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STUDY OF CHARACTERISTICS AND MANAGEMENT OF DRAINAGE PROBLEMS IN UBUD DISTRICT

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Abstract. Ubud District is one of the tourism areas in Bali which is growing very rapidly. Ubud District has problems related to inundation and flooding which often occur during the rainy season. The drainage canals cannot accommodate the peak flood discharge. Because the capacity of the channel is insufficient, besides the influence of sediment and garbage, water overflows through the freeboard of the channel. This study aims to determine the characteristics of inundation and drainage in Ubud District. Primary and secondary data are used in this study which will then be used in data analysis. The analytical method used are field survey, identification of inundation and flood locations, inventory of existing drainage system, hydrology and hydraulics analysis, and drainage network planning. The result is 27 inundation locations were found in Ubud District. The inundation locations included 5 points in Lodtunduh Village, 3 points in Mas Village, 2 points in Peliatan Village, 5 points in Petulu Village, 2 points in Sayan Village, and 10 points in Ubud Village. The duration of the inundation that occurs is a minimum of 15 minutes and a maximum of 360 minutes. The height of the inundation that occurs is 12 – 50 cm with an inundation area of 0.032 – 4.67 ha and an inundation length of 12 – 2.309 m. The frequency of inundation is 3 to 10 times per year. Parameters for determining priority for drainage management based on priority scale are determined based on the characteristic parameters of inundation, economic losses, social disturbances and government facilities, transportation disturbances, and losses in residential areas. The recommendations given include normalizing the existing canal with river stone pairs of the required size that are more adequate to accommodate water discharge, especially during rains; making diversion channel with precast box culvert with the required size; and construction of new channels equipped with inlet drains per segment as entry points for inundation on the roads into the drainage channels.

Keywords : Drainage, Inundation, Flood, Characteristic, Management, Ubud

1. INTRODUCTION

According to Indonesia's Law No. 26 of 2007 concerning spatial planning, urban areas are areas that have non-agricultural main activities with the function of the area as a place for urban settlements, centralization, and distribution of government services, social services, and also economic activities [1]. In urban areas, there are many people living, and there are many public facilities, transportation, communication, and so on [2]. One of the urban areas that function as a Regional Service Center in Gianyar Regency, Bali Province is the Ubud Urban Area. Ubud District is one of the tourism areas in Bali which is growing very rapidly. The total area of Ubud District is 42.38 ha, which is 11.52% of the total area of Gianyar Regency [3]. Ubud District consists of 7 villages and 1 sub-district including Kedewatan Village, Lodtunduh Village, Mas Village, Peliatan Village, Petulu Village, Sayan Village, Singakerta Village, and Ubud Village.

One of the urban infrastructure network systems is the drainage network system. The drainage network system in question is a primary drainage channel system that is established in order to reduce waterlogging and support flood control, especially in residential, commercial, office, and tourism areas [4]. The drainage system is an important infrastructure for an urban area that is closely related to the physical environmental conditions and the socio-cultural environment that exists in the urban area [5],[6].

Flood disaster is a problem that must be faced by residents who even in certain locations must be faced them routinely. The problem of flooding is inseparable from the poor drainage caused by the development of business and housing areas which often results in the conversion of land functions from safety areas and catchment areas such as river riparian areas, and temporary water storage ponds to turning into residential areas and trading centers [7],[8],[9],[10]. This is what happened in the Ubud District, where there are stagnant water and flooding, especially during the rainy season and for a long time.

The drainage canals cannot accommodate the peak flood discharge, especially during the heavy and consecutive rainy season. Because the capacity of the channel is insufficient, besides the influence of sediment and garbage, water overflows through the freeboard of the channel. Due to minimal maintenance, there is the accumulation of waste which has become a mound of earth, thus blocking the drainage flow to the main river (estuary). The system of developing settlements from paddy fields has resulted in a change in the direction of channel use from irrigation canals to drainage canals.

On the other hand, drainage problems are also caused by significant changes in land use which have contributed greatly to increasing surface runoff. The development of tourism in Ubud District is inseparable from land use where land is needed in tourism development related to the construction of supporting facilities and infrastructure or transportation infrastructure [3]. The increase in existing water runoff is not matched by an adequate increase in drainage capacity.

Based on these problems, this study aims to determine the characteristics of inundation and drainage in Ubud District. This is done so that the flood points in several places in Ubud District can be described so that they can create a healthy and inundation-free urban environment, and can play a role in increasing water conservation, utilization, and control.

2. METHODS

2.1 Data

In researching the drainage system of an urban area, the description of the physical environment is very important information. The placement of canals, buildings, and the densities of these facilities will be greatly influenced by the condition of the planned area. In this regard, sensitivity from researchers is needed in interpreting available data both in the form of primary data and secondary data in the form of basic data and flood phenomena that have occurred, as well as existing flow patterns. Information about natural flow patterns can also be obtained from direct observations in the field during rain or flood conditions.

The data needed in this study includes primary data and secondary data. Primary data is data obtained from the field by direct measurement, and observations in the field or at the study location. While secondary data is data that can be obtained directly without having to go to the location. Secondary data is generally obtained from agencies such as the Meteorology and Geophysics Agency, the Center for Geological Research and Development, the National Coordinating Agency for Surveys and Mapping (Bakosurtanal), Bakosurtanal and other related agencies as well as previous studies. Secondary data collection includes an inventory of the existing drainage system, Gianyar District Spatial Data and its surroundings, hydrological data, regional geological maps, and topographical maps.

2.2 Analysis Methods

2.2.1 Field Survey

A tracing survey is carried out by seeking information about inundation points and the direction of flow on the main road sections, starting from the source of the arrival of water to its final disposal in the form of a river. This survey was also carried out in addition to knowing the direction of drainage flow, knowing the existing conditions, as well as knowing the causes of flooding or inundation.
Regarding people's behavior towards the existence of an existing drainage network, it is necessary to study matters relating to the management of the surrounding drainage network, whether it is following the actual drainage function, whether the community has routinely maintained the cleanliness of the canals or vice versa, even drainage channels that are not clean. there is used to accommodate household waste so it does not function optimally.

2.2.2 Identification of Inundation and Flood Locations

This activity was carried out to collect data related to the history of inundation at the study site and its surroundings which had been carried out by the Regional Government or related agencies before. Inundation and flood data identified include the location of the inundation, the length of the inundation, and the height of the inundation. It is also necessary to study the possibility of flooding from upstream which can be taken into account in planning. Accurate locations of inundation and flooding points will also provide information about the hydraulic regime of the area.

2.2.3 Inventory of Existing Drainage System

An inventory of the existing drainage system is carried out thoroughly and identification and classification are carried out based on regional zones, shape and construction model, length of the drainage channel, level of damage, a function of the dam system, and the type of drainage water carried. Also pay attention to the shape and slope of the land, the area or area to be drained to determine the drainage discharge, the types of waste water, the existence of natural settlements, the type of soil, and its characteristics. All of that will affect the condition of the existing drainage system.

2.2.4 Hydrology and Hydraulics Analysis

Hydrological analysis was carried out on the estimated design rainfall, rainfall frequency analysis, design flood discharge analysis, runoff coefficient analysis, time concentration analysis, and rain intensity analysis. The entire analysis is carried out using the applicable technical provisions. The flood calculation takes into account land cover in the study location and takes into account future development plans for the area concerning existing spatial planning conditions, and when effective rain occurs, the runoff coefficient takes into account land cover in detail [11],[12],[13].

Hydraulics analysis is carried out to determine the properties or characteristics of the flow of water in a flowing medium, which is mainly influenced by the topographical conditions of the media being traversed. This analysis is carried out to determine the condition of water flow in drainage channels, and rivers and the capacity or ability of drainage channels to carry discharge according to the topographical conditions of the drainage and to analyze hydraulic details. In this analysis, a numerical model analysis of the planned drainage system was also carried out [14], [15],[15].

2.2.5 Drainage Network Planning

In planning drainage channels, the basics of erosion-resistant channel planning will be used, namely, channels that can withstand erosion satisfactorily, which is the same by adjusting the speed of the flow or by using the walls and bottom of the channel which are given a layer that is useful both for resisting erosion. and control the loss of water seepage. The hydrological, topographical, and soil mechanical characteristics mentioned above are also very necessary when creating a new drainage network.

It can also be proposed to make horizontal drainage to eliminate the stagnation of water on the main road. Horizontal drainage above the road directly drains water into the road drainage canal, and this system can overcome flow congestion in the holes in the concrete locking the sidewalk when the road level is raised later.

3. RESULTS AND DISCUSSION

3.1 Inundation and Flood Inventory

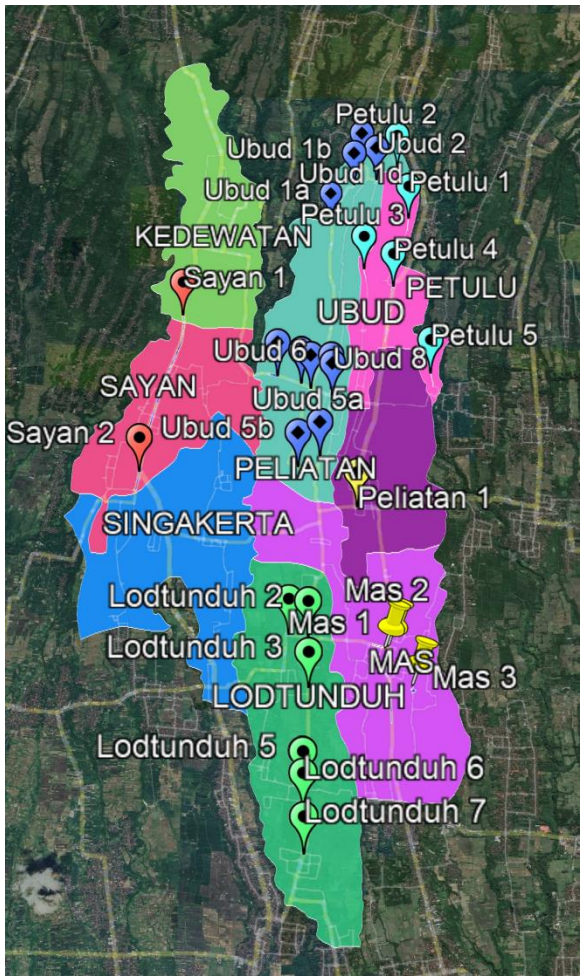
From the results of field surveys and interviews with residents and related agencies, 27 inundation points were found in Ubud District, the locations shown in Figure 1. The inundation locations included 5 points in Lodtunduh Village, 3 points in Mas Village, 2 points in Peliatan Village, 5 points in Petulu Village, 2 points in Sayan Village, and 10 points in Ubud Village. The duration of the inundation that occurs is a minimum of 15 minutes and a maximum of 360 minutes. The height of the inundation that occurs is 12 – 50 cm with an inundation area of 0.032 – 4.67 ha and an inundation length of 12 – 2.309 m. The frequency of inundation is 3 to 10 times per year.


Lodtunduh 3


Mas 1


Sayan 1


Peliatan 1




Petulu 1


Ubud 6


Ubud 9

Figure 1. Location of inundation and flooding in Ubud district

The following is a list of inundations that occurred in Ubud District which is shown in Table 1.

Table 1. List of inundation and flooding in Ubud District in 2022

Location	Time (minute)	Height (cm)	Area (ha)	Length (m)	Frequency (per year)	Indication
Lodtunduh 1	60	50	0,35	549	6	The water overflows because the canals and culverts are shrinking
Lodtunduh 2	60	50	0,2	50	6	Water overflows due to small channels and is disturbed by sedimentation
Lodtunduh 3	180	40	0,43	678,3	6	The water is overflowing because the channel is getting smaller
Lodtunduh 4	240	50	0,02	53	6	The water is overflowing because the channel is getting smaller
Lodtunduh 5	240	50	0,03	93	6	There is a inundation due to the absence of road drainage channels
Mas 1	30	20	1,17	1,078	10	Water overflows because drainage channels mix with irrigation channels
Mas 2	25	25	0,33	169	6	Water overflows because drainage channels mix with irrigation channels
Mas 3	60	30	0,31	103	6	Water overflows because drainage channels mix with irrigation channels
Peliatan 1	60	20	0,85	1072	6	The water in the drainage ditch overflows onto the road
Peliatan 2	60	20	0,84	1277	6	The water in the drainage ditch overflows onto the road
Petulu 1	45	15	0,1051	220	6	The water is overflowing because the channel is getting smaller
Petulu 2	30	12	0,00972	23,2	3	Overflow of irrigation water mixed with rainwater due to small channels

Petulu 3	30	20	0,064	115	6	Overflow of irrigation water mixed with rainwater due to small channels
Petulu 4	60	30	0,9855	966	10	The water in the drainage ditch overflows onto the road
Petulu 5	15	15	0,086	229	3	The water overflowed and pooled onto the road
Sayan 1	20	20	4,67	2.309	7	The water overflowed and pooled onto the road
Sayan 2	20	20	0,57	307	4	The water overflowed and pooled onto the road
Ubud 1	180	25	0,02675	20	5	There is a inundation due to the absence of road drainage channels
Ubud 2	360	20	0,01325	17	5	There is a inundation because the drainage position is higher than the road body
Ubud 3	360	20	0,004817	8	4	There are inundation due to the large number of wild plants that prevent water from flowing into the drainage canals
Ubud 4	30	20	0,0151	20	5	There are inundation due to the large number of wild plants that prevent water from flowing into the drainage canals
Ubud 5	180	20	0,0032	12	6	There is a inundation because the drainage channel is clogged
Ubud 6	120	40	0,0537	32	5	There are inundation because the road body is broken and the channel is clogged
Ubud 7	120	25	0,0301	100	5	There are inundation because the road body is broken and the channel is clogged
Ubud 8	180	15	0,0397	52	6	There is a inundation due to clogged drainage channels
Ubud 9	60	15	0,0779	195	4	There are inundation due to the overflow of water in the gutters and the road above them
Ubud 10	60	25	0,19	230	3	There is a inundation due to clogged drainage channels

3.2 Identification of Existing Drainage Problems

Drainage in the Ubud District area has several problems related to the inundation and flooding that often befalls this area. Some of the identification of the causes of inundation and flooding are also related to drainage, including the following:

1. Drainage channels cannot accommodate peak flood discharges, especially during the heavy and consecutive rainy season. Because the capacity of the channel is insufficient, besides the influence of sediment and garbage, water overflows through the freeboard of the channel.
2. Significant changes in land use change have contributed greatly to increasing surface runoff. The increase in existing water runoff is not matched by an adequate increase in drainage capacity.
3. The settlement development system using the Land Consolidation (LC) system from paddy fields has resulted in a change in the direction of canal usage from irrigation canals to drainage canals.
4. The topography of a flat area makes it difficult for the water to drain into the sewer.
5. There is a narrowing of the river channel, especially in the middle and downstream, so that it often causes flooding
6. There is a building that crosses the river which affects the river flow system downstream. This condition can be seen in several permanent weirs, other former irrigation buildings, bridges, and other buildings.
7. High sedimentation rates in river channels have the effect of reducing river capacity. This condition can be seen in almost all river sections.
8. Disposal of garbage into the river/canal bodies. This condition occurs as a result of low public awareness to participate in maintaining the function of existing drainage channels and rivers. The existence of garbage that enters the body of the canal or river occurs in almost all existing sections.
9. Effect of tides. This condition greatly affects the discharge of water towards the estuary, especially downstream. Conditions of seawater tides will function as backwater which can hold the rate of drainage flow to the main system (river).

3.3 Management of Drainage with Priority Scale

3.3.1 Parameters for Determining Handling Priorities

Parameters for determining the priority of drainage treatment based on the priority scale determined from the following parameters:

1. The inundation parameters are height, area, duration, and frequency of inundation per year

2. Economic loss parameters include: estimated losses on existing economic facilities such as industrial areas, public facilities, social facilities, offices, housing, agricultural areas, and landscaping
3. Parameters of social disturbance and government facilities include public health, social unrest, environmental damage, and damage to government facilities
4. Parameters of transportation losses and disruptions such as obstruction of transportation access due to inundation that overflows over the road body and transportation that is economically strategic does not run smoothly
5. Parameters of losses in residential areas, especially in densely populated areas

3.3.2 Ranking of Drainage Handling Priorities

The determination of the priority scale for handling is carried out based on the five parameters of prioritization above. The value of each parameter ranges from 0-100. Scores are totaled for five parameters, where the maximum score is 500. The highest score will receive handling priority. Based on the calculation of the drainage parameter score, the priority scale ranking for each location village is obtained as follows:

Table 2. Ranking of drainage handling in each village

Location	Score	Ranking in Each Village	Location	Score	Ranking in Each Village
Lodtunduh 1	336	4	Petulu 5	209	4
Lodtunduh 2	336	5	Sayan 1	268	1
Lodtunduh 3	346	1	Sayan 2	244	2
Lodtunduh 4	346	2	Ubud 1	328	8
Lodtunduh 5	346	3	Ubud 2	319	9
Mas 1	435	1	Ubud 3	319	10
Mas 2	389	2	Ubud 4	349	6
Mas 3	223	3	Ubud 5	424	3
Peliatan 1	459	1	Ubud 6	433	2
Peliatan 2	433	2	Ubud 7	328	7
Petulu 1	179	5	Ubud 8	394	5
Petulu 2	244	3	Ubud 9	394	4
Petulu 3	384	2	Ubud 10	463	1
Petulu 4	481	1			

3.3.3 Drainage Handling Recommendations

The recommendations for handling drainage that can be given based on the ranking of treatment priorities are shown in the Table 3.

Table 3. Drainage handling recommendations

Location		Drainage Handling Recommendations
Lodtunduh	1	Channel planning with more adequate cross-sectional dimensions to catch water, especially when it rains with dimensions of 0.50 m x 0.70 m, 0.80 m x 0.40 m, 0.80 m x 1.20 m and 0.80 m x 1.00 m
	2	Making diversion channel with a precast box culvert measuring 0.80 m x 0.80 m
	3	New channel equipped with an inlet drain per segment as the entry point for stagnant water on the road into the drainage channel
Mas	1	Normalization of the existing canal with stone masonry with dimensions of 0.50 m x 0.50 m and 0.80 m x 0.80 m on the right and left sides
	2	Making diversion channel with a precast box culvert measuring 0.50 m x 0.50 m and 0.80 m x 0.80 m
	3	The new channel is equipped with an inlet drain per segment as a path for stagnant water on the road to enter the drainage channel
Peliatan	1	Channel planning with more adequate cross-sectional dimensions to catch water, especially when it rains with dimensions of 0.60 m x 1.00 m and 0.80 m x 1.00 m
	2	New channel equipped with an inlet drain per segment as the entry point for stagnant water on the road into the drainage channel
Petulu	1	Normalization of the existing channel with stone masonry with a size of 0.80 m x 0.60 m and 1.00 m x 0.60 m along the inundation path on both the right and left sides
Sayan	1	Normalization of the existing canal with stone masonry with a size of 0.80 m x 0.80 m on both the right and left sides
	2	New channel equipped with an inlet drain per segment as the entry point for stagnant water on the road into the drainage channel
Ubud	1	Normalization of the existing canal with stone masonry with dimensions of 0.40 m x 0.40 m, 0.50 m x 0.80 m, and 0.80 m x 0.80 m on both the right and left sides

2 The existing canal design will be enlarged to a size of 0.40 m x 0.60 m, 0.50 m x 1.00 m, 0.70 m x 1.00 m, and 1.00 m x 1.00 m with river stone masonry
3 Paving around the shoulder of the road is carried out so that water can flow directly into the drainage canal
4 The new channel is equipped with an inlet drain per segment as a path for stagnant water on the road to enter the drainage channel

4. CONCLUSION

Based on the discussion that has been carried out, it can be concluded that 27 inundation points were found in Ubud District. The inundation locations include 5 points in Lodtunduh Village, 3 points in Mas Village, 2 points in Peliatan Village, 5 points in Petulu Village, 2 points in Sayan Village, and 10 points in Ubud Village. The duration of the inundation that occurs is a minimum of 15 minutes and a maximum of 360 minutes. The height of the inundation that occurs is 12 – 50 cm with an inundation area of 0.032 – 4.67 ha and an inundation length of 12 – 2,309 m. The frequency of inundation is 3 to 10 times per year.

Drainage in the Ubud District area has several problems related to the inundation and flooding that often afflicts this area, the majority of which are caused by the capacity of the drainage channels not being able to accommodate rainwater discharge, and drainage blockages caused by garbage, wild plants, and sedimentation. Parameters for determining priority for drainage management based on priority scale are determined based on the characteristic parameters of inundation, economic losses, social disturbances and government facilities, transportation disturbances, and losses in residential areas.

The treatment recommendations given include normalizing the existing canal with river stone pairs of the required size that are more adequate to accommodate water discharge, especially during rains; making diversion channel with precast box culvert with the required size; and construction of new channels equipped with inlet drains per segment as entry points for inundation on the roads into the drainage channels.

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