

Influences of Regional Development on Land Use of Nagara Basin and Flood Risk Control

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Abstract. Land developments, and construction of factories or logistic centers should be implemented with the well-considered land use plans by taking account of disaster risks to improve the resilience of region to mitigate damages. In this paper, the relationship between regional development and land use from the perspective of flood risk control. Nagara basin in Gifu prefecture (Gifu, Mino, and Seki City), where transportation network has been developed to raise the potential for more development, is selected as a case study site. First, changes of industrial structures of the region and its influences on land use were analyzed. Then, possible flood control measures were summarized, and issues from the land use perspective are analysed

1 Introduction

Sustainable development was defined in Brundtland Report as “development which meets the needs of current generations without compromising the ability of future generations to meet their own needs” [1]. It is our responsibility to leave beautiful natural environment to the future generation; however, it sometimes conflicts with our economic environments. Moreover, intervention to the natural force can cause or enhance disaster. Appropriate land use practice is a key to cooperate with nature and land use planning measure to balance those [2].

As a local region is developed, infrastructure (e.g., roads, commercial facilities, factories) and residential districts are actively constructed and the regional industrial structure and land use are subsequently altered in an interactive manner. Although it is desirable to implement development processes following a master plan for city planning or land use, this is not always the case, which causes concerns that deregulated development and land use may not align with the applicable city plans. It is also possible that a master plan exists, but the city and land use plans were developed without sufficient consideration of disaster risks, resulting in unrestricted use of high disaster risk areas. Thus, land use must also be controlled from the viewpoint of disaster risk mitigation.

In the basin of the Nagara River in the Gifu Prefecture (Figure 1), especially in the middle basin (Gifu, Seki, and Mino Cities), the land use has changed as industrial core areas and the associated residential areas have been developed. The flood control measures in the middle basin may significantly affect the potential flood damage in the downstream basin. Because it is

difficult to fundamentally mitigate flood damage using only flood prevention facilities in a downstream basin, comprehensive flood control measures must be considered from the perspective of land use. However, flood risks have increased as local regions are actively developed.

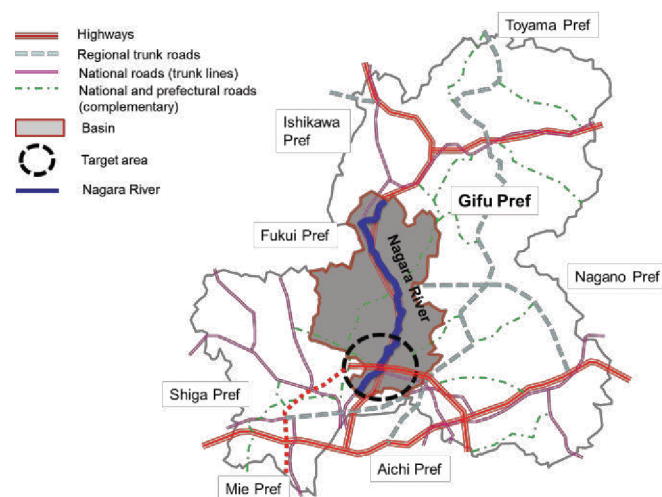


Figure 1. Nagara River Basin and Transportation Network

It is discussed how land use, which is the result of development intended for revitalization of the region's economy, affects flood risks. Flood control and flood damage mitigation measures in the basin of the Nagara River are discussed, and problems are analysed based on the relationship between flood risk control and land use. Finally, future tasks for flood risk control measures through land use control are discussed.

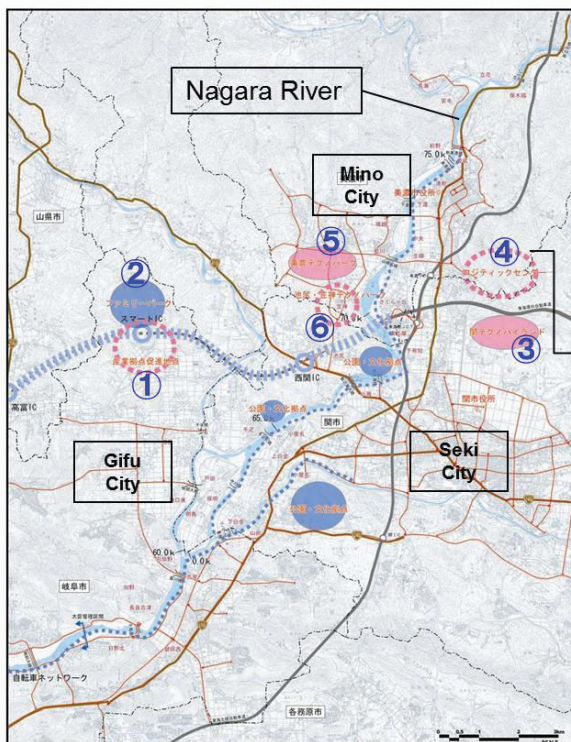
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2 Regional Development of Target area: the middle basin of the Nagara River

2.1 Regional development policies

The target area has been developed in forty years, and especially industrial developments are promoted in recent years. In regional development, which are described in the master plans for Gifu, Seki, and Mino Cities. Seki and Mino Cities have a city planning policies that strive for harmony between people and nature, while Gifu City aims to develop safe and secure city. Under such concepts, the development of industrial cores has been planned along the Nagara River (Figure 2). To realize such development, a vast area of land is required. In addition, the construction of new houses is expected due to the newly generated employment opportunities.

According to the plan, factories built around the middle basin of the Nagara River as well as those built in the Chuno region (the middle Mino region) have altered the population in the area. Due to the transportation network plan (Prefectural Land 1700 km Framework Arterial Network), which aims to reinforce the connections among regions, the transportation infrastructure has been vastly expanded; in addition to the local high-standard highways that connect major cities and the supplemental road network that connects to other areas in the Prefecture, arterial high-standard highways



① Smart interchange construction plan ② Recreational facilities ③ Seki Techno highland (Industrial park) ④ Mino Techno Park (Industrial park) ⑤ Ikejiri-Kasagami Techno Park (Industrial park) ⑥ Logistic Center

Figure 2. Location of industrial complex

Source: Revised materials provided by officials of Gifu Prefecture [3]

connect major cities in the region and throughout Japan (Figure 2). The initiative also strives to improve access to major transportation hubs such as the Chūbu Centrair International Airport, the Port of Nagoya, and the Port of Toyama to promote overseas exportation.

Thus, this region has become a production and logistics hub as these wide-area transportation nodes and networks have been developed. Since 2005, the number of factories constructed in the Gifu Prefecture has increased. Although there was a lull in the latter half of 2009, construction has increased since then due to the new construction and relocation of manufacturing facilities into the area after the Great East Japan Earthquake (Figure 3). Gifu has overtaken the Aichi Prefecture in the total area of land used for factory construction, and is now the second largest in Japan. Moreover, Gifu is now third largest in terms of factories constructed. The future development of the transportation network is expected to sustain this upward trend.

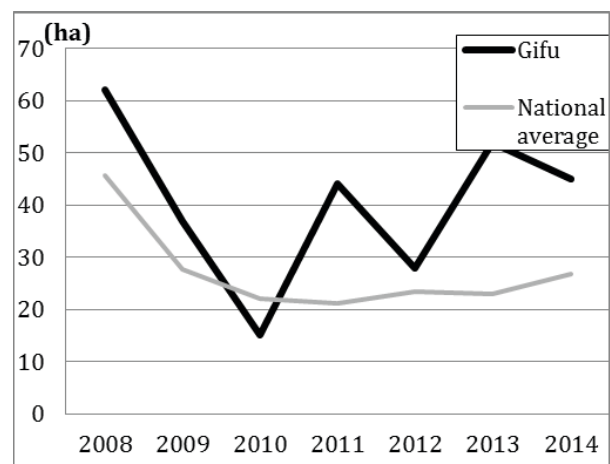


Figure 3. Area of Manufacturing Factories constructed in Gifu Prefecture.

Source: Statistics of Gifu Prefecture Statistics [4]

2.2 Change of Industrial Structure

Due to the recent increased factory construction and the resulting changes in the industry structure, the ratio of the working population in Gifu Prefecture industries has been significantly altered. In Gifu City, the ratio of the population working for primary and secondary industries has decreased, while that of tertiary industries has increased and accounted for 70% in 2001 (Figure 4). In Mino City, although 40% of the working population engaged in primary industries in the 1960s, which was the largest sector back then, over the last four decades the percentage has decreased to just over 3%. On the other hand, those working in secondary and tertiary industries have increased to about 50% in 2001 (Figure 5). The decreased working population in agriculture has caused a lack of successors and an increase in abandoned farmlands, which have resulted in changes in the city's land use, including conversion of agricultural land for land to construct factories due to the increased demand.

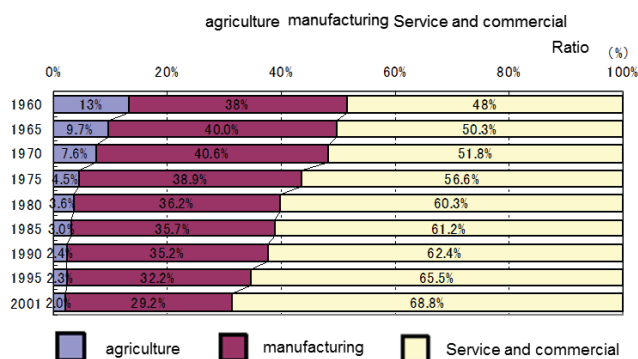


Figure 4. Ratio of employees of agricultural, manufacturing and service and commerce industries of Gifu City
 Source: Statistics of Gifu Prefecture [5]

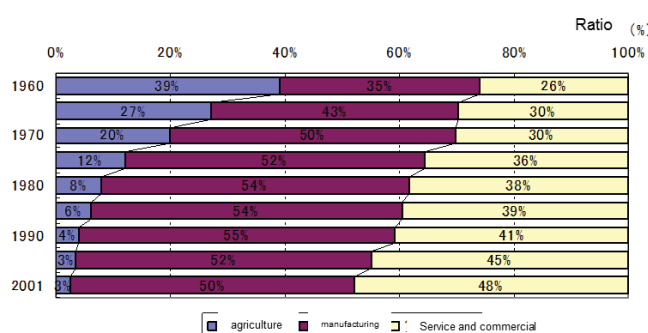


Figure 5. Ratio of employees of agricultural, manufacturing and service and commerce industries of Mino and Seki Cities
 Source: Statistics of Gifu Prefecture [5]

2.3 Development Control

Appropriate land use plan and control measures should be prepared in implementing regional development projects. The Gifu Prefecture has a number of municipalities with areas that are not classified into Urbanization Promotion Areas or Urbanization Control Areas under the City Planning Act, Japan (hereinafter referred to as “Non-classified Areas”). Around the middle basin of the Nagara River, there are a number of Urbanization Control Areas and Non-classified Areas. Areas belonging to Gifu City are classified as Use Districts or Urbanization Control Areas, whereas those belonging to Seki City and Mino City are classified as Use Districts or Non-classified Areas. In Urbanization Control Areas along the river that belong to Gifu City, development is somewhat suppressed, but construction under Article 34 of the City Planning Act of Japan allows for development activities in Urbanization Control Areas subject to certain conditions. In Non-classified Areas in Mino City and Seki City, many small-scale projects may be developed, considering the development permission standards.

In addition, areas along the Nagara River have many regions that are designated as Agricultural Promotion Areas or Agricultural Zones under the Act on the Establishment of Agricultural Promotion Regions, which makes development difficult because regulations require

permission to convert agricultural land to non-agricultural land for urban use. However, such conversions may be considered because the aging of farmers and the decrease of young labor force in agriculture, which has resulted in an increase in abandoned farmland. As the demand for residential houses for factory employees rises and the pressure to convert farmland increases, farmland is converted into the land for housing developments. Those housing developments are usually not well planned, the scattered small-scale housing developments are appeared (Figure 6). It causes suburban sprawl as a result of inappropriate land use practices. In fact, quite a few conversions of farm lands are implemented as shown in Figure 7.

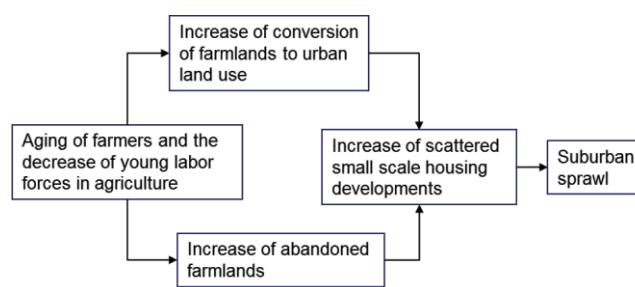


Figure 6. Reasons of suburban sprawl

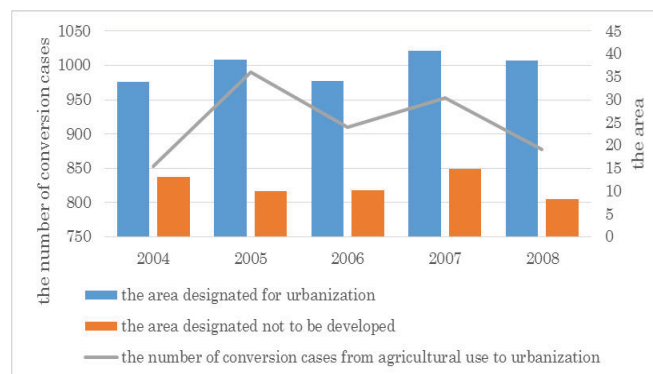


Figure 7. Conversion of farm land to urban land use
 Source: 2007 City planning basic survey of Seki City[6]

3 Flood Risk of the Target Area and Control Measures

The most severe flood since the end of World War II occurred in October 2004 (Figure 8), and the flood risk has risen with the influences by the expected climate change. In addition, the increase of population due to the industrial developments resulted in inappropriate developments, which causes flood disaster risks.

One of the problems of flood control measures in the basin of the Nagara River is the lack of a cross-section area of the river channel, leading to issues with safely discharging severe flood flows.

Major flood control techniques include 1) river channel improvement and 2) flood control facilities. We consider the methodology and efficacy of these techniques in the basin of the Nagara River.



Figure 8. Flood damages in 2004 [7] (Photos: Provided by Gifu Prefecture)

3.1 River channel improvement

Flood control measures from the perspective of the river channel include setting-back a levee, raising the banks, and river channel dredging as follows (Figure 9).

- Setting-back levee significantly affects the urban districts along the river and their land use because these areas have accumulated population and assets.
- Raising the banks raises the high water level (HWL), which may increase damage due to landside water and flood damage if a dyke breaks.
- Dredging and widening the river channel (river bed) will enhance the discharging capacity, but a high water bed width is to ensure that a flood is prevented with levees while securing egg-laying sites of sweetfishes and conserving a river environment suitable for cormorant fishing.

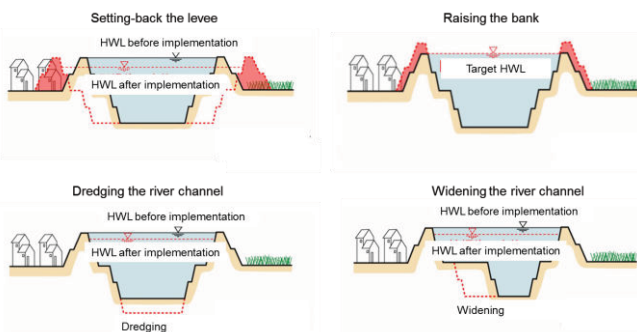


Figure 9. Flood control measures by river channel renovation construction [8]

According to the interview of officials of the Chubu Regional Development Bureau of Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) has concluded that setting-back a levee or raising the banks is unrealistic. These techniques may include river channel

dredging and river widening, but both have complicated environmental considerations and require a huge amount of financial and human resources, limiting their applications.

3.2 Enhancement of flood control function

Enhancement of flood control functions includes the development of dams, discharge channels, retarding basins to control flood, etc. Regarding this issue, CRDB of MLIT has concluded that the development of dams and discharge channels is difficult because the amount of suitable land is insufficient and urban develop has advanced in this area. Consequently, regulating land use in expected flood areas while maintaining the current open levee structure should be effective to develop a retarding basin to control flood. In addition, disaster dangerous zones should be designated after taking countermeasures against flood damage on existing residential housing lands.

- Dams: Although existing and under-construction dams (Atagi Dam and Uchigatani Dam) are incapable of providing sufficient flood control effects, construction of additional dams is difficult due to lack of suitable sites and the financial burden.
- Discharge channels: In case of floods around Gifu City, which has potential flood risks, construction of new channels (discharge channels) to bypass flood flows into other rivers (or downstream of the Nagara River) is unrealistic, considering current situation of urbanization.
- Flood control basins
 - Development of flood control basins by constructing overflow levees for the main stream and main levees for expected flood areas should promote the development of flood control basins and countermeasures for expected flood areas.
 - Conservation of flood control functions should sustain flood control functions and deal with development pressure until retarding basins to flood control are developed.

3.3 Flood disaster mitigation using a retarding basin for flood control

In the middle basin of the Nagara River, flood disaster mitigation using retarding basins is realistic. Because securing a retarding basin is relatively easy, it may be an effective measure. However, relocating buildings necessary to secure retarding basin sites requires time and money. Hence, if retarding basins already exist and developing additional ones are unnecessary, conserving the current retarding basins as much as possible is very effective.

- Advantages of a retarding basin:
 - It allows planned land use because a retarding basin defines the range of flood plain.

- It mitigates flood damage in areas outside of the retarding basin.
- It can be utilized for more than just a flood if certain restrictions are adhered to.
- Disadvantages of a retarding basin:
 - In a retarding basin, land use that lowers its flood control function (e.g., construction of buildings that have a structure preventing flood control functions) is regulated because the flood control functions must be maintained.
 - Relocation of existing buildings within the retarding basin sites may be necessary.

3.4 Policy of flood disaster mitigation measures in the basin of the Nagara River

The flood control measures for the Nagara River are basically a combination of small-scale dams with retarding functions because geological restrictions inhibit suitable sites for large-scale dams. The disadvantages of setting-back a levee and raising banks prevent either from being a realistic option. Thus, utilization of the flood control function should be the most suitable measure for this area.

Measures to secure retarding functions include development of an artificial retarding basin and conservation of current flood control functions. However, a large quantity of land must first be purchased to develop a retarding basin, which is a significant obstacle.

The middle basin of the Nagara River has played an important role in flood control and has contributed to the mitigation of flood damages in areas around the midstream and downstream because the physical features of the middle basin provide flood control functions. Considering the population and assets accumulated in the floodplain of the midstream and downstream as well as the history of flood prevention policy on this river, maintaining and continuing to secure flood control functions is a practical solution. Consequently, agricultural lands play an especially important role.

4 Mutual Effects of Land Use and Flood Risks

As regional development led by industrial development in association with the construction of transportation network proceeds, demands for residential houses are increased and more farmland has been converted for housing development.

In agricultural land located in low altitude areas across Seki City and Gifu City, agricultural land continues to decrease and small-scale development projects are common as the development potential has increased and urban districts are actively expanding. There is a concern the subsequent infrastructure upgrades of highways and the expansion of industry may further advance suburban sprawl. Comparing land use of 1970's and 2000's, urban sprawl is observed as a result of conversion of farmland as shown in Figure 10.

While flood risks have increased due to the suburban sprawl, flood control functions have declined because of the disappearance of farmland. The concern of flood

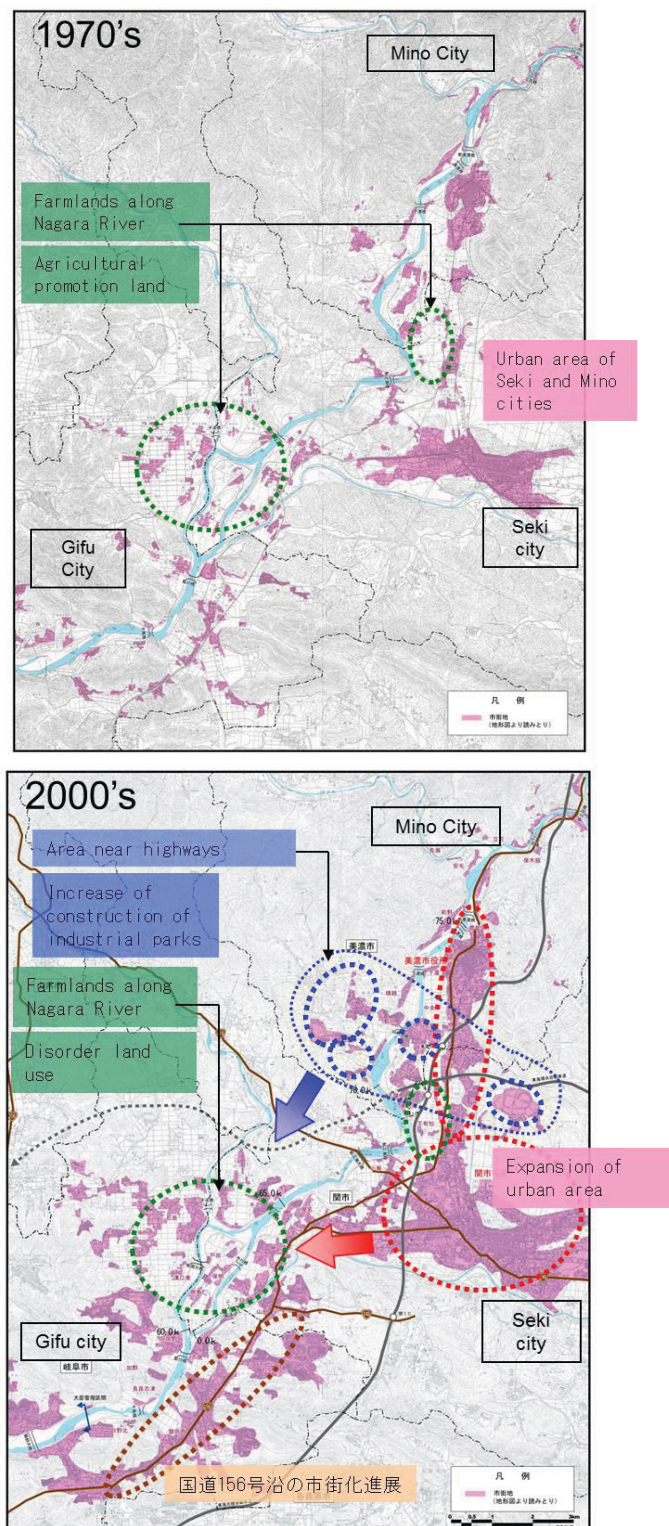


Figure 10. Land use of 1970's and 2000's
 Source: Revised materials provided by officials of Gifu Prefecture [9]

damage in the middle basin and the disaster potential in the lower basin have increased because converting agricultural land into residential housing land involves

leveling off the ground, which decreases the lands' flood control function.

Agricultural lands provide flood control functions, but are currently not conserved in a well-planned manner. Although the conversion of agricultural land should adhere to the standards for conversion of agricultural land, the conversion standards do not include disaster prevention.

As discussed in the previous chapter, retarding function of farmland is quite important for flood control in the target area due to the difficulties of river improvement construction. However, the decrease of farmland has heightened flood risks. Under the circumstances, urgent and deliberate measures that will continuously ensure inherent flood control effects are needed. Those relationship of factors is shown in Figure 11.

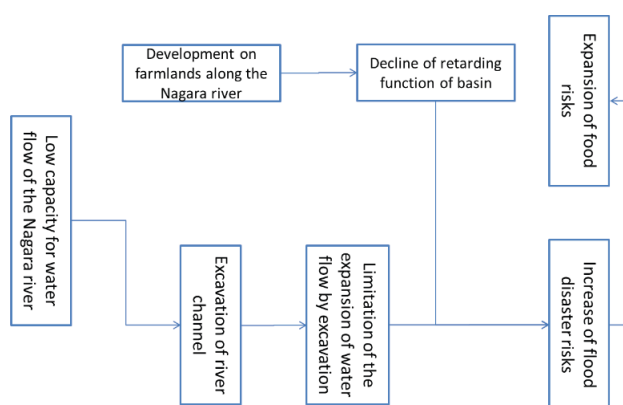


Figure 11. Relationship factors related to development and flood risks

5 Conclusion

Although the conversion of agricultural land should adhere to the standards for conversion of agricultural land, the conversion standards do not include disaster prevention. Agricultural lands provide flood control functions, but are currently not conserved in a well-planned manner.

Although flood risks have increased, the budget allocated for flood control projects and flood disaster mitigation measures is limited. In addition, it is difficult to construct large-scale infrastructure in urbanized areas. Thus, in urban areas, effective flood control and mitigation measures must combine various measures while developing infrastructure. This study examines flood risk control from the perspectives of regional development and land use with an emphasis on utilization of existing flood control functions as a flood disaster mitigation measure.

Land use plays an important role in flood risk control. Development without sufficient consideration of flood risks increases the potential flood risks. In addition, the loss of agricultural lands, which have flood control functions, decreases the ability to mitigate flood risks.

Consequently, land use along with infrastructure should be considered for flood control.

Ideally, specific measures, such as conservation of agricultural lands, should be integrated into master plans regarding city planning or land use. Because development should be guided with consideration of flood risks, city-planning techniques should suppress deregulated development while regulating the conversion of agricultural land into non-agricultural lands.

As described above, it is crucial that land use control is integrated into flood control across the whole basin. Thus, the challenge becomes developing comprehensive policies and plans on flood risk control and land use in cooperation between different departments responsible for city planning, agriculture, and river control. In addition, flood disaster mitigation measures on the river must be considered based on a basin, which means multiple municipalities and prefectures must collaborate. Successful flood risk control depends on the effective coordination among these plans and organizations.

Even though Japan whose population has decreased since 2008 [9], there is still pressure for development locally. It is easily assumed that land development pressure is stronger in countries which are experiencing high economic growth. Figure 22.10 shows the population in rural and urban area will continue to increase in developing countries, and the increase in urban area is expected to exceed the one of rural area in 2020. It is seen that urban and suburban areas are spread to show sprawl phenomena creating disorder land use for residential and industrial developments [10][11].

Developments and conservation of natural environments have to be balanced otherwise, the unbalanced situation can create disaster. Disaster risk reduction can play an important role to balance them by mitigating and avoiding disaster risk. Land use planning is a key to mitigate or avoid risks through appropriate land use practices. As stated in Hyogo Framework for Action 2005-2015 and Sendai Framework for Disaster Risk Reduction 2015 – 2030 (United Nations Office for Disaster Risk Reduction), land use management is one of the important measures for disaster risk reduction, and growth management to control development through land use planning is definitely a way to cooperate with nature [2].

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