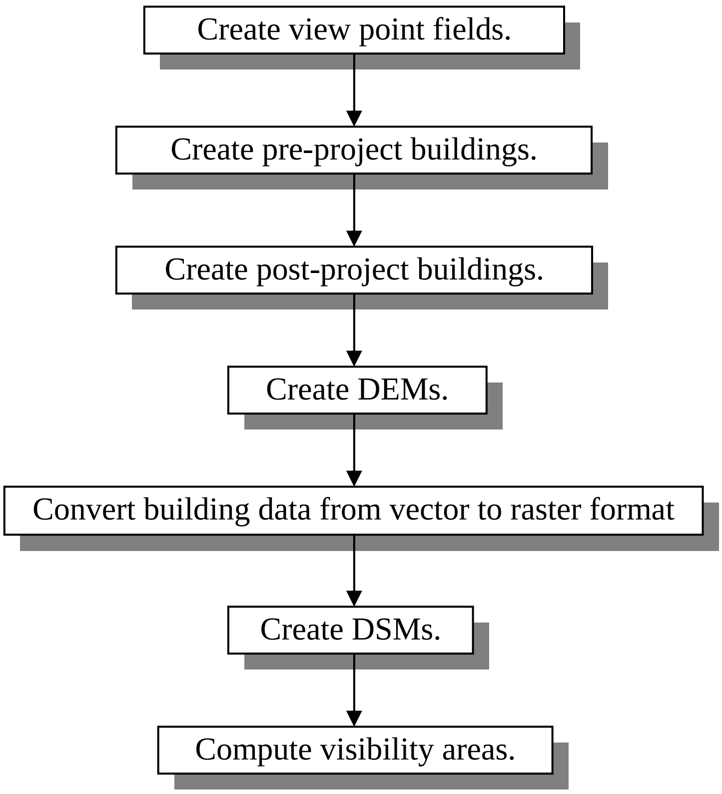

Fig. 3 Visibility Area Computation Flowchart

We first set eight representative view point fields in the project area based on the PFM and project plan loaded onto the GIS (Fig. 4). As criteria, they should be at the common locations for both before and after the project, all physically accessible and mostly on roads. Thus we selected locations that are deemed important as view point fields in the district including the new station square, places near the ancient tomb mound parks and intersections.

Next, data for the buildings before and after the project were created in a vector format including height data. For the buildings before the project the existing structures were represented. For the buildings after the project, their shapes and scales are undetermined. We, therefore, created their data based on assumption that the largest-scale structures would be constructed taking account of the floor area ratios, building coverage ratios, height limits and other such restrictions applicable to the buildings after the project.

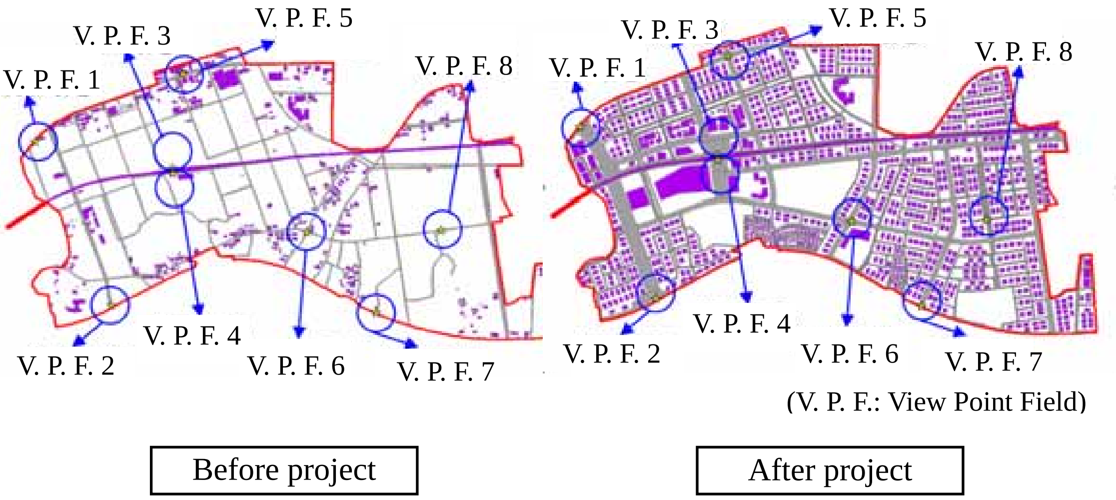

Fig. 4 Roads, Buildings and View Point Fields Before and After the Project

We then loaded 50-meter mesh digital map elevation data onto the GIS to obtain elevation point data. With the topographic elevation data thus loaded, we created DEMs (digital elevation models). To do so, point features from the elevation data were converted first into TIN (triangulated irregular network), then further into the DEMs.

Finally, we converted vector-format building data to those of a raster format, and consolidated them with the DEMs into DSMs (digital surface models).

Using the DSMs generated following the above-explained procedures, we computed areas visible from the respective view point fields. Fig. 5 and Fig. 6 show the visibility areas before and after the project determined by computation, in which the view point height was assumed to be 1.5 meters. The diagrams indicate significant decreases in visibility areas in the district after the project as compared with before. This should be a natural consequence as the former farmlands will be turned into urban area after the project.

The visibility area decrease rates at the respective view point fields are as presented in Fig. 7, with the average rate being roughly 65%. The decrease rates, however, vary by field. The visibility area at the view point field 5 is forecasted to increase after the project than before contrary to general trend in the district. This increase in the visibility area will result from removal of the existing buildings in the land readjustment.

5. Mountains and Skylines in Visibility Areas

View of verdant mountains plays an important role as a component of favorable landscape. For an area abounding with natural environments and historic sites like Ito district, in particular, consideration is required to lessen interruption of mountain views as much as possible. In this research we analyze how the mountains visible from each view point field in the district would change after the project as compared with before.

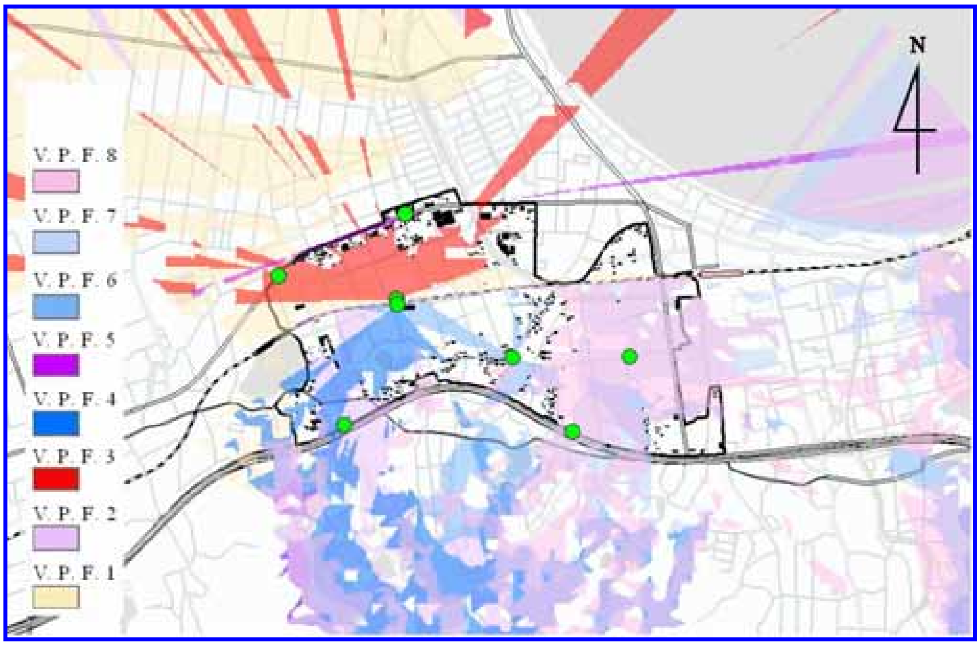

Fig. 5　Visibility Area before the Project

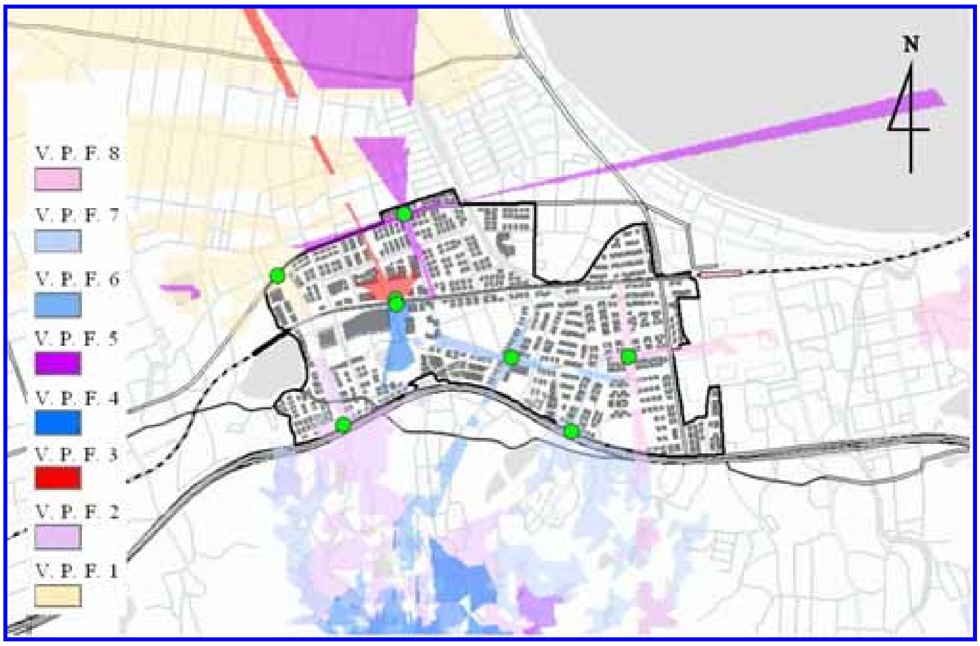

Fig. 6　Visibility Area after the Project

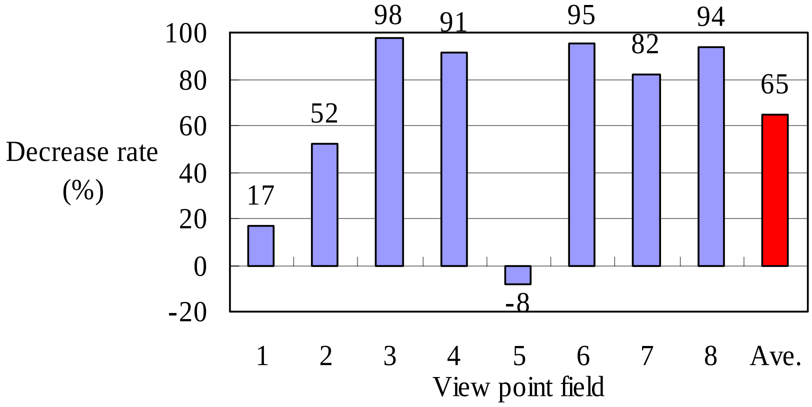

Fig. 7　Decrease Rate of Visibility Areas at Each View Point Field

We first determined verdant mountains on the GIS. Determination of a mountain or not was made based on aerial photographs and elevation data. The computed visibility areas of these mountains are as shown in Figs. 8 and 9. In these diagrams, visibility areas from all view point fields are combined; that is, they represent the entire extent of mountains visible from one or more view point fields in the district. A comparison indicates that, although the visible extent of mountains after the project is less than before, the rate of decrease is not very large, 38% in this case.

The visibility area decrease rates at the respective view point fields are shown in Fig. 10. We understand from this chart that more than 90% of visibility of the mountains will be lost at view point fields 3, 4, 6, and 8 located in the central part of the district. The average decrease rate of all view point fields is 72%.

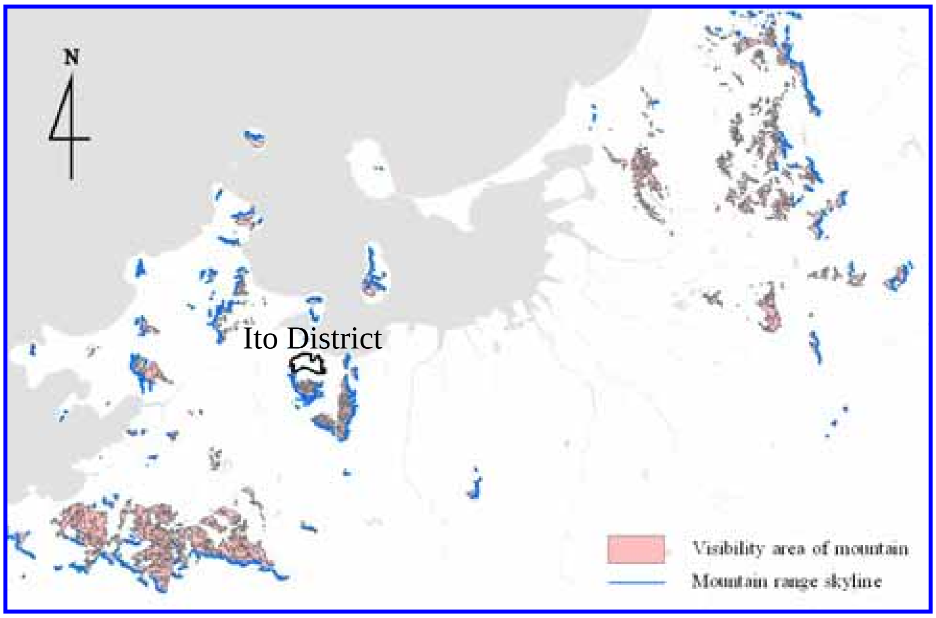

Fig. 8 Visibility Areas of Mountains and Skylines before Project

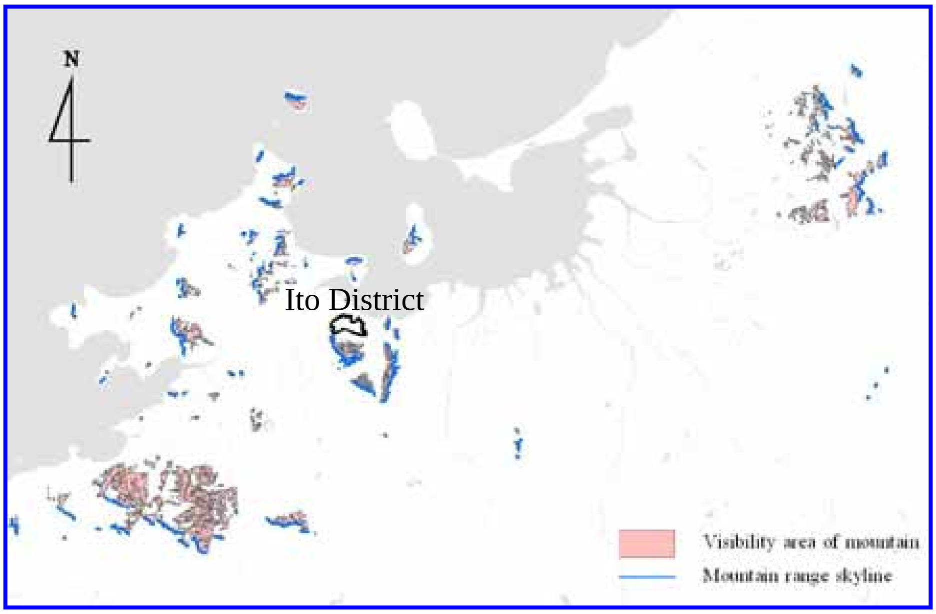

Fig. 9 Visibility Areas of Mountains and Skylines after Project

We then focused on the mountain range skyline visible from each view point field and analyzed how it would change before and after the project. A skyline can be found by connecting by a line the furthest points in the visible area from a view point field. In actual steps, we drew straight auxiliary lines radially from the view point field. Then we sought the furthest overlapping points of the auxiliary lines with the visibility area and connected these points by a line, which is the mountain range skyline (Figs. 11 and 12).

The results are shown in Figs. 8 and 9. In these diagrams, the visible skylines from all view point fields are put together as with the visibility area of the mountains. These diagrams show that although the extent of visible mountain range skylines decreases to some degree, the decrease level is not extremely large.

The visibility decrease rates of the skylines at the respective view point fields are shown in Fig. 13. From the chart, we can see that, as with the visibility areas of the mountains, visible skylines significantly decrease after the project at those view point fields located in the central part of the district. The average decrease rate of all view point fields is 66%.

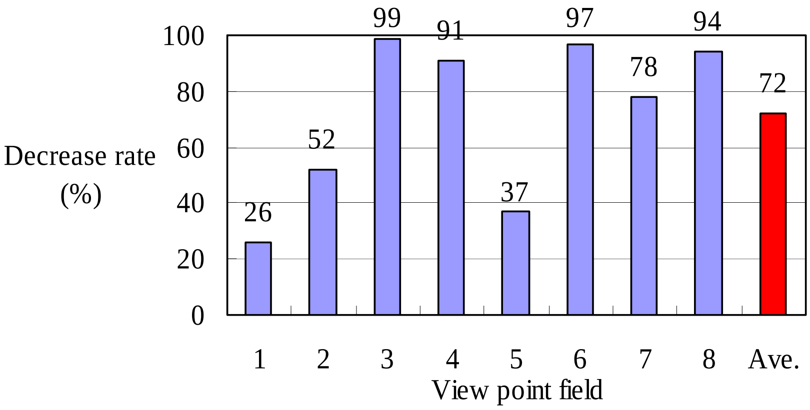

Fig. 10 Decrease Rate of Visibility Areas of Mountains at Each View Point Field

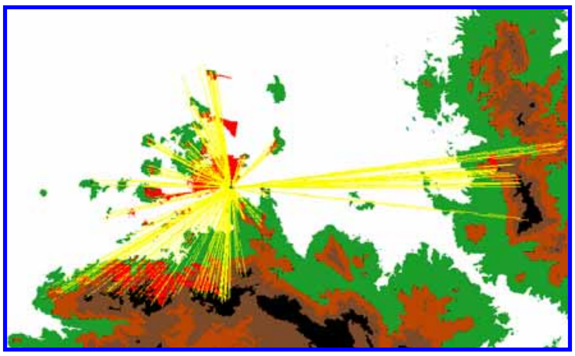

Fig. 11 Radial Auxiliary Lines

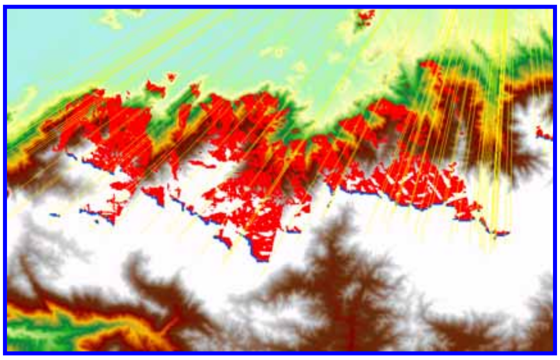

Fig. 12 Creation of Mountain Range Skylines

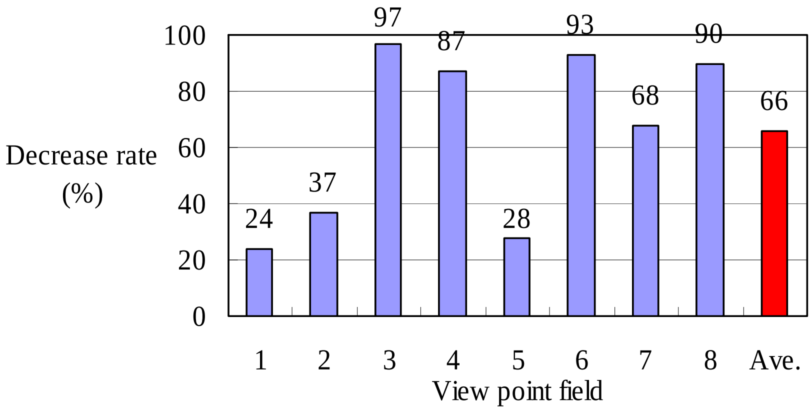

Fig. 13　Visibility Decrease Rate of Mountain Range Skylines at Each View Point Field

6. 3-dimensional Animation

In this research we generated 3-dimensional animations using ArcScene based on pre and post-project topographic and structure data created on the GIS.　The landscapes of the district before and after the project represented in animations are as shown in Figs. 14 and 15.　From them, we can visually understand how the district landscapes will change with the implementation of the Land Readjustment Project, significantly shifting from countryside to urban scenery.

Fig. 14　Ito District before the Project

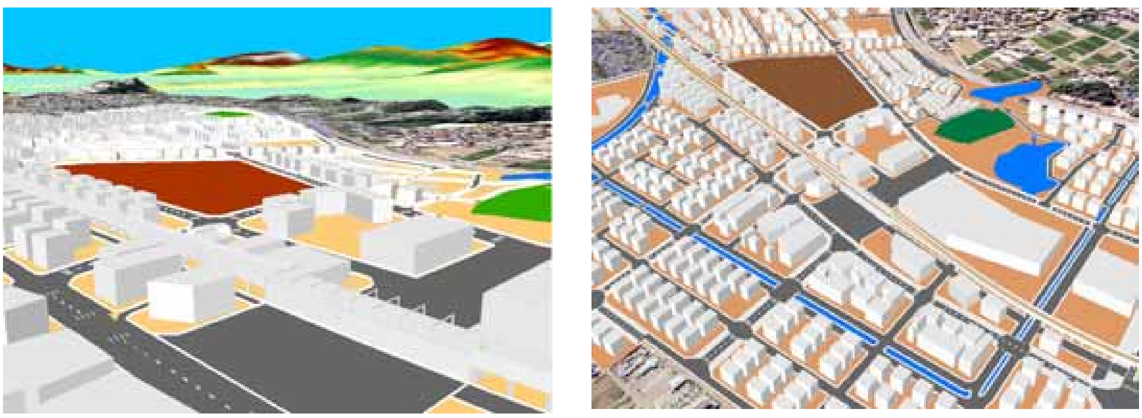

Fig. 15　Ito District after the Project

7. Conclusion

The landscape of Ito district is forecasted to undergo significant changes with implementation of the land readjustment project. We made GIS-based comparison of the landscape before and after the project implementation with the focus on the changes in visibility areas.

Analysis was made on changes in visibility areas in the project area which are near views, and changes in visibility areas of mountains and mountain range skylines which are distant views. The results indicated that visibility areas would be significantly decreased by project implementation.

In the future we plan to investigate whether or not the floor area ratios and other such restrictions to be applied to the district after project implementation are appropriate based on the GIS data created in this research.

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