● 制作

呼吸の土地
—流域水害の補足としてのランドスケープの提案—

BREATHING LAND

-Landscape as a supplement to regional disaster prevention for Yamato River Basin-

毛月　テイン　園芸学研究科 ランドスケープ学コース 環境造園デザイン学領域（主指導教員：武田　史朗）
MAO Yueting

1.Background and Research Objective

Floods paralyze life, create environmental imbalance at all levels, both natural or human, and lead to loss of property and life along with poor economic development. In the present paper, the study area has been exposed to floods over time as a result of climate change and land development. Research shows that, flood discharge highly depends on various factors, including the topography, total catchment area, and rainfall intensity etc. Practice has manifested the terrain can be shaped to absorb overflow and the combination of rigid and flexible vegetation results in a collaborative resistance against surface runoff [1].

In highly urbanized floodplains, it is becoming widely accepted that a change is needed to move away from flood control towards flood adaptation paradigms. Based on the research and landscape practice, the planning proposal aims to leverage the inherent natural benefits of land: capturing, absorbing, and releasing rising water bodies through terrain shaping to mitigate disasters caused by overflow or runoff. This study will focus on the Sahogawa in the upper reaches of Yamato river. Research will firstly recognize inundation areas during different flood intensities. Then, select terrain-shaping locations based on the distribution of affected villages. Floods can be predicted using the River Analysis System model from the Hydrological Engineering Center (HEC-RAS), which is useful in preparing a plan for mitigating and controlling the effects of floods [2].

2.Research Subjects

The Yamato River basin covers an area of 712 square kilometers, accounting for approximately 20% of the area of Nara Prefecture. Yamato river gathers 157 tributaries before flowing into Osaka Bay. The Yamato River catchment covers an area of 1077 km2. Flowing through Nara and Osaka Prefecture, river discharge accumulate in rainy season result in high flood risks in certain period of the year. Floods in the basin is mainly caused by rainstorm, and large floods have occurred frequently in history.

Yamato River is a flood prone river for decades of years. The flat basin terrain, numerous tributaries, and narrow drainage outlet - "Kamenose" contributes to the frequent flood issues in the region. According to the chronology of meteorological disasters in Nara Prefecture, 31 droughts, 50 storms, and 46 floods has been recorded since Meiji Period [3,4].

As an important water source of the region, the river is blessed with a rich culture. The river basin has long been associated with the beginnings of history in Japan. Successive imperial chose to build their capitals, left abundant historical settlements and relics in the basin land. Holding these cultural heritages further increase the importance of regional disaster prevention.

3.Methodology

The research was conducted in two parts:

①Site research on the watershed environment, traditional disaster prevention measures and current issues of the research area.

②Flood process map simulation with Hec-ras to quantitatively analyze the impact of flooding on the study area.

Based on the findings obtained from the above surveys and analyses, obtain the flood inundation patterns and affected areas. The simulation of the flood invasion in this section will also be used to compare to the invasion situation after planning, to verify the effect of the design proposal.

4.River Basin Survey

Interpreting and analyzing floods in any region requires a large amount of data in order to interpret and analyze flooding, evaluate its effects, and reduce risks in the future. It can be seen that (Figure 2), in the past 20 years, 2013 has the highest precipitation intensity, which can be inferred to be caused by the typhoon 18. The precipitation is unevenly distributed throughout the year, the rainy season from May to August, with the annual average approximately 1360 mm.

During the long coexistence with rivers, Nara region has developed a series of methods to regulate regional water use and increase resilience to the potential disasters. Even if people continuous making efforts to response the water issues, disaster prevention is still facing challenges.

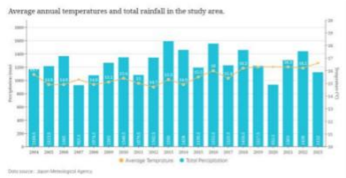


Figure 1. Average annual temperature and total rainfall

Figure 2. Monthly temperature and precipitation 2023

With the rapid development of urbanization, the water retention capacity of river basins has been largely lost in the past few years. After the Meiji period, the water control of Japan's main rivers was based on the construction of continuous dikes using modern methods introduced by Europe. However, this rigid construction method has exposed its limitations under the influence of frequent floods and rapid changes in the watershed environment[5], implying the region need supplemental measures to cope with disasters.

5. Flood invasion simulation

The HEC-RAS hydraulic model was used to manage floods in the basin and limit or reduce their risks. This model was specifically designed for application in floodplain management and flood insurance studies. In this research, HEC-RAS is mainly used to flood intrusion in two scenarios in order to evaluate the flood effects under different precipitation intensity: a. the normal rainy season scenario; b.20-year flood scenario.

From the simulation result (Figure 3), the extent of the damage caused by flooding in the Sahogawa varied due to the difference in the severity of the floods from one region to another. The flood simulation shows that the 2013 flood covered an area of 14.82km2. Water invasion was most severe in Ando and Kawanishi area, while the northern and western part of Yamato Koriyama did not witness any floods due to the elevation of the land surface.

Classify the flood impact based on the depth of the flood into 3 level (Table1). Areas with 0-1m inundation depth have low flooded impact, 1-3m inundation area have medium flooded impact, and 3-5m inundation area have medium flooded impact (Figure 4). The matching of the flood map for the years 2013 with the land uses map of the study area shows that, build area and cropland are most affected by floods, while the other three land type are only slightly affected. The high impact land uses are also concentrated in built areas and cropland, further illustrates the fragility and risks of these two land types.

6.Result and discussion

Flood risk assessment is a vital tool for the predictive planning of adaptation measures based on risk analysis. The following conclusions were drawn from the study.

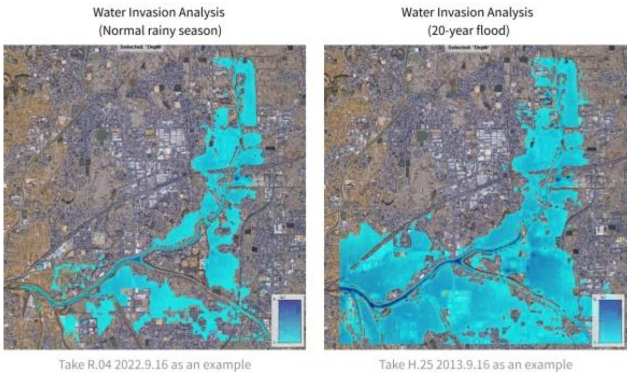


Figure 3. Water invasion analysis under different scenario

	Landuse	Impact	Area (㎡)	Percentage (%)
		Low	11617.23	0.08%
1	Cropland	Midium	2356929.85	15.89%
		High	217131.35	1.46%
		Low	53948.9	0.36%
2	Built land	Midium	4564973.67	30.78%
		High	385625.16	2.60%
		Low	56.63	0.00%
3	Bareland	Midium	30318.78	0.20%
		High	-	-
		Low	431.17	0.00%
4	Grassland	Midium	118738.45	0.80%
		High	30328.98604	0.20%
		Low	5.47	0.00%
5	Forest	Midium	876.18	0.01%
		High	-	-

Figure 4. Flood depth and impact analysis

Table 1. Area of flood impact on different land use categories

1). Due to the significant seasonality of flood risks, response measures should also be flexible and periodical.

2).Based on the results of the inundation analysis, the upstream Sahogawa has relatively low risk from disaster, and the area at the junction of the Asuka River and Yamato River is affected by river convergence, sudden increase in flow, and lower terrain, resulting in higher flood risk.

3). From the perspective of land use, when planning and designing, the construction land and cropland that adjacent to the river should be given priority protection.

Planning and design will be conducted based on these conclusions.

References

1.Rehman, S.U.; Ahmed, A.; Gilja, G.; Valyrakis, M.; Ghumman, A.R.; Pasha, G.A.; Farooq, R. A Laboratory Study of the Role of Nature-Based Solutions in Improving Flash Flooding Resilience in Hilly Terrains. Water 2024, 16, 124.

2. Awad, T.; Bansode, M.; Chavan, R.; Bhise, R.; Shivamurti, B.K. Flood Management by Using HEC-RAS software. Int. Res. J. Mod. Eng. Technol. Sci. 2022, 4, 148–154.

3.大和盆地における請堤の機能と分布.梅崎秀滑.地理学評論. 1958 年 31 巻 10 号 p. 590-601

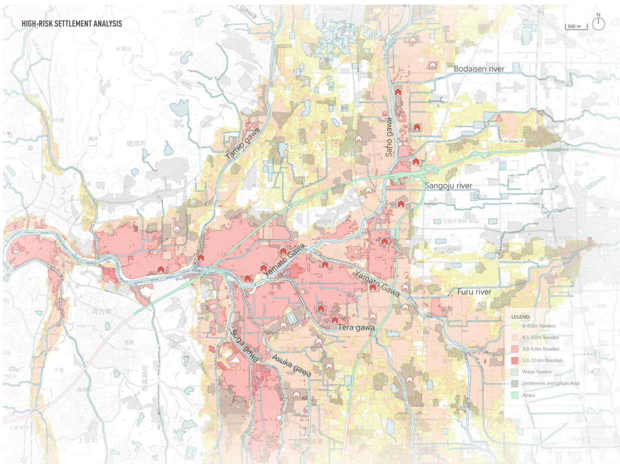
4.『治水の地域史 ： 大和郡山市筒井地区』 地域史研究会編 京都 ： 地域史研究会（517.2-12）

5.末次忠司.明治時代の水管理技術.水利科学.No359.2018

（主査：武田 史郎，副主査：章俊華，木下 剛）

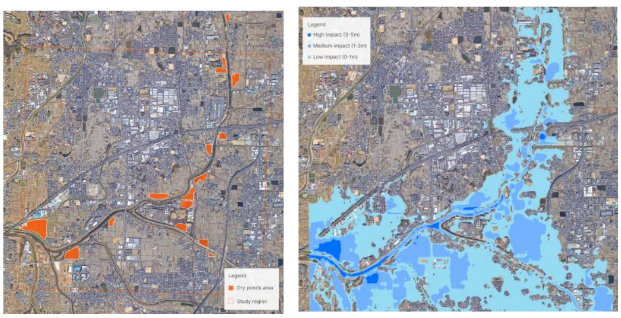
7.Planning Proposal

Nature-based solutions (NBS) is the sustainable management and use of natural features and processes to tackle socio-environmental issues. NBS Flood Adaptation Measures is to deal with the relationship between land and water. Under natural conditions, the land-water interaction can be classified according to 6 functional objectives: infiltration(to recharge aquifers), purification(to clean runoff),conveyance(to move stormwater), retention(to reuse rainwater), detention(to delay stormwater)and attenuation(to slow down flood water). Reasonable utilization of land functions can maximize the effectiveness of land ’ s capacity of disaster prevention.



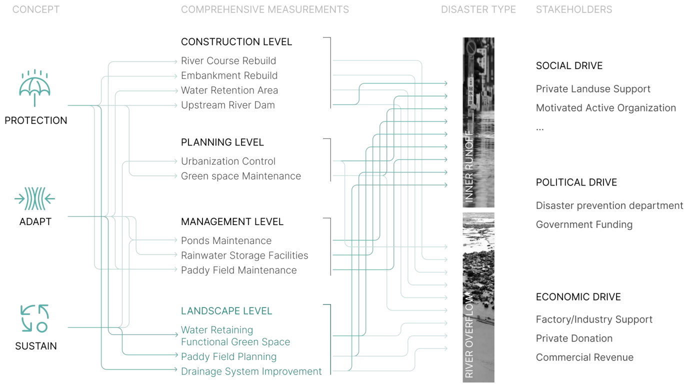
High risk area identification

Based on the above process, the study proposes that actively setting up depression terrain in flood prone areas of rivers can enhance the ability of land to retain floods.By overlaping the GSI hazard maps with landuse map,high risk settlement area were recognized. The depression area were distributed along the lowland of riverside based on the location of the affected construction areas and the layout of water ways. 15 depression areas were selected in the study area. Modify the DEM elevation values of these areas in ArcGIS by sinking 2 meters, and generate a new raster terrain .

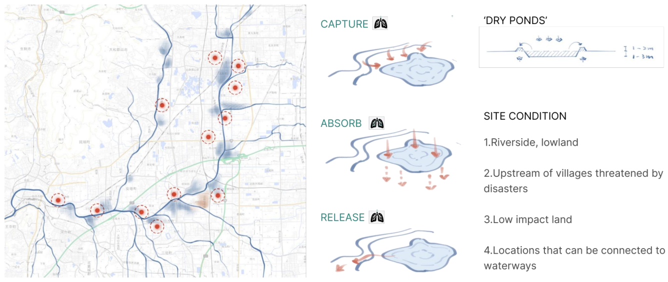


Depression area and Flood depth analysis after planning

The effect of adding depression areas on flood control is verified by re-conducting flood simulations. Result shows that the mid impact area and high impact area has significantly reduced after planning.



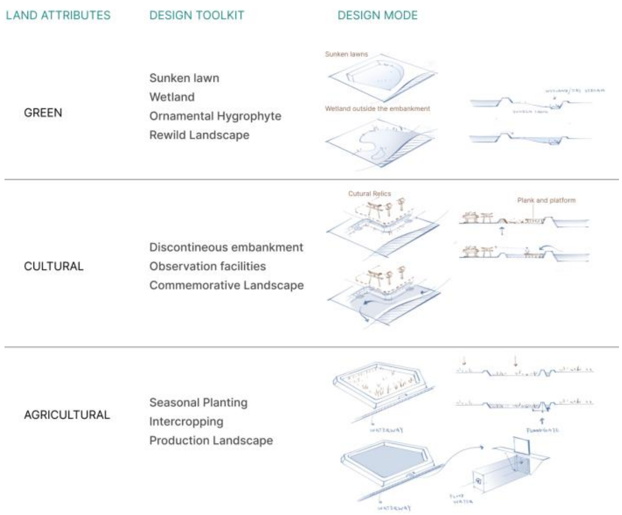
Landscape’s role in disaster prevention



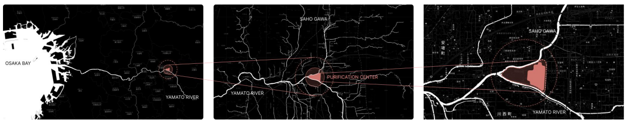
Planning area and design concept

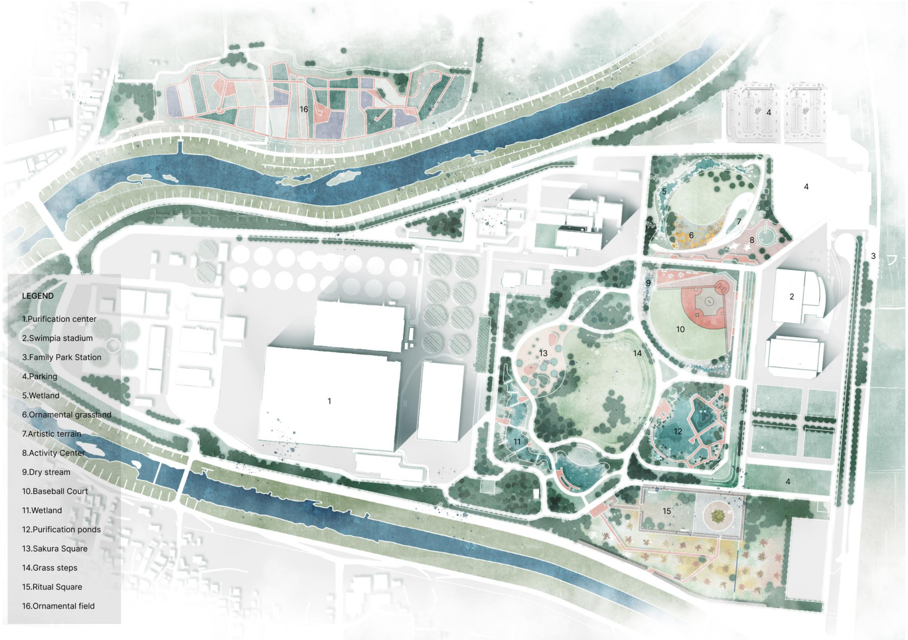
8.Design Proposal

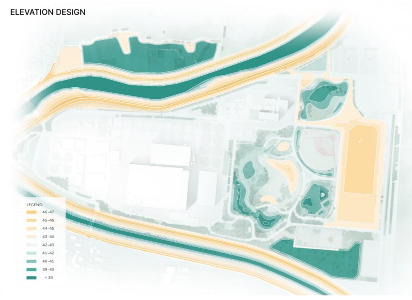
In modern planning, allowing floods to occur in certain areas has been recognized as a way of designing and using public outdoor spaces. The approach can be implemented through the perspectives of landscape multifunctionality and nature-based solutions. According to the land use types in the study area, the land attribute of the depression are divided into three categories: Green space,cultural land,and Agricultral land. Implement different design strategies for different attributes as impressions.



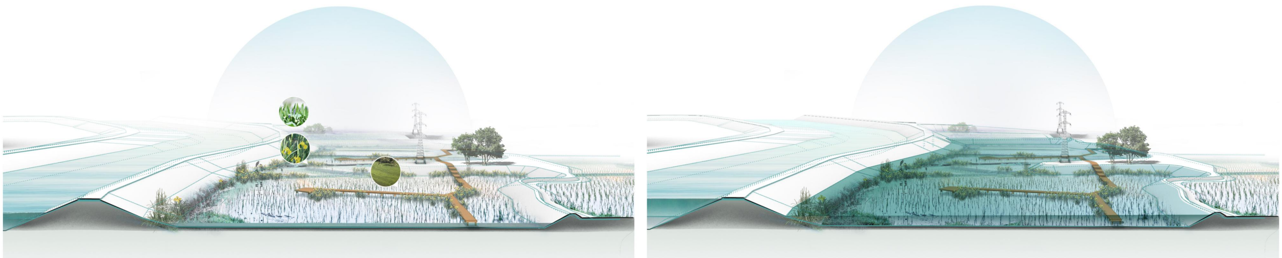
Design Site



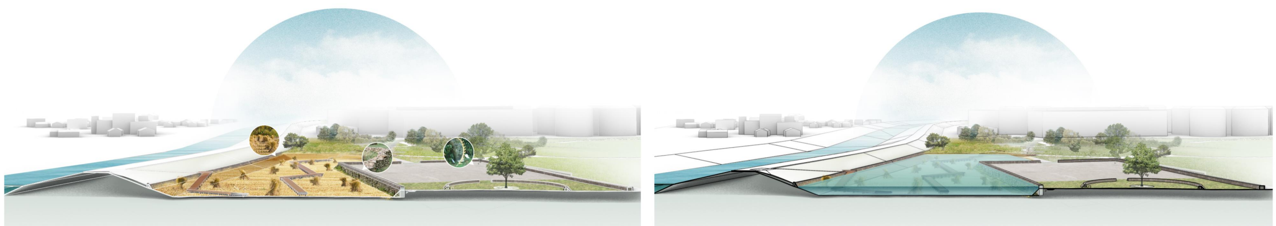




Agricultural depression



Cultural depression



Green Space depression